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Understanding Gender Disparities in Healthy Ageing in France: The contribution of Health and Social conditions

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Comprendre les disparités de genre face au vieillissement en bonne santé en France : La contribution des maladies et des conditions sociales

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Dedicated to my mother, sister, and nieces.

ماما أمل، رانيا، أمل زينة، آية

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Reading guide.

This thesis comprises three independent studies that can be read separately. Key definitions and tools are introduced in the general introduction and developed further within each chapter. As the chapters target different journals, their structure and formatting may vary. Supplementary materials and references are provided at the end of each chapter. The supplementary analyses present the most relevant additional results. Occasionally, the main text refers to complementary analyses that are not included in the appendices; these are available upon request.

The following acronyms appear repeatedly across chapters. While each chapter redefines them, a summary is provided here for reference.

- **MSD / MSC:** Musculoskeletal diseases / Musculoskeletal conditions (e.g., arthritis, osteoporosis, chronic back pain)
- **CVD:** Cardiovascular diseases (e.g., stroke, myocardial infarction, coronary heart disease)
- **DS:** Depressive symptoms
- **AL:** Activity limitation in general activities (e.g., housework, leisure, work)
- **NENR:** "Neither employed nor retired" (detailed in the General introduction)

Summary.

Women live longer than men, yet spend more years with activity restrictions, a pattern known as the gender-health survival paradox. This thesis examines how specific health and social conditions contribute to gender disparities in healthy ageing in France. Drawing on the disablement process framework, which identifies chronic diseases as initiating factors in the pathway toward disability, it investigates which diseases drive women's excess activity restrictions, and whether they do so through higher prevalence or a stronger disabling impact. The analysis extends from older ages to mid-adulthood and connects these health vulnerabilities to pension reforms extending working lives. Three complementary studies are conducted on recent French data, combining cross-sectional and longitudinal designs.

The first chapter assesses how eight categories of chronic diseases contribute to activity limitation among adults aged 60 and over, using nationally representative data from the French CARE surveys (2015–2016), across gender and socio-occupational groups. Musculoskeletal and cardiovascular diseases emerge as the leading contributors, with musculoskeletal diseases and depression more prevalent among women, and cardiovascular diseases among men. Additive hazard regressions and decomposition analyses show that disparities are primarily driven by differences in disease prevalence rather than disabling impact: women's higher prevalence of musculoskeletal diseases, depression, and neurodegenerative conditions accounts for their excess limitation, while the greater prevalence of musculoskeletal and cardiovascular diseases among manual workers and farmers explains their higher burden compared to highly skilled workers.

Building on these findings, the second chapter focuses on musculoskeletal conditions and depressive symptoms in mid-adulthood (ages 50–69), using longitudinal data from the French CONSTANCES cohort. It broadens the outcomes to include employment restrictions, captured through the risk of being "Neither employed nor retired" (NENR). Both conditions increase the risk of onset and persistence of activity limitation and of transitioning into NENR status. No gender differences in the strength of these

associations are found: women's disadvantage stems from greater exposure rather than a stronger disabling impact.

The third chapter carries the inquiry of employment restrictions into the policy domain, asking whether the employment effects of raising retirement ages are heterogeneous with respect to health. It examines whether individuals with histories of the conditions examined in the preceding chapters, depression, osteoarticular diseases, and cardiovascular diseases, face a higher risk of being NENR when the 2010 French pension reform raised statutory retirement ages. Combining CONSTANCES with administrative records from the French National Old-Age Insurance Fund in a difference-in-differences approach, the analysis finds evidence of heterogeneity for all three conditions, with the most robust results for depression, a condition more prevalent among women and for which early retirement provisions remain limited.

These findings show that gender disparities in healthy ageing arise primarily from women's higher prevalence of musculoskeletal diseases and poor mental health, while cardiovascular diseases, though more relevant to men's burden and to the social gradient, are also important contributors to activity limitation. The unequal prevalence of these conditions reflects both biological vulnerabilities and social circumstances, including occupational exposures and domestic responsibilities, and the interaction between the two. These findings point to prevention and improved disease management as essential levers for promoting healthy ageing and reducing inequalities, and underscore the importance of accounting for health vulnerabilities in the design of pension reforms extending working lives.

Keywords: Gender, Disparities, Healthy ageing, Diseases, Restrictions, Disability

Résumé.

Les femmes vivent plus longtemps que les hommes, mais passent davantage d'années avec des restrictions d'activité, un paradoxe bien documenté. Cette thèse s'interroge sur la contribution des maladies chroniques et de conditions sociales aux disparités de genre dans le vieillissement en bonne santé en France. Dans le cadre du processus d'incapacité, elle cherche à identifier quelles maladies expliquent l'excès de restrictions chez les femmes, et si celui-ci relève d'une prévalence plus élevée ou d'un impact plus invalidant. L'analyse couvre les âges à partir de 50 ans et met en lien ces vulnérabilités de santé avec les réformes des retraites. Trois études sont menées sur des données françaises récentes, en approches transversale et longitudinale.

Le premier chapitre évalue la contribution de huit catégories de maladies chroniques aux limitations d'activité chez les 60 ans et plus, à l'aide des enquêtes CARE (2015–2016), selon le genre et la catégorie socioprofessionnelle. Les maladies musculo-squelettiques et cardiovasculaires en sont les principaux contributeurs, les premières ainsi que la dépression étant plus fréquentes chez les femmes, les secondes chez les hommes. Analyses d'attribution et de décomposition montrent que les disparités s'expliquent avant tout par des différences de prévalence : chez les femmes, la prévalence plus importante des maladies musculo-squelettiques, de la dépression et des maladies neurodégénératives contribue à leur excès de limitations ; chez les ouvriers et agriculteurs, celle des maladies musculo-squelettiques et cardiovasculaires explique leur désavantage par rapport aux cadres.

Le deuxième chapitre se concentre sur les troubles musculo-squelettiques et les symptômes dépressifs, notamment en raison de leur plus grande prévalence chez les femmes, chez les adultes de 50 à 69 ans, en mobilisant les données longitudinales de CONSTANCES. L'étude élargit l'analyse aux restrictions d'emploi, appréhendées à travers le statut « ni en emploi ni à la retraite » (NENR). Les deux conditions augmentent le risque de survenue et de persistance des limitations d'activité et de passage au NENR. Aucune différence de genre n'est observée dans l'effet de ces conditions : le désavantage des femmes tient à leur plus grande exposition, non à un impact invalidant plus fort.

Le troisième chapitre prolonge la question des restrictions d'emploi dans le champ des politiques publiques, en examinant si les effets du relèvement de l'âge de la retraite sont hétérogènes selon l'état de santé passé. L'étude analyse si les personnes ayant des antécédents des pathologies étudiées précédemment sont davantage exposées au NENR suite à la réforme de 2010. En combinant CONSTANCES avec les données de la CNAV en doubles différences, l'analyse met en évidence une hétérogénéité pour les trois pathologies, les résultats les plus robustes concernant la dépression, plus fréquente chez les femmes et pour laquelle les dispositifs de départ anticipé demeurent limités.

Les résultats montrent que les disparités de genre dans les restrictions d'activité s'expliquent davantage par la prévalence plus élevée des maladies musculo-squelettiques et des troubles de santé mentale chez les femmes. Les maladies cardiovasculaires, plus liées à la charge des hommes et au gradient social, contribuent aussi aux limitations d'activité. La distribution inégale de ces maladies reflète des vulnérabilités biologiques mais aussi des conditions sociales, notamment les expositions professionnelles et les responsabilités domestiques. Ces résultats appellent à renforcer la prévention et la prise en charge pour favoriser le vieillissement en bonne santé et réduire les inégalités, et soulignent la nécessité d'intégrer l'hétérogénéité des profils de santé dans la conception des réformes des retraites.

Keywords: Genre, Veilliessement en bonne santé, Maladies, Incapacité, Disparités

Résumé substantiel.

Contexte.

L'espérance de vie à la naissance a connu des progrès considérables au cours du vingtième siècle. Dans la plupart des pays européens, elle atteignait en moyenne 81,5 ans en 2023, bien que son rythme de croissance se soit ralenti par rapport aux décennies précédentes et ait été temporairement interrompu par la pandémie de COVID-19 (OECD/European Commission, 2024). La France se distingue avec l'une des espérances de vie les plus élevées d'Europe, atteignant 85,9 ans pour les femmes et 80,3 ans pour les hommes en 2025 (INSEE, 2026). Ces niveaux élevés reflètent les avancées médicales et les stratégies de prévention ayant réduit la mortalité liée à des pathologies autrefois fatales, en particulier les maladies cardiovasculaires et les cancers, ainsi que les progrès antérieurs en matière de survie infantile (GBD 2021 Europe Life Expectancy Collaborators, 2025 ; Wéber et al., 2023).

Toutefois, l'allongement de la durée de vie s'accompagne d'importants défis. En France, la proportion des personnes de 65 ans et plus est passée de 16,4 % en 2005 à 22,2 % début 2026, et devrait atteindre 28 % d'ici 2050 (Bonnet et al., 2021 ; INSEE, 2026). Ce vieillissement démographique exerce une pression croissante sur les dépenses publiques et les systèmes de protection sociale, notamment en matière de santé et de prise en charge de la dépendance (Belmonte et al., 2023 ; Kallestrup-Lamb et al., 2024 ; Okamoto et al., 2023). Or, une part importante des difficultés fonctionnelles apparaît dès 50 ans, et les restrictions d'activité qui en découlent réduisent la participation au marché du travail, accroissent le recours aux pensions d'invalidité et aux allocations chômage, et peuvent conduire à des sorties prématurées de l'emploi, engendrant des coûts sociaux et économiques considérables (Bloom et al., 2015 ; Meyer & Mok, 2013 ; Okamoto et al., 2023). Dès lors, l'enjeu ne porte plus seulement sur la durée de la vie, mais sur la qualité de santé dans laquelle se déroulent les années vécues.

C'est sous ce contexte que se sont développés les travaux sur l'espérance de vie sans incapacité (EVSI), un indicateur complémentaire de l'espérance de vie qui estime le nombre d'années qu'une personne peut espérer vivre sans limitations fonctionnelles ou restrictions d'activité (Cambois et al., 2013 ; Jagger et al., 2011, 2020 ; Sullivan, 1971). Dans l'Union européenne, les années de vie en bonne santé à la naissance atteignaient 63,3 ans pour les femmes et 62,8 ans pour les hommes en 2023, soit environ trois quarts et quatre cinquièmes de l'espérance de vie totale, respectivement (Eurostat, 2024). Si environ deux tiers des gains d'espérance de vie des deux dernières décennies ont correspondu à des années en bonne santé, le tiers restant a été vécu avec des problèmes de santé et des incapacités (OECD/European Commission, 2024). En France, l'EVSI à 65 ans augmente régulièrement depuis 2008, atteignant 11,8 ans pour les femmes et 10,5 ans pour les hommes en 2024 (DREES, 2026). Cependant, environ la moitié des années de vie restantes après 65 ans continuent d'être vécues avec une forme de restriction d'activité (DREES, 2026).

D'importantes inégalités traversent ces indicateurs. Le long du gradient social, les individus de catégories socioprofessionnelles désavantagées vivent non seulement moins longtemps, mais passent également une part plus importante de leurs années avec des limitations, et ce dès 50 ans (Cambois et al., 2020 ; Darin-Mattsson et al., 2017 ; Head et al., 2019 ; Mackenbach et al., 2008 ; Solé-Auró et al., 2020). Les inégalités sociales d'EVSI sont souvent plus marquées que celles d'espérance de vie, ce qui indique que la position sociale affecte la qualité des années vécues davantage encore que leur nombre (Cambois et al., 2001 ; Jagger et al., 2008 ; Valverde et al., 2021). En France, ces inégalités sont bien documentées : les ouvriers ont des chances nettement plus faibles que les cadres de parvenir aux âges élevés, et lorsqu'ils y parviennent, ils y vivent davantage d'années avec des incapacités (Cambois et al., 2011).

Sur le plan du genre, un constat solidement établi dans la littérature mérite une attention particulière : les femmes vivent plus longtemps que les hommes, mais passent davantage de leurs années supplémentaires avec des incapacités (Cambois et al., 2013 ; Crimmins et al., 2011 ; Oksuzyan et al., 2009 ; Van Oyen et al., 2010, 2013). Ce paradoxe, souvent désigné dans la littérature anglophone sous le terme de *gender-health survival paradox*, signifie que l'avantage des femmes en longévité ne se traduit pas par un avantage

équivalent en années vécues en bonne santé. Ce constat ne se limite pas aux années supplémentaires : dès 50 ans et à âges comparables, les femmes déclarent des taux de limitations d'activité plus élevés que les hommes (Augustsson et al., 2023 ; Hosseinpoor et al., 2012 ; Oksuzyan et al., 2008).

Une explication majeure de ce paradoxe renvoie aux différences de profils pathologiques entre hommes et femmes (Crimmins et al., 2011 ; Kingston et al., 2014 ; Nusselder, Cambois et al., 2019). Les hommes développent plus fréquemment des pathologies potentiellement fatales, telles que les maladies cardiovasculaires et les cancers agressifs, qui raccourcissent leur espérance de vie. Les femmes, en revanche, sont plus susceptibles de connaître des conditions invalidantes mais moins souvent fatales, telles que les maladies musculo-squelettiques, la dépression et certaines maladies liées à l'âge comme les maladies neurodégénératives, avec lesquelles elles vivent plus longtemps.

Ces différences de profils pathologiques sont elles-mêmes façonnées par l'imbrication de facteurs biologiques et sociaux. D'un point de vue biologique, les différences liées au sexe dans les profils hormonaux, les réponses immunitaires et le patrimoine génétique contribuent à une vulnérabilité différentielle face à des pathologies spécifiques (Khadilkar, 2019 ; Murtagh & Hubert, 2004 ; Oksuzyan et al., 2008). D'un point de vue social, les différences de genre dans l'éducation, les trajectoires professionnelles, les conditions de travail, les comportements de santé, les responsabilités familiales, l'accès aux soins et leur utilisation, façonnent la distribution des facteurs de risque des maladies invalidantes au cours de la vie (Augustsson et al., 2023 ; Bloomberg et al., 2021 ; Cambois et al., 2017 ; Campos-Serna et al., 2013 ; Crimmins et al., 2011 ; Hosseinpoor et al., 2012). Or, ces dimensions ne sont pas indépendantes : les rôles de genre et les conditions sociales influencent l'exposition aux risques sanitaires et l'accès aux soins, qui interagissent à leur tour avec les vulnérabilités biologiques pour produire les profils observés de maladies et d'incapacité. Examiner comment des maladies spécifiques contribuent aux disparités de genre dans le vieillissement en bonne santé constitue donc un point d'entrée pertinent pour comprendre ces disparités, car cela capture les effets combinés des déterminants biologiques et sociaux.

Par ailleurs, les disparités de genre dans le vieillissement en bonne santé ne se manifestent pas seulement aux âges les plus élevés : elles commencent à émerger dès 50 ans, une période de plus en plus pertinente dans le contexte des politiques d'allongement de la vie professionnelle. Comprendre quelles conditions spécifiques contribuent le plus à ces disparités en deuxième partie de vie active, et si elles y contribuent par des différences de prévalence, d'impact invalidant, ou les deux, est directement informatif pour les politiques publiques : cela identifie les maladies à prioriser dans les stratégies de prévention et de prise en charge, et les dimensions sur lesquelles les interventions sont les plus nécessaires.

Objectif de la thèse et questions de recherche.

Cette thèse a pour objet de comprendre comment les maladies chroniques et les conditions sociales contribuent aux disparités de genre dans le vieillissement en bonne santé en France. Si le rôle des profils pathologiques différenciés dans ces disparités a été documenté dans la littérature, cette explication mérite un examen continu. Les profils de maladies, leurs déterminants biologiques et sociaux, ainsi que les environnements institutionnels dans lesquels ils se déploient, évoluent au fil du temps, et il importe d'évaluer si les relations mises en évidence dans les travaux antérieurs se vérifient avec des données plus récentes. Par ailleurs, ces disparités de genre ne se manifestent pas seulement aux âges les plus élevés : elles prennent forme dès 50 ans, période qui revêt une importance croissante dans un contexte de réformes allongeant la vie professionnelle.

Trois questions structurent la thèse. Premièrement, quelles maladies chroniques contribuent le plus aux limitations d'activité, et dans quelle mesure les disparités de genre et sociales dans ces limitations s'expliquent-elles par des différences de prévalence des maladies et/ou par des différences dans leur impact invalidant ? Deuxièmement, les conditions identifiées comme les plus pertinentes pour l'écart de genre sont-elles également associées aux restrictions d'emploi à partir de 50 ans ? et l'impact de ces conditions diffère-t-il entre hommes et femmes ? Troisièmement, ces vulnérabilités de santé constituent-elles un facteur d'inégalité face aux réformes des retraites allongeant la vie professionnelle?

Cette thèse contribue à la littérature à travers trois études menées sur des données françaises récentes et complémentaires, combinant des approches transversale et longitudinale. La dimension longitudinale permet d'évaluer la direction des effets entre conditions de santé et restrictions d'activité, ce qui constituait une limitation des travaux antérieurs fondés sur des données transversales. Les analyses couvrent les âges à partir de 50 ans et mobilisent des indicateurs de restrictions qui ne se limitent pas aux formes sévères d'incapacité, plus fréquentes aux âges les plus élevés, mais incluent également les restrictions dans les activités générales et les restrictions d'emploi. La dernière partie de la thèse examine l'interaction entre vulnérabilités de santé et réformes des retraites.

La France constitue un terrain particulièrement pertinent pour cette recherche. L'espérance de vie y figure parmi les plus élevées d'Europe, en particulier pour les femmes, ce qui rend le paradoxe décrit précédemment particulièrement prononcé. En outre, malgré un système de protection sociale étendu et une couverture maladie universelle (Chevreul et al., 2015), d'importantes inégalités de santé persistent (Cambois et al., 2011 ; Mackenbach et al., 2008), ce qui suggère que des mécanismes opèrent au-delà de l'accès aux soins. Enfin, l'infrastructure de données française, combinant enquêtes représentatives, grandes cohortes épidémiologiques et dossiers administratifs, permet d'examiner les questions de recherche de cette thèse en profondeur.

Définitions et cadres théoriques adoptés.

Définition du vieillissement en bonne santé.

Cette thèse adopte la définition de l'Organisation mondiale de santé (OMS), qui conçoit le vieillissement en bonne santé comme « le processus de développement et de maintien des capacités fonctionnelles permettant le bien-être aux âges avancés » (World Health Organization, 2020). Ce cadre met l'accent sur la capacité des individus à réaliser ce qu'ils valorisent et reconnaît le rôle des environnements physiques et sociaux (Papa et al., 2019). Il se distingue du modèle du « vieillissement réussi » de Rowe et Kahn (1997), critiqué pour son caractère restrictif excluant les personnes vivant avec des maladies chroniques (Cho et al., 2012 ; Hung et al., 2010 ; Martinson & Berridge, 2015).

Le processus d'incapacité.

Le cadre théorique mobilisé dans cette thèse est le modèle du processus d'incapacité, introduit par Nagi (1964), développé par Wood et Badley (1978) dans le cadre de la Classification internationale du handicap de l'OMS, puis formalisé par Verbrugge et Jette (1994). Ce modèle identifie les maladies chroniques comme les facteurs déclencheurs d'une progression allant des déficiences corporelles aux limitations fonctionnelles (physiques, sensorielles ou cognitives), puis aux restrictions d'activité dans les tâches quotidiennes et sociales. Le modèle reconnaît que cette trajectoire est modulée par les traitements, les aides techniques et les facteurs contextuels, et que des effets de rétroaction peuvent survenir, l'incapacité pouvant générer de nouvelles pathologies. Ce cadre est cohérent avec la Classification internationale du fonctionnement, du handicap et de la santé (CIF) de l'OMS (Jette, 2006 ; WHO, 2001) et demeure fondamental dans la recherche contemporaine (Lane et al., 2020).

Mécanismes des inégalités.

Dans le cadre du processus d'incapacité, les différences de risques de restrictions d'activité entre groupes peuvent relever de deux canaux (Klijs et al., 2011, 2014 ; Nusselder, Cambois et al., 2019 ; Nusselder et al., 2005). Le premier opère par les différences de prévalence : les groupes plus exposés à certaines pathologies sont plus susceptibles de connaître des restrictions. La littérature a attribué une part substantielle de l'excès de restrictions chez les femmes à leur prévalence plus élevée de maladies musculo-squelettiques (Nusselder, Cambois et al., 2019 ; Oksuzyan et al., 2008 ; Yokota et al., 2015), tandis que la prévalence plus élevée de maladies cardiovasculaires chez les hommes contribue à leur surmortalité, interrompant le processus d'incapacité avant qu'il ne se développe pleinement (Crimmins et al., 2011). Le long du gradient social, les taux plus élevés de maladies musculo-squelettiques et cardiovasculaires chez les ouvriers contribuent à leur fardeau d'incapacité (Cambois et al., 2011 ; Nusselder et al., 2005).

Le second canal opère par les différences d'impact invalidant : la progression de la maladie vers l'incapacité est façonnée par l'accès aux soins, la qualité de la prise en charge, les aides techniques et l'adaptabilité des environnements (Verbrugge & Jette, 1994). Dans la dimension social, une condition musculo-squelettique peut être plus invalidante, par exemple, pour un travailleur manuel avec peu d'aménagements que pour un cadre

(Gjesdal et al., 2011) . Les différences de genre dans l'impact invalidant peuvent refléter, par exemple, le temps limité de récupération lié aux responsabilités domestiques (Hosseinpoor et al., 2012 ; Nusselder, Cambois et al., 2019). Les deux canaux, de différences de prévalences et d'impact invalidant, peuvent opérer simultanément et se renforcer mutuellement (Klijs et al., 2014 ; Marmot, 2005). Les démêler est essentiel pour orienter les politiques : prévention si le désavantage tient à la prévalence, amélioration de la prise en charge s'il tient à l'impact invalidant.

Indicateurs de restrictions d'activité.

La thèse se concentre sur les restrictions d'activité, point d'aboutissement du processus d'incapacité, et mobilise deux indicateurs complémentaires. Le premier est le GALI (Global Activity Limitation Indicator), qui mesure les limitations de longue durée dans les activités habituelles,du fait d'un problème de santé au cours des six derniers mois. Utilisé pour le suivi des années de vie en bonne santé en Europe (Jagger et al., 2011 ; Van Oyen et al., 2006), il capture un spectre large de restrictions, y compris celles émergeant avant les limitations sévères et est adapté au milieu de la vie adulte (Berger et al., 2015 ; Cambois et al., 2016). Le second indicateur porte sur les restrictions d'emploi, appréhendées à travers le statut de « ni en emploi ni à la retraite » (**NENR**). Ce statut recouvre les situations dans lesquelles des individus ont quitté ou sont exclus de l'emploi avant l'âge de la retraite, le plus souvent en lien avec des problèmes de santé. En France, 11 % des adultes de 53 à 69 ans se trouvaient dans cette situation en 2015, majoritairement des femmes, et leur taux de pauvreté atteignait 32 % (D'Isanto et al., 2018).

Données mobilisés.

L'examen de la relation entre maladies chroniques et restrictions d'activité selon le genre et la position sociale nécessite des données combinant informations médicales détaillées, caractéristiques sociales et démographiques étendues, et échantillons suffisamment importants. Aucune source unique ne réunit l'ensemble de ces exigences pour les différentes questions de recherche abordées dans cette thèse. Trois sources complémentaires ont donc été mobilisées, chacune offrant des avantages spécifiques alignés avec les objectifs de l'étude correspondante.

La première étude, qui porte sur la contribution des maladies chroniques aux limitations d'activité chez les 60 ans et plus, s'appuie sur l'enquête Capacités, Aides et Ressources des Seniors (CARE), conduite par la DREES en partenariat avec l'INSEE en 2015–2016 (Carrère et al., 2019). CARE est représentative de la population française de 60 ans et plus et comprend deux volets : un volet ménages (CARE-Ménages, N = 10 593), construit à partir de l'enquête Vie Quotidienne et Santé (VQS, 2014) avec un sur-échantillonnage des personnes les plus dépendantes, et un volet institutions (CARE-Institutions, N = 2 958), tiré du répertoire national des établissements sanitaires et sociaux (FINESS). L'inclusion des personnes résidant en établissement est essentielle pour l'étude de l'incapacité aux âges élevés, leur exclusion conduisant à sous-estimer les niveaux de limitations. Les données, collectées en face-à-face, couvrent un large éventail de maladies chroniques, de limitations fonctionnelles, de restrictions d'activité et de caractéristiques sociales, ce qui en fait un outil adapté à l'exploration des contributions différenciées des maladies aux limitations selon le genre et la catégorie socioprofessionnelle.

Les deuxième et troisième études mobilisent la cohorte CONSTANCES, une cohorte prospective en population générale conçue comme une infrastructure de recherche épidémiologique, avec un accent particulier sur les déterminants professionnels et sociaux de la santé (CONSTANCES team et al., 2015 ; Goldberg et al., 2017). CONSTANCES a recruté environ 220 000 adultes de 18 à 69 ans entre 2012 et 2020, parmi les affiliés du régime général d'assurance maladie. À l'inclusion, les participants ont rempli des questionnaires détaillés sur leur santé, leurs conditions de vie et de travail, et ont bénéficié d'un examen médical standardisé dans l'un des 21 centres d'examen de santé participants. Des questionnaires annuels de suivi permettent des mesures répétées dans le temps. Le taux de participation, d'environ 8 %, et la surreprésentation des individus plus éduqués et en meilleure santé parmi les participants limitent les estimations de prévalence en population générale. Cependant, la grande taille de la cohorte et la diversité des situations sociales et de santé qu'elle couvre permettent d'explorer les mécanismes épidémiologiques étudiés, en particulier les associations entre conditions de santé et restrictions d'activité au sein de sous-groupes détaillés.

La troisième étude nécessitait en outre des données administratives permettant de reconstituer les trajectoires d'emploi sur longue période. Les données de la Caisse nationale d'assurance vieillesse (CNAV), issues du Système national de gestion des carrières (SNGC), ont été appariées à la cohorte CONSTANCES à cette fin. Ces relevés retracent, pour chaque assuré du régime général, l'ensemble des périodes de cotisation depuis l'âge de 16 ans, incluant les périodes d'emploi, de chômage, d'invalidité, de maladie et de congé parental. Leur principal avantage réside dans le caractère objectif et continu de l'information sur les trajectoires professionnelles, moins sujette aux biais de déclaration et de rappel qui affectent les mesures issues d'enquêtes. En croisant ces trajectoires administratives avec les informations de santé collectées dans CONSTANCES, il devient possible d'examiner comment les antécédents de maladies chroniques interagissent avec les réformes des retraites pour façonner le statut d'emploi en fin de vie active.

Résumés des chapitres.

Chapitre 1. Contribution des maladies chroniques aux limitations d'activité chez les 60 ans et plus selon le genre et la catégorie socioprofessionnelle.

Aux âges élevés, les maladies chroniques sont très répandues et inégalement distribuées entre les groupes de genre et les groupes sociaux, tout comme les restrictions d'activité auxquelles elles sont associées. Ce chapitre examine la contribution de huit catégories de maladies chroniques aux limitations d'activité générales (LA, mesurées par le GALI) chez les adultes de 60 ans et plus en France, en tenant compte des comorbidités. Il évalue dans quelle mesure les écarts de genre et les écarts socioprofessionnels dans la prévalence des LA s'expliquent par des différences dans la prévalence des maladies, par des différences dans leur impact invalidant, ou par une combinaison des deux. Des travaux français antérieurs ont examiné cette question à partir de données françaises de 2008–2009, en appréhendant la position sociale principalement par le niveau d'éducation (Nusselder, Wapperom et al., 2019 ; Palazzo et al., 2019). Ce chapitre les prolonge en mobilisant des données plus récentes et en adoptant une approche par les

catégories socioprofessionnelles, plus directement liées aux conditions de travail et aux expositions professionnelles.

L'analyse s'appuie sur l'enquête CARE (2015–2016), représentative de la population française de 60 ans et plus, incluant les personnes vivant à domicile et en institutions (N = 13 551). Huit catégories de maladies, identifiées à partir d'un diagnostic médical ou d'un traitement en cours au cours des 12 mois précédant l'enquête, sont considérées : maladies musculo-squelettiques (MMS), cardiovasculaires (MCV), neurodégénératives (MND), rénales, diabète, dépression, dégénérescence maculaire et cancer. La position sociale est appréhendée à travers la dernière profession déclarée, classée selon la nomenclature française des professions et catégories socioprofessionnelles (PCS) (INSEE, 2020) en sept groupes : agriculteurs, travailleurs indépendants, ouvriers, employés, professions intermédiaires, cadres et professions intellectuelles supérieures, et personnes n'ayant pas exercé de profession.

La stratégie empirique procède en trois temps. Dans un premier temps, les prévalences des maladies chroniques et des LA sont calculés par genre et catégorie socioprofessionnelle à l'aide des pondérations d'enquête, avec standardisation sur l'âge par la méthode directe. Dans un deuxième temps, une méthode d'attribution fondée sur des modèles additifs binomiaux est appliquée. Ces modèles estiment, pour chaque catégorie de maladies, la force de son association avec les LA, désignée sous le terme d'« impact invalidant », tout en tenant compte de la présence simultanée d'autres pathologies. Les estimations obtenues permettent ensuite de décomposer la prévalence globale des LA en contributions additives de chaque catégorie de maladies, faisant apparaître leur rang et leur poids relatif dans l'explication des LA au sein de chaque groupe de genre et de chaque catégorie socioprofessionnelle. Un terme résiduel, désigné comme « background », capture la part des LA attribuable à des facteurs non explicitement modélisés, tels que les maladies non diagnostiquées ou l'effet propre de l'âge. Dans un troisième temps, une méthode de décomposition fondée sur l'extension non linéaire de l'approche d'Oaxaca-Blinder, proposée par Yun (2004, 2008), est appliquée pour séparer les écarts de prévalence des LA entre deux groupes, par exemple entre femmes et hommes, ou entre ouvriers et cadres, en deux composantes : l'une

attribuable aux différences de prévalence des maladies entre les groupes, l'autre aux différences d'impact invalidant de ces maladies.

Les résultats montrent que la prévalence des LA est significativement plus élevée chez les femmes que chez les hommes en population générale, bien que cette différence perde sa significativité après standardisation sur l'âge. Des gradients sociaux prononcés sont observés au sein des hommes et des femmes: les agriculteurs et les ouvriers rapportent des prévalences de LA plus élevées que les cadres. Les femmes présentent une prévalence plus élevée de MMS, de dépression, de MND et de dégénérescence maculaire, y compris après standardisation sur l'âge, tandis que les hommes rapportent davantage de MCV.

Dans tous les groupes de genre et catégories socioprofessionnels, les MMS et les MCV sont les deux principaux contributeurs à la prévalence des LA. La dépression contribue également de manière notable aux LA chez les femmes. Les MND, la dégénérescence maculaire et les MCV présentent les impacts invalidants les plus forts dans tous les groupes, mais la faible prévalence des MND et de la dégénérescence maculaire limite l'ampleur de leur contribution à la prévalence globale des LA. Aucune différence significative d'impact invalidant n'est détectée entre genres ni entre catégories socioprofessionnelles pour la plupart des pathologies ; seuls le diabète et le cancer montrent des différences significatives dans certains groupes. Les maladies rénales constituent un contributeur important aux LA parmi les femmes travailleuses indépendantes. Le diabète contribue davantage aux LA chez les hommes en population générale, mais présente des schémas hétérogènes selon les strates de genre et de catégorie socioprofessionnelle.

Les analyses de décomposition confirment que les écarts de genre et les écarts sociaux dans la prévalence des LA sont principalement portés par les différences de prévalence des maladies entre les groupes, et non par des différences dans l'impact invalidant de ces maladies. Les MMS, les MCV et les MND sont les catégories qui contribuent le plus à ces écarts, du fait de leur distribution inégale entre les groupes. Les différences de

structure d'âge entre genres et catégories socioprofessionnelles participent également de manière significative aux écarts de prévalence des LA.

Les résultats de ce chapitre soulignent la nécessité d'interventions ciblées visant à réduire la prévalence des maladies qui pèsent le plus sur les restrictions d'activité, en particulier les MMS et les MCV. La prévalence plus élevée des MMS chez les femmes reflète à la fois des vulnérabilités biologiques, notamment les modifications hormonales liées à la ménopause qui accroissent le risque d'ostéoporose et d'arthrose, et des expositions sociales, telles que les contraintes biomécaniques dans un large éventail de professions féminisées et la charge des responsabilités domestiques. La prévalence plus élevée des MCV chez les hommes et dans les catégories socioprofessionnelles manuelles renvoie quant à elle à des facteurs de risque comportementaux et professionnels socialement distribués. Les efforts de prévention et de prise en charge de ces pathologies pourraient ainsi jouer un rôle décisif dans la réduction des inégalités et la limitation des restrictions d'activité aux âges élevés. Toutefois, le caractère transversal de l'analyse ne permet pas d'établir la directionnalité des associations. La mortalité sélective constitue également un biais à considérer : les individus atteints de pathologies létales, notamment cardiovasculaires, décèdent plus fréquemment avant d'atteindre les âges élevés, ce qui peut conduire à sous-estimer la contribution de ces maladies aux LA. Enfin, la restriction de l'analyse aux 60 ans et plus laisse ouverte la question de savoir si ces schémas se reproduisent plus tôt, aux âges où les restrictions commencent à émerger et où les interventions pourraient être les plus efficaces. Ces considérations motivent les chapitres suivants.

Chapitre 2. Impact des conditions musculo-squelettiques et des symptômes dépressifs sur les restrictions d'activité en milieu de vie adulte.

Le chapitre précédent a montré que les maladies musculo-squelettiques et la dépression sont les conditions qui contribuent le plus à l'écart de genre dans la prévalence des limitations d'activité chez les 60 ans et plus, principalement par leur prévalence plus élevée chez les femmes. Ce deuxième chapitre resserre l'analyse sur ces deux catégories de conditions de santé. Ce choix est conforté par les données de l'étude Global Burden of

Disease (2019), selon lesquelles les troubles musculo-squelettiques et les troubles mentaux constituent les deux premières causes d'années vécues avec incapacité en France, ce qui souligne la pertinence de leur examen conjoint.

Le chapitre élargit l'investigation dans trois directions par rapport au chapitre précédent. Premièrement, il étend la tranche d'âge étudiée aux adultes de 50 à 69 ans, période où les restrictions d'activité commencent à se former et où les politiques d'allongement de la vie professionnelle sont les plus directement pertinentes. Deuxièmement, il diversifie les indicateurs de restrictions en incluant, aux côtés des limitations d'activité générales (LA, mesurées par le GALI), les restrictions d'emploi appréhendées à travers le statut de « ni en emploi ni à la retraite » (NENR). Troisièmement, il mobilise des données à deux points de mesure pour examiner les transitions au cours du temps, renforçant ainsi la robustesse de l'analyse quant à la direction des effets, une limitation des études transversales dont celle du chapitre 1. En outre, en stratifiant les analyses par genre, le chapitre permet de tester si les conditions musculo-squelettiques et les symptômes dépressifs affectent différemment les hommes et les femmes, éclairant ainsi la question de savoir si les disparités de genre reflètent des différences d'exposition, d'impact invalidant, ou les deux.

L'analyse exploite les données de la cohorte CONSTANCES à l'inclusion (t_0) et lors du premier suivi annuel (t_1), complété un an plus tard. Deux échantillons sont constitués selon l'indicateur étudié : l'un pour l'analyse des LA (N = 33 590 à t_0, dont 20 197 disposant d'un suivi à t_1), l'autre pour l'analyse des restrictions d'emploi parmi les individus non retraités (N = 32 003 à t_0, dont 18 869 avec suivi). Les conditions musculo-squelettiques (CMS) sont identifiées lorsque les individus déclarent un diagnostic de maladie ostéo-articulaire au cours des 12 derniers mois (ostéoporose, arthrose, syndrome du canal carpien, polyarthrite rhumatoïde) ou rapportent des douleurs fréquentes, d'au moins 30 jours au cours de l'année précédente, dans une ou plusieurs parties du corps (dos, genou, épaule, nuque, coude, poignet), selon la structure du questionnaire nordique d'analyse des symptômes musculo-squelettiques (Kuorinka et al., 1987). Les symptômes dépressifs (SD) sont identifiés au moyen de l'échelle CES-D (Center for Epidemiologic Studies Depression Scale) (Radloff, 1977), avec des seuils

différenciés selon le genre (score ≥ 20 pour les femmes, ≥ 16 pour les hommes), conformément aux recommandations de la littérature tenant compte des différences d'expression des symptômes entre femmes et hommes. Le statut NENR est défini à partir des questionnaires de CONSTANCES : les individus non retraités qui ne déclarent pas être en emploi sont classés dans cette catégorie, qui recouvre des situations de chômage, d'invalidité, de maladie de longue durée ou d'inactivité.

La stratégie empirique combine des analyses transversales à l'inclusion et des analyses longitudinales de transitions entre t_0 et t_1. À l'inclusion, des régressions logistiques estiment les associations entre CMS, SD et chacun des deux indicateurs de restrictions (LA et NENR). Les analyses longitudinales examinent ensuite deux types de transitions. Pour les LA, des régressions logistiques estiment le risque de survenue des LA à t_1 parmi les individus sans LA à t_0, et le risque de persistance des LA à t_1 parmi ceux déclarant des LA à t_0. Pour les restrictions d'emploi, des régressions logistiques multinomiales modélisent les transitions entre les trois statuts possibles à t_1 (emploi, NENR, retraite), selon le statut à t_0. L'ensemble des modèles sont ajustés pour l'âge, le niveau d'éducation, la situation conjugale et la présence d'autres maladies chroniques. Un terme d'interaction entre CMS et SD est inclus pour tenir compte de la possibilité que les symptômes dépressifs amplifient les conséquences fonctionnelles des conditions musculo-squelettiques. Tous les modèles sont stratifiés par genre, et des modèles groupés avec termes d'interaction entre le genre et les variables d'intérêt sont également estimés pour tester formellement l'existence de différences de genre dans la force des associations.

Les résultats montrent qu'à l'inclusion, les CMS et les SD sont fortement associés aux LA et au statut NENR chez les deux genres. Les régressions logistiques confirment que les CMS et les SD augmentent significativement la probabilité de déclarer des LA, après ajustement pour les caractéristiques sociales et les autres maladies chroniques. La probabilité d'être NENR à t_0 est associée aux CMS et aux SD chez les femmes non retraitées, et aux SD chez les hommes.

Dans les analyses de transitions, les CMS et les SD à t_0 augmentent significativement la probabilité de survenue des LA à t_1 parmi les individus initialement sans restriction, et la probabilité de persistance des LA parmi ceux déjà limités, chez les hommes comme chez les femmes. Les deux conditions accroissent également le risque de passage de l'emploi vers le statut NENR à t_1. Les SD réduisent en outre les chances de retour à l'emploi parmi les personnes initialement en situation de NENR. Un résultat central de ce chapitre est l'absence de différence de genre dans la force de ces associations : ni dans les modèles stratifiés, ni dans les modèles groupés avec termes d'interaction, aucune différence significative n'est détectée. Le désavantage des femmes en matière de limitations d'activité et de restrictions d'emploi tient à leur plus grande exposition à ces conditions de santé, et non à un impact invalidant plus fort chez elles. Ce résultat renforce la conclusion du chapitre 1, selon laquelle le canal de la prévalence, plutôt que celui de l'impact invalidant, est le principal moteur des disparités de genre dans les restrictions d'activité.

Ce chapitre apporte des éléments nouveaux, fondés sur des mesures répétées à deux points dans le temps, sur le lien entre conditions musculo-squelettiques, symptômes dépressifs et multiples dimensions de restrictions d'activité en période de pré-retraite. En montrant que ces conditions conduisent également à des sorties d'emploi, il établit un pont entre la littérature sur le vieillissement en bonne santé et celle sur la participation au marché du travail. Le chapitre présente certaines limites. La cohorte CONSTANCES dispose d'un suivi longitudinal sur plusieurs vagues, mais les variables d'intérêt de cette étude n'étaient pas mesurées de manière continue dans l'ensemble des questionnaires de suivi, ce qui a contraint l'analyse à deux points de mesure espacés d'un an. Cette limitation ne permet pas d'appréhender des dynamiques de plus long terme ni de traiter les conditions de santé comme des variables variant dans le temps. En outre, malgré la grande taille de la cohorte et la diversité des profils sociaux et de santé qu'elle couvre, le faible taux de participation à CONSTANCES implique une certaine sélection des participants, ce qui appelle à la prudence dans la généralisation des niveaux de prévalence estimés, sans remettre en cause l'exploration des mécanismes étudiés.

Chapitre 3. Report de l'âge de la retraite et risque du statut « ni en emploi ni à la retraite » : hétérogénéité selon les antécédents de santé.

Le vieillissement démographique a conduit de nombreux pays de l'OCDE à réformer leurs systèmes de retraite en relevant l'âge légal de départ afin d'assurer leur soutenabilité financière. Si ces réformes ont contribué à augmenter les taux d'emploi des travailleurs âgés, plusieurs études ont montré qu'elles génèrent également des sorties alternatives du marché du travail avant l'éligibilité à la retraite, à travers le chômage, les pensions d'invalidité ou l'inactivité, regroupés sous le statut « Ni en emploi ni à la retraite » (NENR) (Berkman & Truesdale, 2023 ; Pilipiec et al., 2021 ; Rabaté & Rochut, 2020 ; Serrano-Alarcón et al., 2023). Des travaux antérieurs ont documenté l'hétérogénéité des réponses à ces réformes selon le genre et la position sociale, mais la santé a été comparativement peu examinée comme facteur d'hétérogénéité. Lorsqu'elle l'a été, elle a généralement été appréhendée à travers les arrêts maladie (Rabaté & Rochut, 2020 ; Staubli & Zweimüller, 2013), qui captent des absences temporaires plutôt que des conditions chroniques spécifiques pouvant durablement compromettre la capacité de travail. Or, dans un contexte où la santé tend à se dégrader avec l'âge, allonger la vie professionnelle revient aussi à prolonger la période pendant laquelle les problèmes de santé peuvent influencer les trajectoires sur le marché du travail, potentiellement creusant les écarts entre travailleurs « en bonne santé » et travailleurs « en mauvaise santé » (Garrouste & Perdrix, 2022).

Ce chapitre examine si les effets de la réforme des retraites de 2010 en France sur le statut d'emploi à 60 ans ont différé selon les antécédents de santé des individus. Il se concentre sur trois catégories de pathologies, la dépression, les maladies ostéo-articulaires (MOA) et les maladies cardiovasculaires (MCV), choisies en raison de leur prévalence en deuxième partie de vie active, de leur caractère invalidant documenté dans les chapitres précédents, et de leur distribution inégale entre groupes de genre et groupes sociaux. La réforme de 2010 a progressivement relevé l'âge d'ouverture des droits à pension (âge légal) de 60 à 62 ans et l'âge du taux plein de 65 à 67 ans, selon un calendrier générationnel : à partir des personnes nées après le 1er juillet 1951, l'âge légal a augmenté de quatre mois par cohorte, jusqu'à pleine application pour les générations

nées en 1955 et après. Cette réforme se distingue par son caractère inattendu et sa mise en œuvre rapide, affectant des individus à quelques mois de la retraite, ce qui a laissé peu de marge d'ajustement individuel (Caroli et al., 2023). Elle constituait le premier relèvement de l'âge légal de départ depuis 1983.

L'analyse apparie les données médicales de la cohorte CONSTANCES avec les relevés de carrière administratifs de la CNAV, permettant d'observer les individus des générations 1948 à 1953 entre 55 et 65 ans (22 324 répondants, 245 464 observations annuelles, couvrant la période 2005–2018). Chaque année, les individus sont classés dans l'un des trois statuts mutuellement exclusifs, dérivés des relevés de la CNAV : « en emploi » (si plus de deux trimestres ont été validés en emploi), « retraité » (à compter de la liquidation de la pension), ou « NENR » (si plus de deux trimestres ont été passés en chômage, invalidité, ou sans cotisation). Les antécédents de santé sont identifiés à partir des diagnostics déclarés dans le questionnaire médical de CONSTANCES, pour la période comprise entre 40 et 55 ans, afin de limiter le risque d'endogénéité lié à l'étude du statut d'emploi après 55 ans.

La stratégie empirique repose sur une approche en doubles différences (Difference-in-Difference, DiD) exploitant la mise en œuvre progressive de la réforme par cohorte de naissance. Le groupe de contrôle comprend les individus nés entre janvier 1948 et juin 1951, pour lesquels l'âge légal est resté à 60 ans ; le groupe traité comprend ceux nés entre juillet 1951 et décembre 1953, pour lesquels l'âge légal a été progressivement relevé jusqu'à 61 ans. Le modèle DiD est estimé par des modèles linéaires de probabilité, séparément pour chacun des trois statuts (emploi, NENR, retraite). L'hétérogénéité selon les antécédents de santé est estimée en introduisant un terme d'interaction entre l'estimateur DiD et l'indicateur d'antécédent de chaque pathologie. Trois ensembles de modèles sont ainsi estimés, un pour chaque condition de santé (dépression, MOA, MCV). Les modèles sont contrôlés pour le genre, le niveau d'éducation, l'historique de cotisation avant 18 ans et la nationalité.

Les résultats des modèles DiD sans prise en compte des antécédents de santé sont cohérents avec ceux de la littérature antérieure (Rabaté & Rochut, 2020) : la réforme a

significativement augmenté la probabilité d'être en emploi à 60 ans, mais a également accru la probabilité de se trouver en situation de NENR. La réforme a donc effectivement reporté la retraite, mais ne s'est pas traduite par une hausse équivalente de l'emploi : une partie de l'allongement de la vie active a été absorbée par des périodes prolongées d'inactivité, de chômage ou de recours aux pensions d'invalidité. L'analyse de la composition du NENR montre que l'inactivité non indemnisée, plutôt que le chômage ou l'invalidité, représente la très grande majorité du NENR, dépassant 75 % avant 60 ans et 88 % après 61 ans.

Lorsque les antécédents de santé sont introduits, les résultats révèlent que l'augmentation du NENR à 60 ans consécutive à la réforme est significativement plus importante pour les individus ayant des antécédents de dépression, de MOA ou de MCV, par rapport à ceux sans ces antécédents. Plusieurs vérifications de robustesse ont été menées, portant notamment sur la sélection des cohortes, les définitions du statut d'activité annuel et la fenêtre d'âge retenue pour identifier les antécédents de santé. L'hétérogénéité demeure statistiquement robuste pour la dépression dans l'ensemble des spécifications. Pour les MOA et les MCV, les termes d'interaction sont positifs mais perdent leur significativité lorsque la fenêtre de cohortes est réduite, probablement en raison d'une perte de puissance statistique liée à la faible prévalence de ces conditions dans l'échantillon (moins de 10 % chacune).

Ce résultat concernant la dépression est cohérent avec les mécanismes documentés dans la littérature : les individus ayant des antécédents dépressifs connaissent des parcours professionnels plus fragmentés, des absences plus fréquentes et des chances de retour à l'emploi plus faibles, en particulier aux âges avancés. Pour ces individus, le relèvement de l'âge légal prolonge la période pendant laquelle ils se trouvent sans revenu du travail ni pension, dans une situation d'inactivité non indemnisée. La réforme maintient ainsi une situation de non-emploi déjà existante plutôt qu'elle ne génère de nouvelles sorties d'emploi. Le système français de retraite prévoit des dispositifs de départ anticipé pour les personnes en situation de handicap physique reconnu ou d'incapacité permanente d'origine professionnelle, mais les dispositions comparables pour les troubles de santé mentale demeurent limitées : l'éligibilité à la pension d'invalidité requiert une réduction

de la capacité de travail d'au moins deux tiers, un seuil que nombre d'individus ayant des antécédents de dépression n'atteignent pas, les laissant dans une inactivité non compensée.

Le chapitre présente plusieurs limites. La taille de l'échantillon (N = 22 324) n'a pas permis de stratifier les analyses par genre ni par catégorie socioprofessionnelle tout en préservant la puissance statistique. Les informations de santé, issues des déclarations dans le questionnaire médical de CONSTANCES, sont susceptibles de sous-déclarer des conditions non formellement diagnostiquées ; pour la dépression, ce biais est vraisemblablement plus marqué chez les hommes. La santé est utilisée exclusivement comme variable explicative : il n'a pas été possible d'observer si la période de NENR non indemnisé a elle-même affecté la santé, une piste qui mériterait d'être explorée dans des travaux futurs. Enfin, la période d'analyse coïncide avec d'autres ajustements institutionnels, de sorte que les effets estimés reflètent l'impact net de la réforme de 2010 dans cet environnement institutionnel évolutif. Néanmoins, les résultats de ce chapitre sont directement pertinents pour la dimension de genre de la thèse : les chapitres précédents ont établi que la dépression est plus prévalente chez les femmes et que cette prévalence plus élevée explique leur plus grand fardeau de restrictions d'activité et d'emploi. Puisque la dépression est la condition pour laquelle l'hétérogénéité face à la réforme est la plus robuste, les conséquences défavorables de ce type de réforme pèsent vraisemblablement de manière disproportionnée sur les femmes.

Conclusion générale.

Les disparités de genre dans le vieillissement en bonne santé persistent en France. Les femmes vivent plus longtemps que les hommes, mais passent davantage d'années avec des restrictions d'activité, y compris à âges comparables dès 50 ans. Cette thèse a montré, à travers trois études mobilisant des sources de données différentes, des tranches d'âge distinctes et des approches complémentaires, que les maladies musculo-squelettiques et la dépression sont les conditions les plus pertinentes pour comprendre ce désavantage.

La thèse documente un cheminement cumulatif à travers lequel ces deux catégories de conditions affectent le vieillissement en bonne santé dès la deuxième partie de vie active : elles augmentent le risque de limitations dans les activités générales, conduisent à des sorties d'emploi vers le statut NENR, et amplifient la vulnérabilité face au relèvement de l'âge de la retraite. Dans le cas de la dépression, l'augmentation de l' âge légal de départ à la retraite prolonge une situation de non-emploi déjà existante plutôt qu'elle ne génère de nouvelles sorties.

Le résultat le plus central de cette thèse concerne l'origine du désavantage des femmes en matière de restrictions d'activité. Les analyses de décomposition du chapitre 1 et les analyses stratifiées du chapitre 2 convergent sur ce point : lorsque les hommes et les femmes sont affectés par les mêmes conditions, les conséquences en termes de restrictions d'activité sont similaires. L'écart de genre ne tient donc pas à un impact invalidant plus fort de ces conditions chez les femmes, mais à leur plus grande exposition aux maladies musculo-squelettiques et à la dépression. Cette prévalence plus élevée reflète à la fois des vulnérabilités biologiques, telles que les modifications hormonales liées à la ménopause, et des conditions sociales, incluant les expositions professionnelles, les responsabilités domestiques et la tension liée à l'articulation entre vie professionnelle et vie familiale, ainsi que l'interaction entre ces deux dimensions.

Les maladies cardiovasculaires, bien que plus prévalentes chez les hommes, constituent également le deuxième contributeur aux limitations d'activité chez les femmes et le principal moteur des disparités socioprofessionnelles, du fait de leur prévalence plus élevée chez les ouvriers et les agriculteurs.

Implications pour les politiques publiques.

La prévention des maladies musculo-squelettiques et de la dépression, en agissant sur les facteurs de risque sociaux modifiables, constitue un levier majeur pour réduire les disparités de genre dans le vieillissement en bonne santé. L'exposition des femmes aux risques biomécaniques dans un large éventail de professions, les facteurs de risques psychosociaux tels que la forte pression professionnelle et la précarité de l'emploi, et la

charge disproportionnée des responsabilités domestiques et d'aidant constituent autant de facteurs de risque pour ces deux catégories de pathologies. Les résultats de la thèse sont cohérents avec cette interprétation : les maladies musculo-squelettiques contribuent de manière substantielle aux limitations d'activité des femmes dans toutes les catégories socioprofessionnelles, y compris les plus qualifiées, ce qui suggère que les expositions professionnelles touchant les femmes dans ces groupes, ainsi que d'autres expositions comme le travail domestique, participent au fardeau de ces pathologies dans l'ensemble du spectre social.

Ces résultats appellent à renforcer les normes ergonomiques dans les professions à prédominance féminine où les contraintes biomécaniques sont parfois sous-estimées, comme les métiers du soin, du nettoyage et du secteur des services impliquant la station debout prolongée ou des gestes répétitifs (European Agency for Safety and Health at Work, 2013). Au-delà du milieu professionnel, les politiques visant une répartition plus équitable des responsabilités domestiques et d'aidant permettraient de réduire une source de contrainte physique et psychologique qui affecte les femmes dans toutes les catégories socioprofessionnelles. Pour la dépression, les stratégies de prévention devraient cibler les déterminants sociaux qui contribuent à la prévalence plus élevée chez les femmes, incluant les facteurs de stress professionnels, la précarité de l'emploi et la tension liée à la conciliation des responsabilités professionnelles et familiales. Intégrer la prévention de la santé mentale dans les stratégies de santé au travail, plutôt que de traiter santé mentale et santé physique au travail comme des domaines séparés, contribuerait à agir sur ces facteurs de risque (OMS, 2022).

Le dépistage précoce et la prise en charge adaptée sont par ailleurs essentiels face aux vulnérabilités biologiques non directement évitables. Pour les maladies musculo-squelettiques, garantir l'accès à un traitement adapté, incluant la rééducation et les programmes d'activité physique, peut limiter les conséquences fonctionnelles de ces affections. Pour la dépression, l'accès à des soins adéquats est indispensable pour réduire sa chronicité et ses effets en chaîne sur l'activité et l'emploi. Plus largement, il est essentiel que les stratégies de prise en charge atteignent les femmes de tous les groupes sociaux, y compris celles en position moins avantagée qui peuvent faire face à de plus grandes

barrières d'accès aux soins. Ainsi, la prévention des maladies cardiovasculaires demeure importante pour l'ensemble des groupes de genre et des groupes sociaux.

Les résultats soulignent enfin la nécessité d'intégrer l'hétérogénéité des profils de santé dans la conception des réformes des retraites. La dépression occupe une place particulière à cet égard : le système français de retraite reconnaît le handicap physique comme motif de départ anticipé, mais ne prévoit pas de dispositif équivalent pour les troubles de santé mentale. Cette asymétrie signifie que les travailleurs dont la capacité à se maintenir en emploi est compromise par la dépression peuvent manquer de voies institutionnelles de sortie anticipée, tout en étant dans l'incapacité de maintenir leur position sur le marché du travail. Le développement de mécanismes tels que des aménagements de transition en fin de carrière et un soutien renforcé en santé au travail dans les années précédant la retraite contribuerait à atténuer l'impact inégal des réformes allongeant la vie professionnelle. Les conditions amplifiant la vulnérabilité face à ces réformes, en particulier la dépression, étant plus prévalentes chez les femmes, ces considérations sont directement pertinentes pour la réduction des disparités de genre dans le vieillissement en bonne santé.

Portée plus large pour favoriser le vieillissement en bonne santé.

Promouvoir le vieillissement en bonne santé ne vise pas seulement à réduire les dépenses de santé et les inégalités, mais aussi à permettre aux personnes vieillissantes de continuer à contribuer à la société et au bien-être des générations suivantes. Notamment, des grands-parents en bonne santé peuvent soutenir les parents d'âge actif dans la conciliation entre garde d'enfants et emploi (Arpino et al., 2014), contribuant ainsi à réduire la charge cumulative des responsabilités domestiques qui alimente, à la génération suivante, les disparités de genre documentées dans cette thèse. Inversement, lorsque les personnes âgées vieillissent avec des restrictions, elles requièrent des soins informels qui pèsent disproportionnément sur les femmes (Hosseinpoor et al., 2012), ajoutant à leur fardeau et renforçant le cycle des inégalités de genre en matière de santé.

Limites et perspectives.

Cette thèse s'appuie sur des données récentes et des approches complémentaires, or, plusieurs limites transversales méritent d'être mentionnées, qui ouvrent autant de pistes pour de futurs travaux.

Une première limite concerne la mesure des maladies, qui repose dans l'ensemble sur des déclarations ou des instruments de dépistage validés. Ces mesures demeurent sujettes à des biais de déclaration et de rappel, et à un possible sous-diagnostic différentiel selon les groupes de population. Le recours à des données cliniques ou administratives de santé permettrait de renforcer la robustesse des mesures d'exposition. De manière complémentaire, le GALI, s'il présente l'avantage de capturer un spectre large de restrictions, ne distingue pas les types ni les sévérités de limitations. De futures recherches gagneraient à examiner des dimensions plus fines de la restriction d'activité, par exemple à travers les items individuels des échelles AVQ et AIVQ ou en exploitant la structure ordinale du GALI.

Une deuxième limite tient aux contraintes des données longitudinales mobilisées. Dans le chapitre 2, la disponibilité des variables d'intérêt dans les questionnaires de suivi de CONSTANCES a contraint l'analyse à deux points de mesure espacés d'un an, ce qui ne permet pas d'appréhender des dynamiques de plus long terme ni de modéliser les conditions de santé comme des variables variant dans le temps. Dans le chapitre 3, la taille de l'échantillon n'a pas permis de stratifier les analyses par genre, ce qui constitue une limite importante pour une thèse centrée sur la dimension de genre des inégalités de vieillissement en bonne santé. Des échantillons plus larges, combinant données de santé détaillées et trajectoires administratives, permettraient de dépasser ces contraintes.

Enfin, si le premier chapitre s'appuie sur des données nationalement représentatives, les deuxième et troisième chapitres reposent sur la cohorte CONSTANCES, dont le taux de participation implique une certaine sélection des participants. La cohérence des résultats entre ces différentes sources de données suggère néanmoins que les schémas documentés ne sont pas tributaires de la composition des échantillons. Il convient également de noter que les données utilisées couvrent pour l'essentiel des périodes antérieures à la pandémie

de COVID-19. L'adoption du travail à distance a pu atténuer certaines expositions professionnelles liées aux conditions musculo-squelettiques, tandis que la sédentarité accrue, l'isolement social et la détresse psychologique ont pu exacerber les risques tant pour les conditions musculo-squelettiques que pour la santé mentale. L'interaction de ces évolutions avec les schémas documentés dans cette thèse constitue un enjeu de recherche pour l'avenir.

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General introduction.

Life expectancy at birth has long been a central indicator of interest for demographers, economists, and policymakers, given the remarkable gains observed over the twentieth century and the questions they raise for contemporary societies. Across most European countries, life expectancy reached 81.5 years on average in 2023, although its pace of increase has slowed in recent years compared to previous decades, and was temporarily disrupted by the COVID-19 pandemic (OECD/European Commission, 2024). France stands out as one of the countries with the highest life expectancies in Europe, reaching 85.9 years for women and 80.3 years for men in 2025 (INSEE, 2026). These high levels largely reflect advances in medical treatments and prevention strategies that have reduced mortality from previously fatal conditions, particularly cardiovascular diseases and cancers, as well as earlier improvements in infant and child survival (GBD 2021 Europe Life Expectancy Collaborators, 2025; OECD/European Commission, 2024; Wéber et al., 2023). Yet, while rising life expectancy represents a major achievement of modern public health, it also raises important challenges for societies and policymakers.
One of the most pressing challenges relates to population ageing. In France, the share of adults aged 65 and over rose from 16.4% of the population in 2005 to 22.2% in early 2026, and projections indicate that this proportion will reach 28% by 2050 (Bonnet et al., 2021a; INSEE, 2026). This demographic shift poses many challenges for societies, including growing pressure on public expenditures and social protection systems, particularly in sectors of healthcare and long-term care (Belmonte et al., 2023; Kallestrup-Lamb et al., 2024a; Okamoto et al., 2023). Moreover, when individuals age with health problems that restrict their daily activities, the consequences extend beyond care needs: while substantial functional difficulties emerges in mid-adulthood, the activity restrictions they generate reduce labor market participation and productivity, increase reliance on disability pensions and unemployment benefits, and can lead to premature exits from employment, all of which induce considerable social and economic costs (Bloom et al., 2015; Meyer & Mok, 2013; Okamoto et al., 2023). In this context, the

question is not only how long people live, but how well they age, and whether the additional years of life gained are spent in good health or with limitations and restrictions. This question has motivated a growing body of research on health expectancies, indicators that complement traditional measures of life expectancy by estimating the number of years a person can expect to live without diseases and/or activity restrictions (Cambois et al., 2013; Jagger et al., 2011, 2020; Mathers et al., 2004; Spiers et al., 2021; Sullivan, 1971). In the European Union, healthy life years at birth reached 63.3 years for women and 62.8 years for men in 2023, representing approximately three-quarters and four-fifths of total life expectancy, for women and men respectively (Eurostat, 2024). While about two-thirds of the gains in life expectancy over the past two decades in the European Union have been years lived in good health, the remaining third have been years lived with health issues and disabilities (OECD/European Commission, 2024). In France, disability-free life expectancy at age 65 has been rising steadily since 2008, reaching 11.8 years for women and 10.5 years for men in 2024 (DREES, 2026). These trends indicate that healthy ageing has been improving, yet, around half of the remaining years of life at age 65 continue to be spent with some form of activity restriction (DREES, 2026). Understanding the determinants of the years spent with activity restrictions at old ages is therefore a relevant public policy concern, which calls for examining how they are distributed across population groups.

Inequalities in healthy ageing have been extensively documented along both social and gender dimensions. Along the social gradient, individuals with lower educational attainment, lower income, or employment in manual and low-skilled occupations not only live shorter lives but also spend a larger share of the years starting mid-adulthood with limitations (Cambois et al., 2020; Darin-Mattsson et al., 2017; Head et al., 2019; Mackenbach et al., 2008a; Solé-Auró et al., 2020; Stonkute et al., 2023; Wu et al., 2020). Research has shown that social inequalities in disability-free life expectancy are often wider than those in total life expectancy, indicating that social position affects the quality of years lived even more than their quantity (Cambois et al., 2001; Jagger et al., 2008; Valverde et al., 2021). In France, these patterns are well established: For instance, individuals in manual occupations were found to face considerably lower chances of reaching and living older ages in good health compared to those in higher-skilled occupations (Cambois et al., 2011). These social health inequalities partly reflect the

unequal distribution of risk factors across groups, including adverse working conditions, health-related behaviors, and differential access to preventive care and effective treatments (Mackenbach et al., 2019; Marmot, 2005; OECD/European Commission, 2024; Valverde et al., 2021).

Along the gender dimension, a particular paradox has received sustained attention, given that it persists across countries worldwide, including France: women live longer than men, yet spend more of their additional years with disabilities (Cambois et al., 2013; Crimmins et al., 2011; Oksuzyan et al., 2009; Van Oyen et al., 2010, 2013). This "gender-health survival paradox" means that women's advantage in longevity does not translate into an equivalent advantage in years lived in good health at old ages. In the European union, the gender gap in healthy life years is considerably narrower than the gap in total life expectancy, as most of women's additional years of life are lived with health problems (Eurostat, 2025). This paradox is not limited to the additional years women live: evidence consistently shows that, at similar ages , women report higher rates of functional limitations and activity restrictions than men (Augustsson et al., 2023; Hosseinpoor et al., 2012; J. Lee et al., 2021; Murtagh & Hubert, 2004; Oksuzyan et al., 2008). Understanding why women's longer lives come with more years of disability, and why they experience more restrictions even at comparable ages starting mid adulthood, has been a central question in the literature on gender and health.

A prominent explanation for the gender-health survival paradox centers on differences in the types of diseases experienced by men and women (Crimmins et al., 2011; Kingston et al., 2014; Nusselder, Cambois, et al., 2019; Oksuzyan et al., 2009). Men are more likely to develop life-threatening conditions, such as cardiovascular diseases and aggressive cancers, which shorten their life expectancy. Women, in contrast, are more likely to experience conditions that are disabling but less frequently fatal, such as musculoskeletal diseases, depression, and certain age-related conditions like neurodegenerative diseases, with which they live more years. These differences in disease profiles are themselves shaped by an interplay of biological and social factors. From a biological perspective, sex-related differences in hormonal profiles, immune responses, and genetic makeup contribute to differential vulnerability to specific diseases (Khadilkar, 2019; Murtagh & Hubert, 2004; Oksuzyan et al., 2008). From a social perspective, gender differences in education, occupational trajectories, working conditions, health-related behaviors,

caregiving responsibilities, healthcare access and utilization, shape the distribution of both risk factors and health outcomes across the life course (Augustsson et al., 2023; Bloomberg et al., 2021; Cambois et al., 2017; Campos-Serna et al., 2013; Crimmins et al., 2011; Daher et al., 2021; Hosseinpoor et al., 2012; J. Lee et al., 2021). Overall, these biological and social dimensions are not independent: gender roles and social conditions influence exposure to health risks and access to care, which in turn interact with biological vulnerabilities to produce the observed patterns of disease and disability. Examining how specific health conditions contribute to gender inequalities in healthy ageing is therefore a relevant entry point for understanding these disparities, as it captures the combined effects of both biological and social determinants.

It is this perspective that constitutes the central focus of this thesis: understanding how specific health and social conditions contribute to gender disparities in healthy ageing in France. While the role of differential disease profiles in shaping gender inequalities in healthy ageing has been documented in the literature, this explanation deserves continued examination. Disease patterns, their social and biological determinants, and the policy environments in which they unfold evolve over time, and it is important to assess whether and how these relationships hold in more recent periods, compared to the ones explored in the literature. Moreover, gender disparities in healthy ageing do not only manifest at the oldest ages: they begin to emerge in mid-adulthood, a period that is increasingly relevant in the context of policies extending working lives. Understanding which specific conditions contribute most to gender disparities starting mid-adulthood, and whether they do so through differences in their prevalence, in their association with health outcomes, or both, is directly informative for public policy: it points to the conditions that should be prioritized in prevention and disease management strategies, and to the dimensions on which interventions are most needed.

This thesis modestly contributes to the existing body of literature on gender inequalities in healthy ageing, as well as to the broader literature on social health inequalities, through three different studies, conducted on French data. The analyses draw on recent and complementary data sources that have not been fully exploited in prior research on this topic in France, combining cross-sectional and longitudinal designs. The longitudinal dimension allows for an assessment of the direction of effects between health conditions and disability outcomes, which has been a limitation in much of the prior work based on

cross-sectional datasets. The scope of the thesis extends to mid-adulthood, where gender disparities in healthy ageing take shape, and considers outcomes that go beyond traditional indicators of severe disability to capture broader dimensions of healthy ageing, including employment-related outcomes. Some analyses also document socio-occupational differences in healthy ageing, which provides additional insights into how diseases contribute to inequalities beyond the gender dimension. In its last part, the thesis also examines how these health vulnerabilities interact with pension reforms aimed at extending working lives, bringing the analysis of diseases and activity restrictions into the policy domain.

France provides a particularly relevant context for this research. As noted earlier, France is one of the European countries with the highest life expectancy, particularly for women, which makes the gender-health survival paradox especially pronounced there. At the same time, France is characterized by a comprehensive social protection system and universal health coverage, with a range of policies aimed at reducing social inequalities and ensuring access to care (Chevreul et al., 2015). Yet, despite these institutional features, substantial gender and social inequalities in health and healthy ageing persist (Cambois et al., 2011; Mackenbach et al., 2008a). This makes France a case where studying the remaining drivers of these inequalities is particularly informative, as it points to mechanisms that operate beyond access to the healthcare system. Moreover, the French institutional landscape offers specific data infrastructure while combining nationally representative surveys, large epidemiological cohorts, and administrative records, that allows the research questions of interest to be examined with depth.

This introductory chapter gives an overview of the thesis and is organized as follows. The first section presents the conceptual framework that underpins the analyses conducted in this thesis, beginning with the adopted definition of healthy ageing, and then turning to the theoretical framework used to study the links between chronic diseases, subsequent activity restrictions, and health inequalities. The second section describes the main outcomes of interest examined across the three studies that compose the thesis. The third section presents the data sources used. The final section provides a summary of the three studies making up the thesis, and their respective contributions to the literature.

I. Theoretical framework.

This section presents the conceptual foundations of the thesis. It begins by defining the concept of healthy ageing as adopted in this work, then introduces the disablement process model, which provides the theoretical basis for understanding how chronic diseases lead to activity restrictions. It concludes by discussing how this framework can be used to identify the mechanisms through which inequalities in healthy ageing arise across population groups.

I. 1. Healthy Ageing.

"Healthy ageing" is defined by the World Health Organization (WHO) as "the process of developing and maintaining the functional ability that enables well-being in older age" (World Health Organization, 2020). This framework focuses on individuals' ability to do what they value, such as being able to meet their basic needs, sustaining social relationships, and participating in society. It also recognizes that healthy ageing depends not only on intrinsic health capacities but also on the physical and social environments in which people live (Papa et al., 2019). While "healthy ageing," "successful ageing," "ageing well", and other terms, are often used interchangeably in the literature, they refer to distinct conceptual frameworks. The "successful ageing" model, introduced by Rowe & Kahn (1997), is structured around three key dimensions: absence of disease and disability, high physical and cognitive functioning, and active engagement with life. Although widely cited, this model has been criticized for being too "idealistic" and "restrictive", as it excludes a large proportion of older adults living with chronic conditions, and for its limited consideration of cultural and social diversity (Cho et al., 2012; Hung et al., 2010; Martinson & Berridge, 2015; McLaughlin et al., 2010; Stowe & Cooney, 2015). The concept of "ageing well", also used in the literature, puts more emphasis on subjective well-being and psychosocial health, yet lacks a consensus around a unified definition (Waddell et al., 2025). More recent research has increasingly converged on the WHO's framework of healthy ageing, which offers a broader and more inclusive understanding of ageing by emphasizing functional ability and contextual factors (Papa & Scherer, 2023;

Silva et al., 2023). This thesis adopts the WHO's framework of healthy ageing as the main conceptual foundation.

I. 2. From diseases to disability: The "Disablement process" model.

Building on the WHO's framework, recent studies have increasingly used indicators of disability to assess healthy ageing. In order to understand the determinants and identify measures of disabilities at older ages, the literature often refers to the theoretical framework of the disablement process model. This model was first introduced by Nagi (1964), further developed by Wood & Badley (1978) leading to the WHO International Classification of Handicap (World Health Organization, 1980), and was later expanded by Verbrugge and Jette (1994).

The disablement process model identifies chronic diseases as the initiating factors in the progression toward functional decline and disability. Diseases lead to bodily impairments, which in turn cause functional limitations, whether physical, sensory, or cognitive, such as a reduced capacity to hold objects, climb stairs, walk long distances, see and hear clearly, or recall memories. These limitations can then restrict individuals' performance of various activities, from essential daily tasks such as feeding oneself or bathing or household management, to broader social activities such as work and social gatherings. While diseases are recognized as the primary drivers of this process, the model also acknowledges that feedback effects can occur, whereby disability itself may generate new pathology or accelerate existing conditions (Verbrugge & Jette, 1994). The trajectory of disablement is further shaped by treatments, technical aids, and social and environmental factors, which influence how diseases translate, or not, into disabilities. This emphasis on contextual factors is shared with the revised version of WHO's classification: the International Classification of Functioning, Disability and Health (ICF), which similarly describes how health conditions affect activity and participation while highlighting the role of environmental and personal factors (Jette, 2006; World Health Organization, 2001). The disablement process model remains foundational in contemporary research on disability and ageing (N. E. Lane et al., 2020). This framework

motivates the thesis' goal on examining the link between health conditions and activity restrictions, in understanding gender and social inequalities in healthy ageing.

I. 3. Mechanisms driving inequalities in healthy ageing.

As documented in the literature, disability risks at older ages differ across gender and social groups. Within the framework of the disablement process model, differences in risks of activity restrictions across population groups may stem from two distinct channels: differences in the prevalence of diseases, differences in the association between diseases and disability, often referred to as their "disabling impact" (Klijs et al., 2011, 2014; Nusselder, Cambois, et al., 2019; Nusselder et al., 2005a), or a combination of both. Distinguishing between these two channels is important both for understanding the mechanisms underlying inequalities in healthy ageing and for identifying complementary targets for public policy intervention.

The first channel operates through differences in disease prevalence. Since the disablement process model identifies chronic diseases as the initiating factors in the pathway toward disability, groups that are more exposed to certain diseases are, all else being equal, more likely to experience functional limitations and activity restrictions. If a particular group's higher disability burden is primarily attributable to a higher prevalence of specific diseases, itself reflecting unequal exposure to risk factors over the life course, then policies targeting those risk factors through prevention, workplace safety regulation, or health promotion represent the most direct avenue for reducing inequalities. In the case of gender differences, for instance, the literature has attributed a substantial part of women's higher rates of activity restrictions to their greater prevalence of musculoskeletal diseases (Nusselder, Cambois, et al., 2019; Oksuzyan et al., 2008; R. T. Yokota et al., 2015). Conversely, men's higher prevalence of cardiovascular diseases and aggressive cancers contributes more to their excess mortality, often cutting short the progression through the disablement process before disability fully develops (Crimmins et al., 2011; Nusselder, Cambois, et al., 2019). Along the social gradient, higher rates of musculoskeletal and cardiovascular conditions among individuals in manual occupations

similarly contribute to their greater burden of disability (Cambois et al., 2011; Nusselder et al., 2005a).

The second channel for understanding differences in risks of restrictions at old ages operates through differences in the disabling impact of diseases. As the disablement process model underscores, the progression from disease to disability is not automatic: it is shaped by access to healthcare, early detection, quality of disease management, availability of assistive devices, and the adaptability of living and working environments (Verbrugge & Jette, 1994). Differences in these mediating factors across population groups can lead the same disease to generate more or less disability depending on the group considered. For example, individuals in less advantaged socioeconomic positions may face greater barriers to accessing timely and effective care, whether due to lower health literacy, financial constraints, or residence in underserved areas, leading a given condition to produce more severe functional consequences than it would for more advantaged groups (Klijs et al., 2014; Mackenbach et al., 2019). Working conditions also modulate this channel: a musculoskeletal condition may be considerably more disabling for a worker in a physically demanding job with limited ergonomic accommodations than for one in a sedentary occupation with greater flexibility (Gjesdal et al., 2011). Gender differences in disabling impact may similarly reflect disparities in the time available for rest and recovery given domestic responsibilities, or in workplace adaptations (Hosseinpoor et al., 2012; Nusselder, Cambois, et al., 2019). Overall, if a group's disadvantage in healthy ageing is primarily driven by a higher disabling impact rather than a higher prevalence of diseases, then the policy response should focus on improving disease management, reducing barriers to care, and adapting environments to limit the functional consequences of existing conditions.

In practice, both channels may operate simultaneously and can be mutually reinforcing. Socially disadvantaged groups may face both a higher prevalence of diseases and a higher disabling impact, as the same structural factors (i.e. adverse working conditions, limited access to care, lower health literacy) contribute to both dimensions (Klijs et al., 2014; Marmot, 2005). Disentangling the respective contributions of disease prevalence and disabling impact is therefore essential for understanding the nature of inequalities in healthy ageing, and directly informative for public policy, as it indicates whether

interventions should target disease prevention, disease management and environmental adaptation, or both.

The analyses conducted in this thesis engage with this framework in complementary ways: one part explores the contribution of a broad range of diseases to differential risks of activity restrictions across gender and social groups in France, formally assessing the respective roles of disease prevalence and disabling impact; another part investigates the association between selected diseases, chosen because they are known to be differently distributed across gender, and various dimensions of activity restriction, thereby examining how conditions that are more prevalent in one group relate to broader outcomes of healthy ageing.

II. Outcomes of interest in measuring activity restrictions.

Following the disablement process framework, the analyses in this thesis focus on activity restrictions that is the endpoint of the disablement pathway. While the literature on healthy ageing uses a range of indicators spanning different stages of the disablement process, from functional limitations such as difficulties with mobility, vision, or cognition, to restrictions in daily activities, the focus on activity restrictions is chosen for several reasons. Activity restrictions represent the stage at which health conditions most directly affect individuals' ability to participate in everyday life, which is the core dimension of healthy ageing as defined by the WHO framework adopted in this thesis. Since they follow from functional limitations in the disablement process, they also implicitly capture the consequences of earlier stages of the pathway. Moreover, indicators of activity restrictions are well established and widely validated in the literature, making them particularly suited for comparative analysis across population groups (Cambois et al., 2013; Robine et al., 2003; Van Oyen et al., 2018a).

This thesis examines two complementary outcomes of activity restriction, each capturing a distinct dimension of how chronic diseases can affect individuals' participation in daily and social life.

II.1 Activity Limitation (General activities).

In the literature, activity restrictions are commonly measured through indicators that cover limitations in elementary activities of daily living (ADL), which cover basic self-care tasks (e.g. Eating, bathing, showering), limitations in instrumental activities of daily living (IADL), which include tasks related to independent living (e.g. shopping, preparing meals, or administrative work) which can be more delegated to other people than personal care activities ; the Global indicators such as the Global Activity Limitation Indicator (GALI) captures general long-standing limitations in usual activities without focusing on a list, making people free of reporting limitation of activities that matter most for them (Berger et al., 2015; Katz et al., 1963; Lawton & Brody, 1969; Robine et al., 2003).

For this thesis, the first chosen proxy of activity restriction relates to limitations in general activities as captured by GALI, which has been widely used in population health research and serves as the basis for monitoring healthy life years across European countries (Jagger et al., 2011; Van Oyen et al., 2006). The GALI is a single-item instrument included in various population surveys, which asks respondents whether, over the past six months, they have been limited in activities people their age usually do because of a health problem, with variations in the exact formulation and response options depending on the survey (Berger et al., 2015; Cambois et al., 2016).

The choice of using GALI in the thesis' analyses over more specific indicators such as ADL and IADL is motivated by several considerations. The GALI captures a broader range of activity restrictions, including some that are likely to emerge before the difficulties in essential activities of daily living, that ensure an independent living, measured by ADL and IADL indicators; it makes it particularly relevant for identifying early restrictions where preventive interventions can still have an impact (Berger et al., 2015; Van Oyen et al., 2006). Relatedly, because it is not restricted to the severe limitations typically experienced at the oldest ages, the GALI is well suited to capture restrictions affecting usual activities in mid-adulthood, primary work, which is a key period of interest in this thesis. This indicator is also more available across the data sources used in this thesis,

ensuring consistency in the measurement of activity restriction across the different analyses.

II.2 Employment restrictions: Being 'Neither employed nor retired'.

Covering specific outcomes of health-related activity restrictions in mid-adulthood relating to employment and work, the second outcome used in analyses relates to the status of being "Neither employed nor retired" (NENR), a labor market status observed among individuals in mid-adulthood, prior to the age of official retirement. This status captures situations in which individuals have exited or are excluded from employment before having reached retirement, a situation that often reflects health-related barriers to continued work, including disability, long-term sickness, or unemployment due to health status. While not a traditional disability indicator, this outcome is directly relevant to the assessment of healthy ageing for several reasons. It captures the consequences of health conditions on a key dimension of social participation, that is employment, which is central to the WHO's definition of healthy ageing. It is also particularly pertinent in the current policy context, where reforms extending working lives place increasing demands on older workers' capacity to remain in employment, possibly despite chronic health conditions. In France, 11% of adults aged between 53 and 69 fell into this category in 2015, with the majority being women, and their poverty rate reached 32%, compared to 7% among those who are employed or retired (D'Isanto et al., 2018). This economic precarity may in turn affect health trajectories, such as recovery, as reduced material resources can limit access to care and contribute to further health deterioration, reinforcing the cycle between chronic diseases and activity restrictions.

By examining the status of NENR alongside general activity limitation, the thesis captures both the broader functional dimension and the employment-related dimension of activity restrictions, offering a more comprehensive picture of how diseases affect healthy ageing from mid-adulthood onward, and connecting it with gender inequalities in healthy ageing.

III. Explored French data sources.

Examining the relationship between chronic diseases and activity restrictions across gender and social groups requires data that combine detailed medical information with extensive social and demographic characteristics, and that cover sufficiently large samples of older adults. In the French context, no single data source meets all of these requirements for the different research questions addressed in this thesis. Three complementary data sources were therefore mobilized along the three studies making up the thesis, each offering specific advantages that align with the objectives of the corresponding study.

III.1 'Capabilities, Help, and Resources for Seniors' surveys (CARE).

The first data source used in this thesis (Chapter 1) is the Capabilities, Help, and Resources for Seniors surveys (*Capacités, Aides et Ressources des Seniors* — CARE), conducted by the French Directorate of Research, Studies, Evaluation and Statistics (DREES, that is the statistical and research agency of the French Ministry of Health, in partnership with the National Institute for Statistics and Economic Studies (INSEE) (Amélie Carrère et al., 2019). CARE targeted French seniors aged 60 and above and comprises two components: a household survey (CARE-Ménages), conducted in 2015 among seniors living in private households, and an institutional survey (CARE-Institutions), conducted in 2016 among seniors permanently residing in long-term care facilities.

The household component was constructed as a subsample of a screening survey: the 2014 Everyday Life and Health survey (*Vie Quotidienne et Santé* — VQS) based on a random sample of 210,000 households from fiscal records (DREES, 2016). Within responding households, seniors were classified into four dependency groups based on their reported health and difficulties with basic tasks and with daily activities; one senior per household was selected for CARE-Ménages, with an oversampling of individuals with higher levels of functional difficulties. Of the 15,000 seniors invited to participate, 10,628 responded, yielding a response rate of approximately 76%. The institutional component

(CARE – Institutions) drew a stratified sample of long-term care facilities from the national register of health and social establishments (FINESS), and randomly selected residents aged 60 and above within each participating facility. Of the 3,500 seniors initially sampled, 3,262 completed the survey, yielding a response rate of 93%.

Data were collected through face-to-face interviews and cover a broad range of topics, including health conditions, functional limitations, activity restrictions, social characteristics, living conditions, and the help received by seniors. For the purposes of this thesis, the main advantages of CARE are threefold. First, it is representative of the French population aged 60 and above, providing reliable prevalence estimates across population groups. Second, it includes both community-dwelling and institutionalized seniors, which is essential for studying disability at older ages, as excluding the institutionalized population, who tend to be the most severely affected, would lead to an underestimation of disability levels. Third, the survey collects detailed information on a broad range of chronic diseases alongside rich social and demographic characteristics, making it well suited for the comprehensive exploration of disease contributions to disability differences across gender and social groups conducted in the first chapter of this thesis.

III.2 The French CONSTANCES cohort.

A second data source used in this thesis (Chapter 2 and 3) comes from the CONSTANCES cohort, a large population-based prospective study designed to serve as an open epidemiological research infrastructure, with a particular focus on occupational and social determinants of health and on ageing (CONSTANCES team et al., 2015; Goldberg et al., 2017a; Zins et al., 2015). CONSTANCES recruited adults aged 18 to 69 during annual inclusion waves from 2012 to 2020, reaching approximately 220,000 participants. Recruitment was conducted among individuals registered with the main health insurance fund (CNAM), which covers more than 85% of the French population, excluding self-employed workers. Individuals were randomly selected with stratification by age, sex, occupational status, and region, and invited by mail to participate. At inclusion, participants completed questionnaires on lifestyle, health, physical limitations,

and social and personal characteristics, and attended a standardized medical examination at one of the 21 participating health examination centers, which included physiological and biological assessments, with additional cognitive tests for those aged 45 and older. Information on occupational histories and family medical history was also collected. Participants subsequently received annual follow-up questionnaires that repeated a selection of questions on health and employment status, enabling longitudinal measurements.

Although CONSTANCES was designed to approximate a representative sample of the French adult population, participation required attending a health examination at a participating center, which led to a low participation rate of around 8% (Launay, 2024). As documented in the cohort's protocol and in prior studies using these data (Goldberg et al., 2017a; Neufcourt et al., 2019), participants tend to be more educated and in better health than non-participants, reflecting well-known gradients in health survey participation. Despite this, the cohort includes a broad diversity of social positions, occupations, and health profiles. While this characteristic limits the estimation of population based prevalence of diseases and disability, the diversity of health and social situations included allows exploring epidemiological patterns and their variation across groups. For this purpose, the main advantages of CONSTANCES are on the one hand, its large sample size, which provides sufficient statistical power for studying associations between specific diseases and activity restrictions within refined subgroups, and on the other hand, its longitudinal design, which enables a more robust assessment of the direction of effects between health conditions and disability outcomes. CONSTANCES data are used in the second and third chapters of this thesis.

III.3 Administrative records from CNAV.

Working with the outcome of the status of being “Neither employed nor retired” and exploring the interaction between heath, employment status, and policies evolving over time, required extensive data with administrative records on employment status. This has led to the use and exploration of a third data source of administrative records from the French National Old-Age Insurance Fund (*Caisse Nationale d'Assurance Vieillesse —*

CNAV), which were linked to the CONSTANCES cohort for the purposes of the last part of the thesis (Chapter 3). These records originate from the National Career Management System (*Système National de Gestion des Carrières* — SNGC) used to record the contribution to the national pension insurance system: it traces, for each insured person, all periods of contribution from age 16 until retirement, including insured periods such as unemployment, sickness, disability, maternity, or parental leave. The CNAV manages the pension system for private-sector employees under the *régime général*, the main branch of France's public pension system. The SNGC also tracks quarters validated in other statutory pension schemes for individuals who have contributed outside the *régime général*.

The main advantage of these administrative records for this thesis is that they provide objective and continuously recorded information on individuals' employment histories and pension contributions, which is less subject to the recall and reporting biases that can affect survey-based measures of employment status. By linking these records to the health and social information collected in CONSTANCES, the third chapter of this thesis is able to examine how chronic diseases interact with pension reforms to shape labor market outcomes in later life, drawing on both detailed health data and reliable administrative employment trajectories.

IV. Summary of thesis chapters and contributions.

This thesis investigates how specific health and social conditions contribute to gender disparities in healthy ageing in France. It does so through three independent yet complementary studies that follow a cumulative logic.

Chapter 1. Disease-specific contributions to activity limitation among older adults in France by gender and occupational category: Evidence from CARE.

The first chapter examines the contribution of a broad set of chronic diseases to general activity limitation among French adults aged 60 and over. It asks which diseases

contribute the most to activity limitation, whether they do so through their prevalence or their disabling impact, and how they account for gender and socio-occupational inequalities in this outcome.

The analysis draws on cross-sectional data from the CARE surveys (2015–2016), which are representative of the French population aged 60 and over and include both community-dwelling and institutionalized individuals. Activity limitation is measured using the Global Activity Limitation Indicator (GALI). Eight categories of chronic diseases are considered: musculoskeletal diseases, cardiovascular diseases, neurodegenerative diseases, kidney diseases, diabetes, depression, macular degeneration, and cancer. Social position is captured through socio-occupational categories based on the French occupational classification. The analytical approach proceeds in two steps. First, an attribution method based on additive hazard regression models estimates the disabling impact of each disease while accounting for comorbidities, and decomposes the overall prevalence of activity limitation into additive contributions from each disease. Second, a decomposition method based on a non-linear extension of the Oaxaca-Blinder approach proposed by Yun (2004, 2008) approach separates group differences in activity limitation into components attributable to differences in disease prevalence and differences in disabling impact.

Musculoskeletal and cardiovascular diseases emerge as the leading contributors to activity limitation across all groups. Neurodegenerative diseases and macular degeneration exhibit the strongest disabling impacts, but their relatively low prevalence limits their overall contribution to GALI. Depression also stands out as a notable contributor among women. The decomposition analyses confirm that gender and social gaps in activity limitation are primarily driven by differences in disease prevalence rather than differences in disabling impact. Women's higher prevalence of musculoskeletal diseases, neurodegenerative diseases, and depression accounts for much of their excess activity limitation relative to men. Along the social gradient, the greater prevalence of musculoskeletal and cardiovascular diseases among manual workers and farmers explains a substantial share of their higher burden compared to highly skilled workers.

This chapter extends prior French research on this topic (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2019), which relied on data from 2008–2009 and measured social position primarily through educational attainment, by using more recent data and

examining socio-occupational profiles. Its findings reinforce the central role of unequal disease prevalence in driving disparities in healthy ageing. However, the cross-sectional design limits the capacity to establish the directionality of associations. The focus on individuals aged 60 and over also leaves open the question of whether similar patterns hold earlier in the life course, where restrictions begin to emerge and where interventions may be most effective. These considerations motivate the subsequent chapters.

Chapter 2. Impact of musculoskeletal conditions and depressive symptoms on activity restrictions among men and women in mid-adulthood: Evidence from CONSTANCES.

The second chapter narrows the focus to musculoskeletal conditions and depressive symptoms, the two groups of conditions identified in the first chapter as most relevant to the gender gap in activity limitation. It expands the investigation in three directions. It extends the age range to mid-adulthood (ages 50–69), a period where restrictions begin to take shape and where policies extending working lives are most directly relevant. It broadens the outcomes beyond general activity limitation to include employment restrictions, captured through the risk of being "Neither employed nor retired" (NENR) as associated to health issues. And it draws on two measurement points to examine transitions in outcomes over time, allowing for a clearer assessment of the direction of effects than the cross-sectional analysis conducted in the first chapter.

The analysis uses data from the CONSTANCES cohort at inclusion and the first annual follow-up, completed one year later. Two study samples are constructed depending on the outcome, one for the analysis of activity limitation and one for the analysis of employment restrictions among non-retired individuals. Cross-sectional associations are first estimated at inclusion using logistic regression. Subsequent analyses examine transitions over the one-year follow-up period: onset and persistence of activity limitation, and movements into and out of the NENR status. All models are adjusted for age, educational attainment, marital status, and the presence of other chronic conditions, and are stratified by gender.

Both musculoskeletal conditions and depressive symptoms are strongly associated with activity limitation and employment restrictions. In the analyses of transitions over the follow-up period, musculoskeletal conditions increase the probability of both onset and persistence of activity limitation for men and women alike. Both conditions also raise the risk of transitioning from employment into the NENR status, and depressive symptoms reduce the chances of returning to employment among those initially in that category. Crucially, no evidence of gender differences in the strength of these associations is found. This result reinforces the conclusion from the first chapter: women's higher burden of activity limitation and employment restrictions appears to stem from their greater exposure to these conditions, not from a stronger disabling impact among women.

This chapter contributes new evidence, based on repeated measurements over two time points, on the link between musculoskeletal conditions, depressive symptoms, and multiple dimensions of activity restriction in the pre-retirement period. By showing that these conditions also drive employment exits, it connects the literature on healthy ageing with that on labor market participation. It also raises a further question: how do these health-related vulnerabilities interact with policies that require individuals to work longer? The third chapter takes up this question.

Chapter 3. Postponing retirement and the risk of being "Neither employed nor retired" in France: Heterogeneity with respect to health histories.

The first chapter showed that musculoskeletal and cardiovascular diseases are the leading contributors to activity limitation overall, and that women's higher prevalence of musculoskeletal diseases and depression is a key driver of gender inequalities in this outcome. The second chapter confirmed that musculoskeletal conditions and depressive symptoms are also associated with employment restrictions in mid-adulthood. The third chapter brings these findings into dialogue with pension policy, by examining whether individuals with histories of these conditions, specifically depression, osteoarticular diseases, and cardiovascular diseases, face a higher risk of falling into the NENR status when reforms raise statutory retirement ages.

The chapter focuses on the 2010 French pension reform, which gradually raised the earliest age for claiming pension benefits from 60 to 62 and the full-rate pension age from 65 to 67, phased in by birth cohort. Such reforms are supported by the principle that the statutory age postponement tends to increase the employment rates at older ages. Indeed, prior research confirmed an increased employment rates at age 60 but also generated substitute exits through the NENR status (Dubois & Koubi, 2017; Rabaté & Rochut, 2020a). However, whether this response differed depending on individuals' prior health has only been examined through records of sick leaves. This chapter fills that gap by investigating heterogeneity in the reform's effects with respect to histories of the three conditions of interest, diagnosed between ages 40 and 55.

The analysis combines medical data from the CONSTANCES cohort with administrative employment records from the French National Old-Age Insurance Fund (CNAV). Individuals from birth cohorts 1948 to 1953 are observed through yearly administrative records between ages 55 and 65. The empirical strategy relies on a difference-in-differences approach exploiting the cohort-based phase-in of the reform. Cohorts for whom the statutory retirement age remained at 60 serve as the control group; those facing a gradually increased age up to 61 form the treated group.

The reform increased both employment and NENR status at age 60, consistent with prior findings. Regarding heterogeneity, the increase in the probability of being NENR was significantly larger for individuals with a prior diagnosis of depression, osteoarticular diseases, or cardiovascular diseases. Across robustness checks, including alternative variable definitions and broader measures of NENR, heterogeneity remained most robust for depression. This finding carries particular policy significance. The French pension system provides early retirement pathways for individuals with recognized physical disabilities or incapacity, but comparable provisions for mental health conditions remain limited. Individuals with depression may thus struggle to remain employed while lacking access to early exit on health grounds, leaving them more exposed to the NENR status when retirement is postponed.

Although this chapter does not stratify its analyses by gender due to limitations in sample sizes, its findings are directly relevant to the gender dimension of this thesis. The preceding chapters established that musculoskeletal diseases and depression are more prevalent among women and that this higher prevalence drives their greater burden of

activity limitation and employment restrictions. Since these same conditions amplify the risk of falling into the NENR status when retirement ages are raised, the adverse consequences of such reforms are likely to weigh more heavily on women. More broadly, this chapter underscores the importance of accounting for health vulnerabilities in the design of pension reforms aimed at extending working lives.

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Chapter 1. Disease-specific contributions to activity limitation among older adults in France by gender and occupational category: Evidence from CARE.

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Extended abstract.

Chronic diseases are highly prevalent in the population especially at older ages. Their uneven distribution and links with activity restrictions has been marked by pronounced social and gender inequalities in France, as in other countries. Throughout findings from the literature, women have been more likely to report activity restrictions and disabling diseases than men. Individuals from socially disadvantaged groups were also more likely to report restrictions and various chronic diseases than those from advantaged groups. While accounting for a large set of diseases, this chapter examines the contribution of a list of chronic diseases to activity limitation (AL), which relate to limitations in general activities (i.e housework, leisure, work), among adults aged 60 and over in France. It also explores the contribution of chronic diseases to gender and socio-occupational inequalities in AL. The objectives include assessing the extent to which gender and social specific distribution of diseases, and their associations with AL, contribute to gender and social inequalities in AL prevalence.

Previous French studies, that have relied on data from 2008-2009, have shown that specific chronic diseases substantially contribute to gender and social inequalities in activity restrictions, with social position mostly measured through highest educational attainment. This chapter extends the literature by using more recent French data and looking at profiles of socio-occupational groups rather than educational groups.

We use cross-sectional data from the French "Capabilities, Help, and Resources for Seniors" (CARE) surveys (2015–2016), which are representative of the population aged 60 and over, including individuals living in private households (N = 10,593) and in institutions (N =2,958). AL is measured using the Global Activity Limitation Indicator (GALI). The analysis focuses on a selection of diseases that are known to be disabling, age-related, and unequally distributed across gender and social groups. They are identified based on either a medical diagnosis or ongoing treatment within the past 12 months of the survey timing. Some diseases are grouped, resulting in the following eight categories: musculoskeletal diseases (MSD), cardiovascular diseases (CVD), neurodegenerative diseases (NDD), kidney diseases, diabetes, depression, macular degeneration, and cancer. Regarding socio-occupational status, it is based on the respondent's most recently declared occupation, and is classified into seven groups following the French occupational classification (INSEE, 2020): farmers, self-employed workers, manual workers, clerical/office workers, skilled workers, highly skilled workers, and individuals labelled as "Not employed".

For each gender and socio-occupational group, we estimate the contribution of the list of chronic diseases to AL, considering both their prevalence and their disabling impact. We also assess the extent to which differences in AL prevalence between groups, such as between men and women, or between socio-occupational categories within each gender, can be attributed to differences in disease prevalence and in how these diseases are associated with AL.

Our analytical approach proceeds in three steps: First, we calculate prevalence of self-reported chronic diseases by gender and occupational groups using population weights. We also estimate age standardized prevalence to account for differences in age distributions (using French population structure of 2015) with the direct method, across different groups. Second, we apply the "attribution method" based on binomial additive hazard models, which estimates the association of each disease with AL ("disabling impact"), while accounting for comorbidities and factors that are not explicitly included (like undiagnosed diseases, and age). These estimates are then used to decompose the overall prevalence of AL into additive contributions from each disease, and a component accounting for factors that are not included which we label as "Background". This step highlights the rank and the magnitude of each group of chronic diseases in explaining AL prevalence for each gender and socio-occupational categories. Third, we apply a decomposition analysis using a non-linear adaptation of the Oaxaca-Blinder method, Yun's method, which separates differences in AL prevalence between groups into a component explained by differences in disease prevalence and a component due to differences in their associations with AL.

Results mainly show that:

- AL prevalence was significantly higher among women than men in the general population, while the significance disappears after age standardization.
- Clear social gradients in AL prevalence were observed within both genders: Farmers and manual workers report higher prevalence of AL compared to highly-skilled workers.
- Women have a higher prevalence of self-reported MSD, depression, NDD, and macular degeneration, and men a higher prevalence of self-reported CVD, even after age standardization.
- Across all gender and occupational groups, self-reported MSD and CVD are the leading contributors to AL prevalence. Depression also contributes to AL in women.
- NDD, macular degeneration, and CVD show the strongest disabling impacts across all groups. No significant difference in their disabling impact is detected neither across gender nor socio-occupational group.

- Various differences of diseases disabling impacts are detected across socio-occupational groups, yet don't reach statistical significance. Only diabetes and cancer significantly differ in their disabling impacts across some groups.
- Kidney diseases are important contributors to AL prevalence particularly among self-employed women.
- Self-reported diabetes had a more important contribution to AL among men in the general population, but had heterogeneous patterns in its contribution to AL prevalence across the different strata of gender and socio-occupational groups.
- Decomposition analyses confirm that gender and social gaps in AL are mainly driven by difference in disease prevalence rather than differences in associations of diseases with AL across groups.
- Self-reported MSD, CVD and NDD are main contributors to gender and social gaps in AL prevalence, due to their uneven distributions across gender and social groups.
- Different age distributions across gender and socio-occupational groups also significantly participate in the gender and social gaps in AL prevalence.

Overall, results highlight the need for gender and social specific targeted interventions aimed at reducing the prevalence of diseases, particularly MSD, CVD, and NDD. Efforts to prevent and manage these diseases could play a crucial role in reducing health inequalities and limiting activity restrictions at older ages.

I. Introduction.

Life expectancy at birth has continued to rise over the past decade in many European countries, including France, where it reached 85.9 years for women and 80.3 years for men in 2025 (INSEE, 2026). These gains largely reflect advances in prevention strategies targeting behavioral risk factors such as smoking and excessive alcohol consumption, as well as improvements in disease screening and medical treatments (GBD 2021 Europe Life Expectancy Collaborators, 2025; OECD/European Commission, 2024). Although some diseases are not cured by existing treatments, their association with mortality has declined. A number of conditions, including cancer, cardiovascular or metabolic, have become chronic and contribute to the increase in the number of years lived with a disease. With ageing populations, the growing prevalence of chronic diseases, those emerging at later ages and those with which individuals survive longer, and their role in shaping health trajectories in later life have become increasingly important.

Beyond their considerable economic burden through, for instance, increasing public healthcare costs and medical expenditures (Brennan et al., 2017; Polanco et al., 2025), chronic diseases are strongly associated with disabilities at old ages. In France, more than three in five individuals aged 65 and older reported at least one chronic disease in 2017, and among them, one in six reported limitations in activities of daily living (ADL) such as dressing, eating, or bathing (DRESS, 2017). Both theoretical frameworks and empirical studies consistently demonstrate that chronic conditions, including neurodegenerative, musculoskeletal, cardiovascular, respiratory, and psychiatric diseases, contribute to disability in later life, meaning that they induce some impairments of body functions that can generate activity restrictions. These restrictions encompass general activities (related to housework, leisure, social participation, and employment), besides elementary and instrumental activities of daily living (e.g., bathing, feeding, dressing, meal preparations, managing medications, or using transportation).

The distribution of chronic diseases and their link with restrictions has been marked by pronounced social and gender inequalities in France, as in other countries. Social health

gradients have been well established with individuals of, for instance, higher educational attainment reporting both lower prevalence of chronic conditions and fewer restrictions at old ages (Head et al., 2019; Mackenbach et al., 2008b; Solé-Auró et al., 2020). Gender differences have also been well documented: While women live longer than men, with a life expectancy gap reaching approximately six years in France as of 2025 (INSEE, 2026), their additional years are spent with restrictions. This paradox has been partly attributed to men's higher prevalence of life-threatening conditions, such as cardiovascular diseases, which shorten their life expectancy, and women's higher prevalence of disabling but non-fatal conditions, such as musculoskeletal diseases (Crimmins et al., 2011; Kingston et al., 2014; Oksuzyan et al., 2009), with which they live more years.

Overall, activity restrictions emerging from mid-adulthood (from around age 50) impose substantial social and economic costs: they increase demand for long-term care, intensify pressure on health and social systems, and reduce labor market participation and productivity when they extend into the work sphere (Bloom et al., 2015; Okamoto et al., 2023). Given the rising prevalence of chronic diseases, their strong association with activity restrictions, and the pronounced social and gender disparities in these processes, it is essential to understand how chronic diseases contribute to restrictions across different population subgroups. Assessing how these associations vary by gender and social position is crucial for designing targeted interventions, allocating resources effectively, and addressing health inequalities in the context of population ageing.

This introductory section is organized into four parts. The first three parts review existing literature, beginning with theoretical frameworks in the first part, and empirical evidence on the relationship between chronic diseases and activity restrictions in the next ones. The second part focuses on the role of social and gender differences in these associations, and then turns to evidence on the specific diseases that contribute most to restrictions across gender and social groups. The final part introduces the focus of this chapter and its contribution to the broader literature.

I. 1. From chronic diseases to activity restrictions: The "disablement process" model.

The relationship between chronic diseases and disability at old ages has been widely conceptualized through the "disablement process" model (Jagger et al., 2020; Nagi, 1964; Verbrugge & Jette, 1994), a framework referenced across many disciplines including sociology, medicine, epidemiology, and demography. This model identifies chronic diseases as the initiating factors in the progression toward functional decline and disabilities, proxied with indicators of activity restrictions. The process generally goes as follows: Diseases lead to bodily impairments, which in turn cause functional limitations, whether physical, sensory, or cognitive, such as a reduced capacity to hold objects, climb stairs, do long walks, see and hear clearly, or recall memories. These limitations can then restrict individuals' participation in various activities, from essential daily tasks, like housework, bathing, and meal preparation, to broader social engagements, such as work and social gatherings.

Throughout the literature, several groups of chronic diseases have been consistently associated with restrictions, demonstrating the disablement process. Namely, musculoskeletal diseases (MSD), including osteoarthritis, rheumatoid arthritis, and chronic body pain, have been associated with reduced mobility, and consequently reduced ability to participate in work and social activities (Briggs et al., 2016; Shah et al., 2011a; Walker & Littlejohn, 2007). Apart from their link with mortality, cardiovascular diseases (CVD), including stroke and ischemic heart disease, have been closely linked to physical disabilities leading to higher risks of unemployment and reduced ability of participation in the workforce in many countries including France (Fouillet et al., 2024; Kouwenhoven-Pasmooij et al., 2016; Lisy et al., 2018; Luengo-Fernandez et al., 2023; Taylor et al., 2002; Townsend et al., 2015; Yokota, et al., 2016). Diabetes and kidney diseases, that often co-occur with CVD (Ke et al., 2022; Lucas & Taal, 2023; Khunti et al., 2023; MacRae et al., 2021; Sattar et al., 2024; Sullivan et al., 2020), have also been shown to limit engagements in daily and social activities, as a result of fatigue, reduced mobilities, and sensory or cognitive difficulties linked to the effects of their treatments (de Rekeneire et al., 2003; Low Wang et al., 2016; Martin et al., 2022; Pilla et al., 2023; Tavares et al., 2024; Fletcher et al., 2022; Pépin et al., 2023). Likewise, chronic respiratory diseases, such as chronic obstructive pulmonary disease and asthma, have also been linked with activity

restrictions through the resulting fatigue, and muscle deconditioning, which restrict mobility, and daily functioning (Gruet, 2018; Roche, 2009).

Sensory conditions, particularly age-related ocular diseases such as macular degeneration, and hearing disorders, also contribute to restrictions. By impairing central vision, macular degeneration limits visual functioning and daily tasks such as reading, driving, or navigating spaces (Knudtson et al., 2005; Lim et al., 2012). As for hearing disorders, they result in hearing loss that impairs auditory functioning and limits daily activities, including those involving social participation (Lin et al., 2019). Despite not being highly prevalent, neurodegenerative diseases (NDD), such as dementia, Alzheimer's disease, and Parkinson's disease, have been also strongly associated with cognitive and physical decline, impairing essential functions such as memory, communication, motor skills, and decision-making capacity, which in turn restrict individuals in their daily activities (Bloem et al., 2021; C. A. Lane et al., 2018; Waldman et al., 2024). In regards to mental health, psychiatric disorders, including depression and anxiety disorders, have also been shown to limit engagement in daily and social activities by reducing energy, concentration, and motivation (American Psychiatric Association, 2013; Buss et al., 2022; Covinsky et al., 2010a; Cronin-Stubbs et al., 2000; Kazama et al., 2011; Mezuk et al., 2012).

I. 2. How do chronic diseases contribute to restrictions across different groups?

While the disablement process model identifies diseases as the primary drivers of restrictions, through the described process, social and environmental factors are acknowledged to critically influence how diseases translate into these restrictions, shaping the overall trajectory of disablement (Verbrugge & Jette, 1994). Within this framework, differences in restrictions across different groups may stem from either variation in disease prevalence, or differences in the impact of diseases on restrictions ("disabling impact"), or both. When disparities are mainly driven by differences in prevalence of diseases, they may reflect unequal exposure to their risk factors such as adverse working conditions (e.g. work stressors, or risky postures) or health-related

behaviors (e.g. smoking, excess alcohol consumption, and lack of physical activity), or uneven access to screening and optimal treatments, highlighting the relevance of prevention strategies that address these factors. In contrast, if the same disease results in different levels of disability across groups, that is, if it differs in its association with disability, or "disabling impact", this may indicate inequalities in disease management, due to the uneven access to care, availability and use of assistive devices, or adaptability of living environments (home, community or workplace).

Evidence consistently shows both differences in prevalence and in disabling impact of various chronic diseases across gender and social groups. Starting with MSD, they are strongly linked to occupational exposures such as awkward postures, repetitive movements, and manual handling, which are more frequent in low-skilled and manual jobs, where people with low to medium educational attainment are overrepresented (Govaerts et al., 2021; Greggi et al., 2024; Yung et al., 2020). Women are also disadvantaged by the prevalence and severity of MSD due to both biological and social factors. Biological factors include hormonal changes occurring around menopause which increase vulnerability to joint degeneration (Khadilkar, 2019). Socially, women are more represented in low skilled occupations (Cambois, 2016; Cavallari et al., 2016) and often combine paid employment with domestic and caregiving work, creating a "double exposure" to musculoskeletal risks (Campos-Serna et al., 2013).

CVD also display marked disparities by both gender and social position. In terms of gender, CVD are generally more prevalent among men, a pattern linked to both biological and behavioral differences such as higher smoking and alcohol consumption and lower engagement in preventive care for men (Crimmins et al., 2011; Timmis et al., 2022; Woodward, 2019; Taylor et al., 2018; Pilote et al., 2007). However, some evidence suggest that this gap can narrow with age, specifically after menopause, when women's risk of CVD increases substantially, sometimes surpassing that of men (Bairey Merz et al., 2018; Ryczkowska et al., 2023). Turning to social position, disadvantaged groups face higher CVD risks and severity due to adverse health behaviors, more limited healthcare access, and occupational exposures common in manual jobs, such as dust, fumes, and fibres (Fang et al., 2010; Grahn et al., 2022; Mackenbach et al., 2000; Vandersmissen et al.,

2020). In contrast, among more advantaged groups, other types of risky exposures are at play: long working hours, more frequent in skilled and highly skilled occupations, have also been associated with increased incidence of ischemic and coronary heart disease (Fadel et al., 2020; Kivimäki et al., 2015)

Closely related conditions to CVD such as diabetes and kidney diseases show similar gradients. For diabetes, it is more common among men and among workers in manual occupations (Carlsson et al., 2020; O'Sullivan et al., 2024; Safieddine et al., 2024), and is evidenced to have a stronger impact on work disability in the lowest occupational positions (Ervasti et al., 2016). Evidence on gender differences in diabetes' disabling impact is mixed: some studies find stronger associations with daily limitations in men (Kingston et al., 2014), others in women (Klijs et al., 2014; Nusselder, Cambois, et al., 2019). As for kidney diseases, they are also more severe in disadvantaged groups, reflecting economic vulnerability and lower healthcare access (Nicholas et al., 2015; Plantinga, 2012). In the French context, these inequalities become particularly evident in cases of kidney failure: socially disadvantaged patients are more likely to undergo dialysis, requiring complex and burdensome treatment, and have less access to transplantation, which contributes to worse long-term outcomes and greater disability risks (Baudelot et al., 2016).

In regards to cognition, mixed patterns of differentials are observed for NDD. Women's higher prevalence at old ages is partly attributable to their longer life expectancies and biological factors related to hormonal changes, while men's greater exposure to cardiovascular risks and alcohol consumption can also be linked with neurodegeneration (Mielke et al., 2022; Nebel et al., 2018). Along the social gradient, lower socioeconomic status is associated with increased dementia risk, partly via reduced cognitive reserve linked to lower educational attainment (Bodryzlova et al., 2023; Hyun et al., 2022; Sujarwoto et al., 2025). Occupational exposures such as repetitive tasks and limited cognitive stimulation, common in low skilled and manual jobs can also accelerate cognitive ageing (Coates et al., 2025; Curreri et al., 2022; Yang et al., 2016). For women, limited participation in formal employment has also been connected to cognitive decline (Chung & Kim, 2020; Grewal et al., 2024). Beyond occupational experiences, delayed

diagnosis and reduced access to care, more common among socially disadvantaged groups, can worsen progression and functional consequences of NDD (Bodryzlova et al., 2023; Coates et al., 2025).

Sensory conditions, particularly age-related macular degeneration, also display gender and social differentials. In terms of gender, differences in the prevalence of macular degeneration may partly reflect women's longer life expectancy, given the strong age gradient, as well as possible hormonal influences (Klein et al., 2000; Rudnicka et al., 2012; S. Zhang et al., 2024). In contrast, hearing disorders are consistently more reported among men (Lam et al., 2025). Along the social gradient, disadvantaged groups may face reduced access to regular eye examinations, early detection, and indicated interventions, leading to delayed diagnosis and worse progression (Elam et al., 2022; X. Zhang et al., 2013).

For mental health, depression and depressive symptoms in particular, also show pronounced gender differentials and heterogeneous social patterns. Depression is more prevalent among women and more restrictive, reflecting both biological factors (e.g., hormonal changes) and social exposures such as caregiving and parental responsibilities, occupational stressors, and discrimination (Alblooshi et al., 2023; Engels et al., 2019; Freeman et al., 2006; Girgus & Yang, 2015; Opree & Kalmijn, 2012; Rantanen et al., 2021). Women are also more likely to report adverse psychosocial conditions, including low job control and insecure employment (Beaufils et al., 2023a; Cambois, 2016; Campos-Serna et al., 2013). Turning to social position, patterns are heterogeneous. In disadvantaged groups, depression risks are linked to limited resources, job insecurity, and physically demanding works (T. J. Kim & von dem Knesebeck, 2016; Lorant et al., 2003; Park et al., 2025; Virtanen et al., 2018). In contrast, workers in skilled and highly skilled occupations may also face elevated risks, associated with long working hours, job strain through performance pressures (Heinz et al., 2018; Kang et al., 2016; Laditka et al., 2023; Lee & Kim, 2023). Besides, higher socioeconomic status is associated with better access to mental health services, which may increase diagnosis rates of depression (Allen et al., 2014; Mackenzie et al., 2010).

A final set of evidence on gender and social differentials in prevalence and disabling impact relates to cancer. Cancer, which is strongly linked to restrictions, shows patterns that are more complex than for other diseases, largely due to heterogeneity across cancer sites and disease stages. Its association with restrictions at older ages also depends on disease trajectory: rapidly fatal cancers reduce prevalence in older age groups, while chronic or non-lethal cancers increase survivorship and entail lasting functional consequences (Global Burden of Disease 2019 Cancer Collaboration, 2022); In terms of gender, site-specific prevalence varies strongly with gendered cancers (prostate and breast cancers) being relatively prevalent in the population, making overall prevalence comparisons more difficult. Along the social gradient, disadvantaged groups experience higher incidence of aggressive and lethal cancers (e.g., lung, pancreatic, liver, stomach), which are often underrepresented in prevalence estimates due to lower survival (Marmot, 2005; Mihor et al., 2020; Zadnik et al., 2022). In contrast, advantaged groups benefit from earlier detection and higher survival, leading to a greater prevalence of disabling but non-lethal cancers in these populations (Afshar et al., 2021; Kelly et al., 2017; OECD, 2024; Vaccarella et al., 2022).

I. 3. Accounting for comorbidities: contributions of specific diseases to restrictions across gender and social groups.

A large body of evidence has examined the links between specific chronic diseases and activity restrictions starting mid-adulthood, as well as the social and gender differences in these links. While these studies provide important insights, they generally focus on specific groups of chronic diseases individually. Building on these works, another body of literature has focused on assessing the contribution of chronic diseases to restrictions while accounting for comorbidities. By considering a wide set of conditions simultaneously, these studies distinguished the relative importance of different diseases in contributing to restrictions and in shaping social and gender disparities.

Several studies have examined the contribution of chronic diseases to restrictions using various tools and based on different countries, including research conducted in Belgium (Nusselder et al., 2005; Yokota et al., 2015), the Netherlands (Klijs et al., 2011, 2014),

Finland (Sainio et al., 2007), Brazil (Costa Filho et al., 2018; R. T. de C. Yokota, de Moura, et al., 2016), the United States (Koster et al., 2005; Whitson et al., 2010), and France (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2012, 2019). Across these studies, MSD (including arthritis, back pain, and spine disorder) consistently emerged as the leading contributors to restrictions, whether relating to limitations in global, elementary, or instrumental activities of daily living. These conditions were both more prevalent and more disabling among women, thereby contributing to their higher disability prevalence. CVD, namely stroke and heart failure, were also shown to be strongly associated with restrictions, however contributing more to disability among men due to their higher prevalence in this group. The exception was the findings from the United States which showed that stroke and coronary heart diseases were more disabling among women (Whitson, 2010). MSD and CVD were also found to account for a large share of educational disparities in disability.

In France, the most recent available evidence (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2012, 2019) indicated that CVD were the second most important contributors to disability among men, while psychiatric conditions, particularly depression and anxiety, had a greater contribution among women. For both genders, NDD including dementia, Alzheimer's disease, and Parkinson's disease, were among the most disabling conditions. Yet, their relatively low prevalence compared to that of MSD and CVD, reduced the magnitude of their contribution to activity restrictions in the population.

In regards to social differences in France (Palazzo et al., 2019), arthritis and spine disorders were leading contributors to educational disparities in disability for both men and women. For men, these conditions were followed by chronic obstructive pulmonary diseases and ischemic heart/peripheral artery diseases; while for women, psychiatric disorders had a more prominent role in educational disparities. These educational differences were driven equally by differences in disease prevalence and in disabling impact: that is, individuals with lower educational attainment experienced both higher prevalence and stronger disabling effects of the mentioned health conditions, suggesting that both dimensions contributed to educational inequalities in disability.

I. 4. This work: Motivation and objectives.

Overall, findings from the literature have emphasized the relevance of accounting for gender and social differences in the links between chronic diseases and disability, and highlighted the need for targeted interventions focusing on specific diseases within social groups. For the French context, available evidence relies on data from 2008–2009, pointing to the need for more recent analysis. This step is relevant for the French context, especially in light of national policies introduced after 2009, that aimed to reduce social and gender health inequalities. These policies include, the *Stratégie Nationale de Santé* (2013) (Heard & Crémieux, 2016) focused on improving access to care and reducing social and territorial health gaps; and the *Plan interministériel pour l'égalité entre les femmes et les hommes* (2012–2017) (Gouvernement français, 2012), which encouraged greater attention to gender differences in health risks, working conditions, and access to care.
Further gaps in the literature include the limited number of studies that have included individuals living in institutions when studying health inequalities at old ages, a gap that was only addressed in one study in France (Nusselder, Wapperom, et al., 2019). In addition, most prior research has mostly relied on educational attainment as the sole indicator of social position, with limited consideration of other relevant dimensions such as occupational background, which has been closely linked to social inequalities in health. Besides, while gender differences in activity restrictions have been well documented, there is limited evidence on gender disparities within the same social groups. This is important to explore, as part of the observed gender health inequalities are suggested in the literature to reflect the unequal distribution of men and women across social categories, including occupational experiences. Looking at whether similar patterns of gender differences persist within the same social groups can help clarify the mechanisms underlying gender health inequalities.

This work addresses these gaps by examining the contribution of chronic diseases to activity restrictions in the French 60+ population, with attention to both gender and socio-occupational groups, and by explicitly accounting for comorbidities. Contributions are measured through both the prevalence of chronic diseases and their disabling impact, defined as the strength of their association with activity restrictions. The analysis further

assesses the extent to which differences in disease prevalence and differences in disabling impact contribute to disparities in the prevalence of activity restrictions across subgroups. This study draws on the *Capacités, Aides, et Ressources des Seniors* (CARE) surveys, conducted in 2015–2016, which provide representative data on the French population, including individuals living in households and institutions.

The focus of this work is on activity limitation (AL) covering general activities in the 60+ population. While other works have focused on assessing restrictions in elementary and instrumental activities of daily living (ADL and IADL), these indicators primarily capture severe limitations in specific daily tasks which mostly affect the oldest adults (Graf, 2008; Jagger et al., 2020). In contrast, AL covers more general and moderate limitations that may emerge during mid-adulthood, which are not captured by ADL nor IADL. General AL can also serve as early indicators of the more severe restrictions that may develop in later life, highlighting potential future health concerns (Van Oyen et al., 2018b; von Bonsdorff & Rantanen, 2011).

II. Data.

II.1 Capabilities, Help, and Resources for Seniors' surveys (CARE).

Data used in this study come from the 'Capabilities, Help, and Resources for Seniors' surveys ('Capacités, Aides, et Ressources des Seniors' - CARE), conducted by the French 'Directorate of Research, Studies, Evaluation and Statistics' (DREES) and 'National Institute for Statistics and Economic Studies' (INSEE) (Amélie Carrère et al., 2019; DRESS, 2020). CARE targeted French seniors aged 60 and above, focusing on those living in private households in 2015 (CARE-Ménages), and later extending to those residing in nursing homes in 2016 (CARE-Institution).

The household sample of CARE (CARE-Ménages, 2015) was constructed directly from the 2014 "Everyday Life and Health" French survey (Vie Quotidienne et Santé – VQS) (DRESS, 2016). VQS had initially drawn a random sample of 210,000 households from fiscal records, of which 81,000 households responded. Within these households, seniors aged 60 and above were identified and classified into dependency groups based on their

reported health and difficulties with daily activities. Four groups were identified: Group I comprising individuals in good health; Group II including those with moderate health issues; Group III consisting of individuals with light signs of dependency; and Group IV representing those classified as dependent (with lots of activity restrictions). CARE-Ménages respondents were then selected as a subsample of these VQS seniors: only one senior was chosen per household to avoid interviewing multiple old adults in the same household, and a second draw was applied, oversampling seniors with higher levels of dependency. This resulted in 15,000 individuals aged 60 and above that were invited to participate in CARE-Ménages in 2015 (2800 in group I, 3400 in group II, 4300 in group III, and 4500 in group 4) . Data collection was carried out through face-to-face interviews. Of the 15,000 seniors invited to participate in CARE-Ménages, 10,628 responded, resulting in a response rate of 75.85%.

As for the institutional component of CARE (CARE-Institution, 2016), it focused on seniors permanently residing in long-term care facilities. Its sampling frame was the French national register of health and social establishments (*Fichier National des Etablissements Sanitaires et Sociaux,* FINESS), which lists all licensed institutions in France. In a first stage, a stratified sample of institutions was drawn from this register, with stratification by region and by facility size. In a second stage, residents aged 60 and above were randomly selected within each participating institution. Of the 3,500 seniors initially sampled across about 8,000 eligible facilities, 3,262 completed the survey, yielding a response rate of 93.2%.

Survey weights were calculated and provided in both CARE-M and CARE-I data. Their purpose was to make the surveys representative of the entire French population aged 60 and above, whether living in private households or in institutions. In CARE-M, the weights incorporate the unequal probabilities of selection created by the oversampling of more dependent seniors, then adjust for non-response using auxiliary information available for all sampled individuals from VQS (notably the questions on health and daily difficulties) and fiscal data (housing tax records). Then, the weights are calibrated so that the weighted sample matches population distributions by sex, age, and dependency group as measured in VQS 2014; In CARE-I, the weights similarly reflect the two-stage sampling

design (institutions and then residents), are adjusted for non-response, and are calibrated to reproduce the age–sex structure of the institutionalized senior population.

For this study, we excluded individuals with missing response to questions regarding health conditions and information related to occupational history (N=339). This resulted in a selected sample of 10,593 respondents from CARE-Ménages (CARE-M) and 2,958 respondents from CARE-Institution (CARE-I), merged together in a final sample of 13,551 respondents.

II.2 Variables of interest.

II.1. a Outcome of interest: Activity Limitation (AL)

In both questionnaires of CARE-M and CARE-I, respondents were asked to specify whether they were "limited, over the past six months, because of a health problem, in activities people usually do". This was one among the various versions of the Global Activity Limitation Indicator (GALI), often used to identify situations of activity restrictions, and demonstrated to be of high reliability and validity (Berger et al., 2015; Bogaert et al., 2018). In CARE's GALI version, answer options were "Yes, strongly limited", "Yes, limited but not strongly", and "No, not limited at all". We considered that respondents were reporting an AL when they answered with a "Yes".

II.1. b Chronic diseases.

In both CARE-M and CARE-I, respondents (or their proxy respondents) were given a list of health conditions and asked whether they had experienced any of them during the past 12 months[1]. Respondents were instructed to report only conditions they had either been diagnosed with by a medical doctor (regardless of when the diagnosis occurred), or for which they had taken medication in the past 12 months. This follows the World Health Organization's approach to identifying chronic conditions, which considers both physician diagnosis and ongoing treatment as valid indicators of chronic illness (World Health Organization & Public Health Agency of Canada, 2005). Eight groups of chronic

[1] Full questionnaires can be found on this link: https://drees.solidarites-sante.gouv.fr/sources-outils-et-enquetes/les-enquetes-capacites-aides-et-ressources-des-seniors-care

diseases were of interest to this work and are summarized in Box I. A[2]. These conditions are known to be disabling, age-related, and unequally distributed across genders. Other conditions that were present in the list such as hypertension, pressure ulcers, cataracts, urinary leakage, and bladder control problems were not accounted for, as they are generally regarded as risk factors contributing to chronic diseases or resulting from them, rather than chronic diseases by themselves (Bernell & Howard, 2016; Shere et al., 2017; Whelton, 2015).

Although the questionnaire included a specific item on breathing difficulties, chronic respiratory diseases, such as asthma and chronic obstructive pulmonary disease, were not explicitly listed among the conditions respondents could report as having experienced or received treatment for in the past 12 months. As a result, they could not be separately identified and analyzed in this study.

Box I. A. Detailed composition of selected groups of chronic diseases based on reported health conditions from CARE-M and CARE-I.

Groups of chronic diseases	**Reported health conditions**
Cardiovascular diseases (CVD)	Myocardial infraction, post-infarction sequelae, coronary artery disease, heart failure
Diabetes	Diabetes
Neurodegenerative diseases (NDD)	Parkinson disease, Alzheimer's disease, Dementia
Musculoskeletal diseases (MSD)	Osteoarthritis, rheumatism, polyarthritis; chronic body pain (neck, cervical, upper back, lower back)
Kidney diseases	Kidney failure, nephritis, kidney stones
Macular degeneration	Macular degeneration (Eye disease affecting the macula)
Depression	Depression
Cancer	Any diagnosed Cancer

II.1. c Socio-occupational categories.

Based on responses of individuals who self-reported their occupations, the CARE team classified positions into six groups, following the French occupational classification

[2] Chronic respiratory diseases were not included as they were not present in the described list of diseases

system (Professions et Catégories Socioprofessionnelles, PCS; INSEE, 2020). This classification distinguishes occupations not only by job titles but also by employment status (self-employed versus salaried), employer type (public or private sector), and level of qualification. At its most aggregated level, six major socio-occupational groups are distinguished: Farmers ("Agriculteurs exploitants"); Craft-workers, retailers and business leaders ("Artisans, commerçants et chefs d'entreprise"); Highly skilled workers ("Cadres et professions intellectuelles supérieures"); Skilled workers ("Professions Intermédiaires"); Clerical/office workers ("Employés"); and Manual workers ("Ouvriers"). Craft-workers, retailers and business leaders were labelled as "Self-employed" individuals in our analysis. A detailed description of socio-occupational groups is found in Box I. B. As the majority of CARE respondents were retired (N = 9551 in CARE-M, 89.8%), these categories reflected either the most recent occupation before retirement or the current occupation for those who were still active at the time of the survey. Individuals who had never worked or were identified as "Inactive" by the CARE team were also accounted for in a separate category, labelled "Not employed". However, due to the relatively small subsample (later detailed in *Results* section, **Table I. 1**), the category of inactive men is only included in the analysis estimating the prevalence of diseases across the different groups of interest. The contribution of chronic diseases to AL could not be assessed among men in the "Not employed" category.

Box I. B. Detailed composition of socio-occupational groups in CARE-M and CARE-I, following the French classification of INSEE (2020).

Socio-occupational category	**Occupational positions**
Farmers	Farmers
Self-employed	Craft workers, retailers and business leaders (of businesses with more than 10 employees)
Highly skilled workers	Managers, professionals and intellectual occupations
Skilled workers	Teaching associate professionals, health and social work intermediate occupations, administrative occupations of public and private companies, technicians and associate professionals
Clerical/office workers	Skilled and unskilled clerical workers: e.g Government executives, administrative staff, accounting and insurance clerks, store employees, providing client services
Manual workers	Skilled and unskilled manual workers: e.g workers in farms, workers in handling, storage and transport

II.1. d Other social variables.

Additional information on respondents' social characteristics was available in both CARE-M and CARE-I. Among these, highest educational attainment, geographical origin, and marital status were examined across gender and socio-occupational categories, and later used as control variables in the decomposition analysis of differences in AL prevalence. These social variables were retained because they are likely to differ across groups and have been consistently linked to health inequalities in the literature.

Detailed information on respondents' highest educational attainment, geographical origin, and marital status were available in both CARE-I and CARE-M, yet they were categorized in this work to improve comparability across groups and to ensure sufficient sample sizes. Starting with education, it was measured by respondents' reports of their highest completed diploma from a detailed list of 20 levels, ranging from no diploma (0) and primary school (1) to medical (19) and doctoral degrees (20). These were collapsed into five broader groups of highest educational attainment, which are: "No diploma," "High school diploma," "Vocational certificate," "Undergraduate degree," and "Graduate

or Post-graduate degrees". This followed common practice in French surveys and was consistent with the international standard classification of education (ISCED, 2011) (UNESCO, 2012). As for geographical origin, it was originally classified in CARE as "Metropolitan France," "DOM-TOM (Overseas territories)", "European Union," "countries in the European Union since 2004," "Maghreb," "Other African countries," and "Other countries." These were merged into four categories being: "France including DOM-TOM," "European Union," "Maghreb," and "Other countries". As for marital status, it followed CARE's classifications which distinguished, those "In a civil union" (Marriage or PACS), "Divorced," "Widowed," and "Single" (labelled in our work as "Never in a civil union").

III. Methods.

III.1 Prevalence of chronic diseases and AL.

Using survey weights provided by CARE, we first calculate the weighted prevalence of self-reported chronic diseases and AL across gender and socio-occupational categories, along with their 95% confidence intervals using the R *survey* package. Although confidence intervals are informative, there are cases when statistical significance of the difference between two estimates cannot be reliably inferred from an overlap of confidence intervals alone (Cumming & Finch, 2005; Schenker & Gentleman, 2001). Therefore, we additionnally test the difference in weighted prevalence of health conditions across groups, using a Z-test based on the standard errors of the weighted prevalence estimates. The standard errors used in these tests are derived from the design-based estimation implemented in the R *survey* package (Lumley, 2004), which incorporates the CARE sampling weights as probability weights to correct for unequal selection probabilities. This approach ensures that the weights improve population representativeness without inflating the effective sample size, so the estimated variances and the resulting significance tests appropriately reflect sampling uncertainty.

In an additional analysis, we account for differences in age distributions by applying age standardization, with the direct standardization method, using the French population structure from the 2015 census (INSEE, 2018), to obtain age-standardized prevalence of

the conditions of interest. Age was transformed into a categorical variable and each age category was matched to its corresponding proportion in the external reference population. Using the *svystandardize* function from the R survey package, we constructed a standardized survey design in which the contribution of each age group was reweighted to reflect its share in the reference population. We then computed the age-standardized prevalence and confidence intervals for each health condition from this standardized design using *svymean*. This procedure ensures that observed differences in prevalence across gender or socio-occupational groups are not confounded by differences in age structure.

III.2 Attributing chronic diseases to AL within gender and socio-occupational groups.

III.2. a. Modeling specification: Additive hazard framework.

To estimate the contribution of chronic diseases to AL, we apply the attribution method developed by Nusselder & Looman (2004) and used in the previous mentioned works that have investigated the contribution of chronic conditions to disability, accounting for comorbidities. Based on a multivariate additive regression model (Clayton et al., 2013), this method relies on an additive hazard framework in which diseases contribute additively to a cumulative hazard of disability. In competing risks models in mortality analysis (Chiang, 1991; Manton et al., 1986), an exponential transformation is applied to the cumulative force of mortality to derive cause-specific probabilities of death. The attribution method follows the same principle for disability: the exponential function is applied to the cumulative hazard in order to obtain cause-specific disability probabilities. In this setting, the linear predictor represents the cumulative hazard of disability, and the exponential transformation ensures that predicted probabilities remain bounded between 0 and 1 while preserving additivity at the hazard level.

The attribution method is of particular relevance to our study as it allows to partition the overall prevalence of our outcome of interest, AL, into additive contributions of the individual chronic diseases and a "background" component. The method recognizes that

individuals may report AL even in the absence of diseases, or due to unmeasured, undiagnosed, or underreported conditions, or age-related losses in functioning, all of which are captured by the "background" component. Additionally, it accounts for the fact that individuals can report more than one chronic condition simultaneously (i.e., comorbidity), and allows for the estimation of cause-specific AL prevalence in an additive way. Overall, the method ensures that the estimated contributions of diseases and "background" do not exceed the observed prevalence of AL. For this work, we used the specification of a binomial additive hazard model detailed in Box I. C, as our outcome of interest and explanatory variables are of binary nature[3].

Box I. C. Specification of the fitted binomial additive hazard model.

$$\begin{cases} y_i = Bernoulli(\pi_i) \\ \pi_i = 1 - \exp(-\eta_i) \\ \eta_i = \alpha_i + \sum_{d=1}^{m} \beta_d X_{di} \end{cases}$$

- y_i is the binary variable measuring Activity Limitation ;
- π_i translates to the probability that respondent i declared an AL;
- η_i is the linear predictor representing the overall cumulative rate (or cumulative hazard) of AL for individual i;
- α_i is the cumulative rate of disability for the group of relevant factors that could not be included ("Background" component);
- β_d reflects the cumulative rate of disability (or "disabling impact") for disease d (1, . . . , m)
- X_{di} is an indicator variable for disease d and individual i.

Additive hazard models were fitted separately by gender and occupational category, using the *addhaz* R package (Yokota et al., 2019). Available sampling weights were used in all analysis, to account for non-response and sampling design. Confidence intervals were derived for the cumulative rate of AL for "background" and chronic diseases, based on 1000 bootstrapping simulations. Z-tests were further performed to investigate whether

[3] In a binomial additive hazard model's specification, all explanatory variables **have to be** of binary nature.

diseases' disabling impacts and absolute contribution to AL, differed across gender and occupational categories.

The estimation of cumulative hazard rates of disability, operationalized as AL in our study, using cross-sectional data, relies on several assumptions inherent to the additive hazard framework (Nusselder & Looman, 2004a). First, a causal relationship between the selected diseases and AL is assumed, in line with the theoretical framework of the disablement process model. Second, the observed distribution of AL by cause is assumed to be fully explained by the diseases present at the time of the survey and a residual "background" component. Two structural assumptions are also required: The stationary assumption, which implies that the cross-sectional cumulative hazard rates (α and β_d) reflect the transition rates that would be observed in longitudinal data, and that recovery from AL does not occur; and the proportionality assumption which states that the ratio of disease-specific cumulative hazards (also referred to as disabling impacts) to the overall cumulative hazard remains constant over time. Additionally, the onset of the time at risk to declare AL is assumed to be the same for all the included groups of diseases. Finally, groups of chronic diseases and the "background" component are treated as competing causes of AL.

III.2. b.Deriving the contribution of chronic diseases to AL.

Attributing chronic diseases to AL relies on both the disabling impacts of diseases (β_d), estimated by the model, and the prevalence of these diseases in the sample. The contribution of the selected chronic diseases and the "background" component (α) to the overall AL prevalence, are derived from five different measures detailed in Box I. D. Absolute and relative contributions of diseases and the "background" component were estimated for each gender and for each socio-occupational group within women and men, except for the category of men who were "Not employed" due to limited sample size. Confidence intervals for absolute contributions were calculated and are based on 1000 bootstrapping simulations. Z-tests were also further performed to investigate whether diseases' absolute contribution to AL, differed across gender and occupational categories.

Box I. D. Measures used to examine the contribution of chronic diseases and "background" to AL prevalence.

Measure	Estimation technique
Cause specific disability probability for individual i and each selected chronic condition d ($\widehat{D}_{di}$), background ($\widehat{B}_i$)	$\widehat{D}_{di} = \hat{\pi}_i \left(\frac{\hat{\beta}_d X_{di}}{\hat{\eta}_i}\right)$ $\widehat{B}_i = \hat{\pi}_i \left(\frac{\hat{\alpha}}{\hat{\eta}_i}\right)$
Number of disabled individuals by each given disease d ($\widehat{N}_d$), and by background ($\widehat{N}_b$)	$\widehat{N}_d = \sum_{i=1}^{n} \widehat{D}_{di}$ $\widehat{N}_b = \sum_{i=1}^{n} \widehat{B}_i$
Absolute contribution of each specific disease *d* ($\widehat{AC}_d$) , and by background ($\widehat{AC}_b$) to AL	$\widehat{AC}_d = \frac{\widehat{N}_d}{n}$ $\widehat{AC}_b = \frac{\widehat{N}_o}{n}$
Disease prevalence in sample ($\hat{P}$)	$\hat{P} = \widehat{AC}_o + \sum_{d=1}^{m} \widehat{AC}_d$
Relative contribution of diseases *d* ($\widehat{RC}_d$) and background ($\widehat{RC}_o$) to disability prevalence	$\widehat{RC}_d = \frac{\widehat{AC}_d}{\hat{P}}$ $\widehat{RC}_b = \frac{\widehat{AC}_o}{\hat{P}}$

III.3 Decomposing gender and social differences in prevalence of AL.

Beyond comparing how chronic diseases contribute to AL within each gender and occupational category, we conduct a decomposition analysis to quantify differences in the prevalence of AL between groups. Given the binary nature of the outcome of interest, we apply a nonlinear extension of the Oaxaca-Blinder decomposition (Blinder, 1973; Oaxaca, 1973), following the approach proposed by Yun (2004, 2008). This method decomposes differences in the first moment of a nonlinear model, that is, differences in mean predicted probabilities, which correspond to differences in prevalence when the outcome is binary.

For our study goals, the decomposition approach allows to quantify the gender and social gaps in AL by separating each gap into two parts: an "Explained" component, which

reflects the extent to which the gap in AL is due to differences in the distribution of chronic diseases between two groups of interest, assuming that diseases have the same associations with AL for both; and an "Unexplained" component, which reflects differences in how diseases are associated with AL, assuming the same distributions across groups of interest. This method helps in identifying which chronic diseases contribute to the gaps (positively or negatively), either due to their higher (or lower) prevalence or their stronger (or weaker) relationship with AL in one group over the other.

We proceed with the decomposition which targets differences in the survey-weighted mean predicted probability of AL between groups, using the specification described in Box I. E. We estimate separate logistic regression models by group, accounting for chronic diseases and controlling for sociodemographic variables including highest educational attainment, marital status, geographical origin, and age while accounting for separate age categories (60-69, 70-79, 80-89, 90+). Models were fitted using survey-weighted logistic regressions with the *svyglm* function from R *survey* package, incorporating CARE sampling weights to account for the complex sampling design (Lumley, 2004). Average marginal effects (AMEs), odds ratios (ORs) of variables of interest, and their confidence intervals are calculated. The contributions of individual variables to the gap in AL prevalence between groups were estimated using an R implementation of the multivariate decomposition approach for nonlinear models proposed by Powers, Yoshioka, and Yun (Powers et al., 2011), which operationalizes Yun's decomposition framework. Standard errors for the overall and covariate-specific decomposition components are obtained via the delta method, applied to the Yun weight functions and the estimated variance-covariance matrices from the survey-weighted logistic regressions (Yun, 2005).

Box I. E. Specification used for decomposition analysis following Yun (2004, 2008).

(A) Logistic regression model.

$$P(Y_i = 1 \mid X_i) = \frac{1}{1 + exp(-X_i\beta)} = F(X_i\beta)$$

- Y_i is the binary variable measuring activity limitation;
- X_i is the vector of explanatory variables: chronic diseases, age categories, and social variables.
- **F(.)** is the fitted logistic function
- β denotes coefficients related to variables of interest

(B) Estimated prevalence of AL.

$$\overline{Y}^g = E[F(X^g\widehat{\beta}^g)]$$

- $\overline{Y}^g$ corresponds to the survey weighted mean predicted probabilities of AL across individuals in a given group g.

(C) Overall decomposition of the difference in AL prevalence between groups A and B.

$$\overline{Y}^A - \overline{Y}^B = \underbrace{E[F(X^A\widehat{\beta}^A)] - E[F(X^B\widehat{\beta}^A)]}_{\text{Explained component (E)}} + \underbrace{E[F(X^B\widehat{\beta}^A)] - E[F(X^B\widehat{\beta}^B)]}_{\text{Unexplained component (U)}}$$

- The "explained component" (E) is the part of the difference due to different distributions of explanatory variables across groups A and B (in the counterfactual scenario where β coefficients are equal)
- The "unexplained component" (U) is the part of the difference due to difference in β coefficients across groups A and B (in the counterfactual scenario where distributions of explanatory variables are equal)

(D) Covariate- specific contribution to the explained and unexplained components of the decomposition in AL prevalence between groups A and B.

$$E_k = E.\frac{(\overline{X}_k^A - \overline{X}_k^B)\widehat{\beta}_k^A}{(\overline{X}^A - \overline{X}^B)^T\,\widehat{\beta}^A} \qquad U_k = U.\frac{\overline{X}_k^B\,(\widehat{\beta}_k^A - \widehat{\beta}_k^B)}{(\overline{X}^B)^T\,(\widehat{\beta}^A - \widehat{\beta}^B)}$$

- E_k is the contribution of explanatory variable k to the explained component (E)
- U_k is the contribution of covariate k to the unexplained component (U)
- The contributions sum to the total explained and unexplained components ($\sum_k E_k = E$ and $\sum_k U_k = U$)

IV. Results.

IV. 1 Sociodemographic and health characteristics of men and women in CARE.

Table I. 1. presents the sample and weighted distributions of birth cohorts, age categories, social variables of interest, along with the prevalence (non-weighted and weighted) of AL and chronic diseases in the merged CARE sample, by gender.

Table I. 1. Sample and weighted distribution of cohorts social variables, AL, and chronic diseases, by gender (in merged sample of CARE-M and CARE-I, N = 13,551).

	Women (N= 8695)		**Men (N= 4856)**		
	Counts (with %)	**Weighted %**	**Counts (with %)**	**Weighted %**	**p-values**
Cohorts					
1947-1956 (aged 60-69 in CARE)	1583 (18.2%)	37.44%	1439 (29.6%)	43.3%	**p<0.01**
1937-1946 (aged 69-79 in CARE)	1914 (22%)	30.09%	1398 (28.8%)	33.8%	**p=0.01**
1927-1936 (aged 79-89 in CARE)	3140 (36.1%)	23.28%	1422 (29.3%)	18.32%	**p<0.01**
1917-1926 (aged 89-99 in CARE)	1985 (22.8%)	8.86%	585 (12%)	4.52%	**p<0.01**
1907-1916 (aged 99-109 in CARE)	73 (0.8%)	0.33%	12 (0.2%)	0.06%	**p=0.02**
Living in institutions (CARE-I)	2202 (25.32%)	4.8%	756 (15.57%)	2.1%	**p<0.05**

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N=2,958).
Notes: Weighted distributions were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; p-values are obtained from z-scores that compare weighted distributions across women and men.

Table I. 1. (*Continued*) Sample and weighted distribution of cohorts, social variables, AL, and chronic diseases, by gender (in merged sample of CARE-M and CARE-I, N = 13,551).

	Women (N= 8695)		**Men (N= 4856)**		
	Counts (with %)	**Weighted %**	**Counts (with %)**	**Weighted %**	**p-values**
Socio-occupational group					
Out of labor force	1134 (13%)	7.89%	105 (2.2%)	0.98%	***p<0.05***
Farmers	676 (7.8%)	4.63%	377 (7.8%)	5.27%	*p=0.28*
Self-employed	618 (7.1%)	6.77%	557 (11.5%)	11.05%	***p<0.01***
Manual Workers	1341 (15.4%)	12.91%	1659 (34.2%)	28.22%	***p<0.01***
Clerical or Office Workers	3466 (39.9%)	40.94%	473 (9.7%)	9.99%	***p<0.01***
Skilled workers	975 (11.2%)	17.25%	917 (18.9%)	23.21%	***p<0.01***
Highly-skilled workers	485 (5.6%)	9.61%	768 (15.8%)	21.27%	***p<0.01***
Highest educational attainment					
No diploma	4628 (53.2%)	45.26%	2154 (44.4%)	36.63%	***p<0.01***
High-school diploma	404 (4.6%)	5.94%	282 (5.8%)	7.41%	*p=0.06*
Vocational certificate	2788 (32.1%)	36.48%	1734 (35.7%)	37.97%	*p=0.32*
Undergraduate degree	460 (5.3%)	9.05%	443 (9.1%)	14.02%	***p<0.01***
Graduate or Post-graduate degree	97 (1.1%)	2.61%	141 (2.9%)	3.70%	*p=0.07*
Missing	318 (3.7%)	0.66%	102 (2.1%)	0.26%	***p<0.01***
Geographical origin					
France (including DOM-TOM)	7645 (87.9%)	87.63%	4217 (86.8%)	87.81%	*p=0.86*
European Union	444 (5.1%)	5.30%	202 (4.2%)	3.61%	***p=0.005***
Maghreb (North-west Africa)	446 (5.1%)	5.20%	333 (6.9%)	6.56%	*p=0.05*
Other countries	152 (1.7%)	1.86%	101 (2.1%)	2.01%	*p=0.73*
Missing	8 (0.1%)	0.02%	3 (0.1%)	0.01%	*p=0.301*
Marital status					
In a civil union	2607 (30%)	48.53%	2998 (61.7%)	74.76%	***p<0.01***
Divorced	878 (10.1%)	13.11%	472 (9.7%)	9%	***p<0.01***
Widow(er)	4489 (51.6%)	31.40%	812 (16.7%)	8.01%	***p<0.01***
Never in a civil union	711 (8.2%)	6.94%	570 (11.7%)	8.23%	*p=0.10*
Missing	10 (0.001%)	0.02%	4 (0.001%)	0.01%	*p=0.16*
Health conditions					
Activity Limitation	6420 (73.8%)	42.34%	3281 (67.6%)	39.09%	***p=0.02***
Musculoskeletal diseases	6358 (73.1%)	68.12%	2880 (59.3%)	50.87%	***p<0.01***
Cardiovascular diseases	1943 (22.3%)	12.29%	1476 (30.4%)	18.16%	***p<0.01***
Diabetes	1374 (15.8%)	11.41%	997 (20.5%)	16.13%	***p<0.01***
Depression	1453 (16.7%)	9.27%	509 (10.5%)	4.06%	***p<0.01***
Cancer	616 (7.1%)	5.54%	430 (8.9%)	5.52%	*p=0.98*
Kidney diseases	624 (7.2%)	4.03%	414 (8.5%)	4.71%	*p=0.17*
Neurodegenerative diseases	1280 (14.7%)	3.95%	499 (10.3%)	2.42%	***p<0.01***
Macular degeneration	690 (7.9%)	4.19%	242 (5%)	2.58%	***p<0.01***

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N=2,958).
Notes: Weighted distributions were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; p-values are obtained from z-scores that compare weighted distributions across women and men.

IV. 1. a. Birth cohorts and age distributions.

The majority of respondents were born between 1927 and 1956 (76.3% of women and 87.7% of men in CARE) and thus were between the ages of 60 to 89 at the time of the surveys. In weighted estimates, these cohorts were estimated to have represented around 90.81% of women and 95.42% of men aged 60+ in the French population in 2015-2016. Both sample and weighted distributions indicate that older age groups were more found among women: the proportion of individuals aged 79+ amounted to around 32.5% among women and 22.9% among men in weighted estimates (59.7% and 41.5% among women and men in the sample). This pattern is consistent with the well-documented gender gap in life expectancy in France, which stood at approximately six years in 2015 (78.9 years for men versus 85.0 years for women; INSEE, 2016).

IV. 1. b. Social characteristics.

Respondents from CARE-I represented 25.3% and 15.6% of women and men in the merged sample of 13,551 respondents. In weighted estimates, this translated to an estimation of 4.8% and 2.1% of women and men living in institutions in 2016, respectively.

Most respondents were classified as manual, clerical, skilled, or highly skilled workers, while farmers represented only a small proportion in both genders (7.8% of sample and less than 6% in weighted estimates). Among men, the "Not employed" category accounted for the smallest share in both unweighted and weighted estimates (2.2% and 1.0%, respectively), while among women, the smallest group was highly skilled workers (5.6% in the sample and 9.6% weighted). Inactivity was more frequent among women, whereas self-employment and skilled or highly skilled occupations were more common among men. Manual occupations were more common among men (28.22% weighted), while clerical occupations were more common among women (40.94% weighted).

Regarding other social characteristics, most CARE respondents were of French origin (around 87%), and fewer than 20% had completed either undergraduate or graduate degrees. Clear gender differences were detected: The share of individuals with no diploma was higher among women than among men in the sample (53.2% versus 44.4%) and in

the weighted distributions (45.26% versus 36.63%). Besides, respondents of other EU origins were slightly more frequent among women (5.3% vs. 3.6% in the sample). For marital status, men were more frequently in a civil union (67.6% in the sample and 74.7% in weighted estimates) while divorce and widowhood were more common among women in both distributions (over 40% in the sample and weighted population of women aged 60+, compared to a proportion under 25% among men).

IV. 1. c. Prevalence of AL and chronic diseases.

The prevalence of AL was high in the sample (73.8% for women and 67.6% for men). Weighted estimates indicated lower levels in the general population: 42.3% for women and 39.1% for men, with the prevalence being significantly higher among women ($p<0.01$). For chronic diseases, MSD, CVD, diabetes, and depression were the most common conditions in both the sample and the weighted population estimates. NDD were reported by 14.7% of women and 10.3% of men in the sample, but their weighted prevalence was relatively lower (4.0% among women and 2.4% among men). Cancer, macular degeneration, and kidney diseases also had low estimated prevalence, while cancer and kidney diseases were reported by fewer than 10% of respondents for both men and women, and remained below 6% after weighting. Significant gender differences were observed: MSD, depression, macular degeneration, and NDD were significantly more prevalent among women (all $p < 0.01$), whereas CVD and diabetes were more frequent among men (all $p < 0.01$).

To account for gender differences in age distribution (Table I. 1), Table I. 2 reports age-standardized prevalence estimates based on the 2015 French population structure. For chronic diseases, patterns of gender differences in weighted prevalence remained consistent after age standardization. As for AL, after age standardization, prevalence among women was 40.6% (versus. 42.3% weighted, non–age-standardized), and 40.7% among men (versus. 39.1%): the gender difference was no longer statistically significant ($p = 0.9$). This suggests that the higher share of older women in the sample accounted a relevant part of the gender gap in AL prevalence.

Table I. 2. Age-standardized weighted prevalence of AL and chronic diseases (with 95% confidence intervals), by gender (in merged sample of CARE-M and CARE-I).

	Women	Men	p-values
Health conditions			
Activity Limitation	40.55 (38.75 - 42.34)	40.72 (38.73 - 42.71)	p=0.9
Musculoskeletal diseases	67.85 (65.92 - 69.78)	51.63 (49.44 - 53.82)	p<0.01
Cardiovascular diseases	11.32 (10.35 - 12.3)	18.82 (17.31 - 20.33)	p<0.01
Diabetes	11.39 (10.26 - 12.52)	16.04 (14.51 - 17.57)	p<0.01
Depression	9.19 (8.23 - 10.15)	4.28 (3.61 - 4.95)	p<0.01
Kidney diseases	3.84 (3.27 - 4.41)	4.82 (4.05 - 5.59)	p=0.046
Cancer	5.54 (4.73 - 6.34)	5.59 (4.73 - 6.46)	p=0.92
Neurodegenerative diseases	3.33 (2.99 - 3.66)	2.66 (2.28 - 3.04)	p=0.01
Macular degeneration	3.7 (3.15 - 4.26)	2.84 (2.24 - 3.43)	p=0.04

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates) using the direct standardization method; Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

IV. 2 Characteristics of socio-occupational groups in CARE.

IV. 2. a. Distributions of age and social variables across occupational groups.

Figure.I.1 presents the sample and weighted age distributions across gender and socio-occupational groups, followed by Table I. 3 and Table I. 4 that display the weighted distributions of social variables across the different groups[4].

Distributions displayed in Figure.I.1 indicate that the average age of women significantly exceeds that of men across all occupational categories except among highly skilled workers, in both the sample and the weighted population. Individuals who were not employed and farmers constitute the oldest groups within the 60+ population, with mean

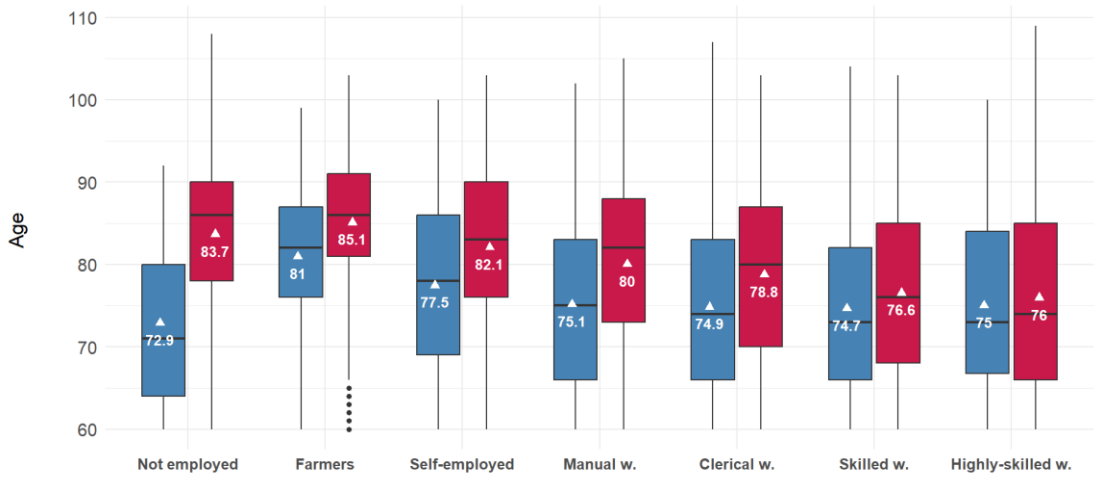
[4] For conciseness and clarity, z-scores and p-values comparing the distribution of the variables across gender and social-groups are not displayed. However, all differences that shall be mentioned were checked and were statistically significant. Results from z-scores and p-values are available upon request

ages above 73 for men and 79 for women. In contrast, highly skilled workers are the youngest. Among women, the self-employed and manual workers, as well as farmers and individuals in the "Not employed" category, include larger shares of older individuals than highly skilled workers.

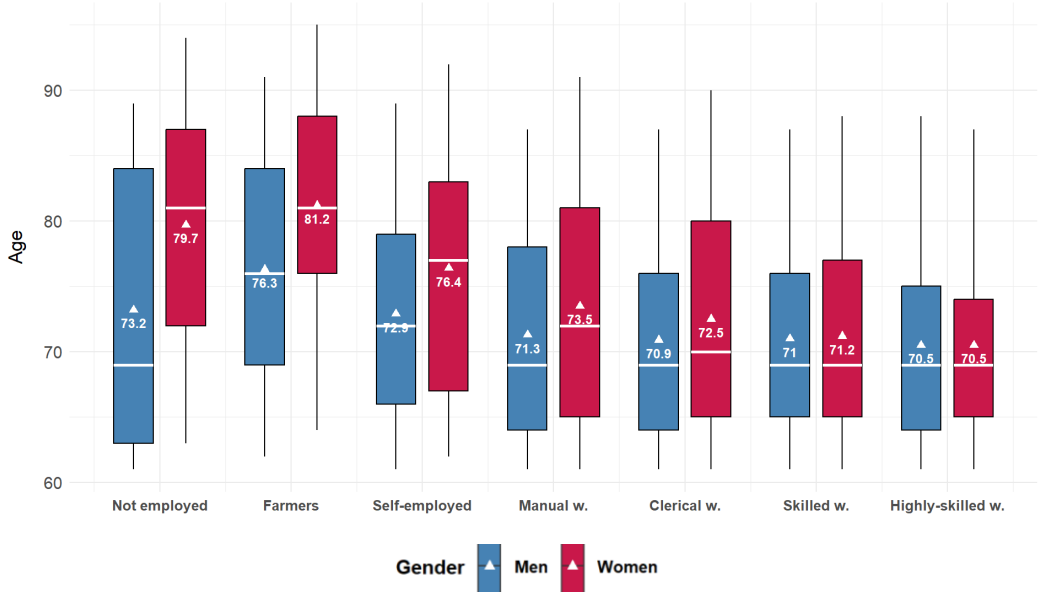
Getting to social distributions, estimations displayed in Table I. 3 and Table I. 4 revealed that more than half of farmers, both women and men, had no diploma or only a high school diploma, while over half of highly skilled workers had completed at least an undergraduate degree. Among manual workers, fewer than 2% had such a degree. Marked gender differences in distributions were observed among the self-employed: over 75% of women in this group had no diploma and less than 1% had completed an undergraduate degree, compared with 15% of men holding at least an undergraduate degree and fewer than 40% without a diploma. In regards to geographical origin, the vast majority of 60+ individuals were French, representing for instance 98.6% of self-employed women and of farmers within men. The highest shares of foreigners from Maghreb countries and from outside the European Union were found among women who were not employed (over 15%), and among manual and clerical workers within men. As for marital status, widowhood was most common among the self-employed and the category of "Not employed" for both genders, while divorce was more frequent among skilled and highly skilled women (over 19% in both categories).

Figure.I.1. Sample (Panel A) and weighted (Panel B) age distributions across gender and socio-occupational categories, with boxplots and mean ages (in merged sample from CARE-I and CARE-M, N=13,551)

(A) Sample distributions



(B) Weighted distributions



Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N=2,958).
Notes: Means are displayed and represented in white triangles. Drawn boxplots in panel A display minimum, inter-quartile range, mean, maximum, and outlier ages for each category. Weighted statistics were estimated with the *svyquantile* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Boxplots of panel B display the 5th percentile, interquartile range, mean, and 95% percentile for each group.

Table I. 3. Weighted distributions of social variables across socio-occupational groups among <u>women</u> in merged sample from CARE-M and CARE-I (N= 8695).

	Socio-occupational category						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Highest educational attainment							
No diploma	65.44%	44.42%	79.25%	75.82%	51.58%	11.38%	5.73%
High-school diploma	2.52%	6.64%	1.96%	1.07%	3.17%	14.98%	12.24%
Vocational certificate	26.60%	46.05%	16.67%	22.26%	41.36%	48.64%	23.89%
Undergraduate degree	3.57%	2.16%	0.09%	0.04%	3.01%	23.65%	34.35%
Graduate or Post-graduate degree	0.16%	0.20%	0%	0%	0.31%	1.14%	23.54%
Missing	1.71%	0.54%	2.04%	0.80%	0.57%	0.21%	0.26%
Geographical origin							
France including DOM-TOM	73.40%	89.51%	98.55%	86.50%	88.24%	89.82%	87.71%
European Union	9.27%	4.69%	1.15%	8.53%	4.63%	3.68%	5.88%
Maghreb (North-west Africa)	14.14%	2.89%	0.17%	3.65%	5.24%	4.96%	4.18%
Other countries	3.14%	2.85%	0.11%	1.32%	1.88%	1.53%	2.21%
Missing	0.06%	0.05%	0.03%	0%	0.01%	0.01%	0.02%
Marital status							
In a civil union	40.26%	46.70%	43.84%	50.32%	49.43%	48.79%	52.15%
Divorced	2.85%	8.28%	2.82%	9.24%	13.55%	19.01%	22.66%
Widow	52.68%	39.53%	50.62%	34.55%	30%	23.52%	14.81%
Never in a civil union	4.17%	5.46%	2.72%	5.88%	6.99%	8.68%	10.38%
Missing	0.04%	0.03%	0%	0.01%	0.03%	0%	0%

Source: Subsample of women aged 60 and over (N=8695) from merged subsamples of CARE-M (2015, N = 6,493) and CARE-I (2016, N=2,202).
Notes: Weighted distributions were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I.

Table I. 4. Weighted distributions of social variables across socio-occupational groups among men in merged sample from CARE-M and CARE-I (N= 4856).

	Socio-occupational category						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Highest educational attainment							
No diploma	52.64%	58.01%	33.82%	60.30%	54.48%	24.62%	5.37%
High-school diploma	5.51%	4.99%	9.18%	1.49%	2.72%	13.21%	10.93%
Vocational certificate	28.02%	34.38%	41.89%	36.56%	37.18%	49.90%	26.52%
Undergraduate degree	5.05%	2.22%	12.25%	1.30%	4.23%	11.86%	42.11%
Graduate or Post-graduate degree	7.75%	0%	2.53%	0%	1.14%	0.33%	14.85%
Missing	1.02%	0.40%	0.33%	0.34%	0.25%	0.09%	0.22%
Geographical origin							
France including DOM-TOM	87.94%	98.02%	89.24%	81.35%	86.60%	89.32%	92.02%
European Union	2.91%	1.67%	3.47%	6.22%	1.13%	3.67%	1.81%
Maghreb (North-west Africa)	5.50%	0.21%	4.88%	9.21%	8.74%	5.57%	5.60%
Other countries	3.65%	0.10%	2.39%	3.20%	3.53%	1.43%	0.56%
Missing	0%	0%	0.02%	0.01%	0%	0.01%	0%
Marital status							
In a civil union	44.74%	75.65%	75.77%	71.74%	72.16%	77.57%	77.54%
Divorced	13.26%	1.11%	9.59%	10.14%	10.66%	7.61%	9.66%
Widower	16.28%	11.47%	10.14%	8.28%	6.67%	6.34%	7.76%
Never in a civil union	25.72%	11.77%	4.46%	9.83%	10.52%	8.47%	5.04%
Missing	0%	0%	0.04%	0.01%	0%	0.01%	0%

Source: Subsample of men aged 60 and over (N=4856) from merged subsamples of CARE-M (2015, N = 4,100) and CARE-I (2016, N=756).
Notes: Weighted distributions were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I.

IV. 2. b. Prevalence of AL across gender and socio-occupational groups.

Figure.I.2 displays the weighted prevalence of AL (age standardized in panel B) , with 95% confidence intervals, by gender and socio-occupational group. Detailed results are provided in Table I.S.1 to Table I.S.4 in supplementary materials. Supplementary Table I.S.5, Table I.S.6 and Figure I.S.1 to Figure I.S.4 also report z-tests comparing AL prevalence between men and women within each socio-occupational category, and between different socio-occupational groups among men and women.

Within socio-occupational categories, no significant gender difference was observed in the prevalence of AL, despite the significant difference detected earlier in the general population (Table I. 1). After age standardization, however, the prevalence of AL among men in the "Not employed" and farmer categories significantly exceeded that of women. This pattern could be explained by the different age distribution between men and women in these categories, with men being younger than women, which could have led to an underestimation of age-specific prevalence of AL among men in these groups when not accounting for age differences across gender. It is also useful to recall that for the case of men labelled as "Not employed", they represented only 2.2% and 0.98% in the sample and weighted distribution of 60+ men in CARE. As for farmers, the 95% confidence intervals of the age-standardized prevalence of AL among men and women slightly overlapped, while the absolute z-score of 2.55 indicated a significant difference. Thus, the higher age-standardized prevalence of AL observed for men, compared to women, in the groups of farmers and those with no employment shall be interpreted with caution.

Figure.I.2. Estimated prevalence of AL, without (A) and with (B) age standardization, with 95% confidence intervals, by gender and socio-occupational group (in merged sample from CARE-I and CARE-M).

(A) Weighted prevalence of AL



(B) Age-standardized weighted prevalence of AL



Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates); Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

Regarding socio-occupational differences, clear gradients emerged. Among workers, a social gradient was detected in AL prevalence (both before and after age standardization) across manual, skilled, and highly skilled workers. Manual workers had a higher prevalence of AL compared with skilled and highly skilled workers, for both women

(42.4%, 34.6%, and 29.1% for manual, skilled and highly-skilled workers, respectively) and men (44.1% , 39.5%, and 31.0%, respectively) (all $p < 0.05$, Figures S1-S4 in supplementary materials). Beyond this gradient, individuals in the "Not employed" category, farmers, and the self-employed also showed higher prevalence of AL compared with other categories. The category of "Not employed" reported the highest prevalence of AL (58.8% for women and 64.3% for men) compared to all worker categories, a pattern that remained after age standardization. Farmers also reported higher prevalence of AL (55.7% for women and 49.3% for men) than skilled and highly skilled workers, for both women and men, even after accounting for age differences across the categories. Among women, farmers also had a higher prevalence of AL compared with manual and clerical workers, although this difference was no longer found after age standardization. For the self-employed, non-standardized estimates among both women and men, indicated significantly higher prevalence of AL (49.3% for women, 42.9% for men) compared with highly skilled workers; however, this pattern persisted after age standardization only for men.

IV. 2. c. Prevalence of chronic diseases across gender and socio-occupational groups in CARE.

Figure.I.3 displays the weighted prevalence of chronic diseases (with age-standardized estimates in panels B), with 95% confidence intervals, by gender and socio-occupational category. Detailed results are provided in Table I.S.1 to Table I.S.4 in supplementary materials. Supplementary Table I.S.5, Table I.S.6 and Figure I.S.1 to Figure I.S.4 also report z-tests comparing the prevalence of chronic diseases between men and women within each socio-occupational category, and between different socio-occupational categories among men and women.

Several gender differences in the prevalence of chronic diseases observed in the general population (Table I. 1) remained consistently observed within socio-occupational categories. This was particularly the case for MSD and depression, which remained significantly more common among women in most occupational categories, and for diabetes and CVD, which continued to be more frequently reported among men in the manual, skilled, and highly skilled categories (these patterns persisted after age

standardization). For the case of NDD and macular degeneration, weighted estimates showed that NDD were more prevalent among women in the categories of farmers, clerical workers, and those not employed, while macular degeneration was more prevalent among women within the category not employed and among manual workers. After accounting for the different age distributions across gender, significant gender gaps in the prevalence of NDD and macular degeneration remained only in the group of individuals not employed. This suggests that the gender differences observed among farmers, clerical workers, and manual workers were largely explained by the older age of women, while among the category "Not employed", the higher prevalence of NDD and macular degeneration among women could not be attributed to age differences. The prevalence of kidney disease and cancer did not differ significantly between men and women in any socio-occupational category, except among clerical workers, where cancer prevalence was significantly higher among women than men (5.5% vs. 2.1%, $p < 0.05$), a difference that also remained after age standardization.

As for socio-occupational differences, clear gradients were detected in the prevalence of various chronic diseases (with the exception of cancer and kidney diseases), and many were common to both women and men: these gradients were clear when comparing the categories of farmers, manual and highly skilled workers. Highly skilled workers consistently reported lower prevalence of most chronic diseases compared with manual workers and farmers. For instance, CVD were less prevalent among the highly skilled compared with both manual workers and farmers, a pattern that persisted after age standardization. Diabetes were more prevalent among manual workers compared with the highly skilled, and MSD were more prevalent among farmers compared with the highly skilled (both consistent with age-standardized estimates). Among men, an additional gradient in MSD prevalence was observed between manual and highly skilled workers, which also remained after age standardization.

Other gradients were more gender-specific. Among women, there were detected differences in the prevalence of diseases between the groups "Not employed", the self-employed and the highly skilled. Women who had not been employed had higher prevalence of NDD and depression compared with the self-employed (results that

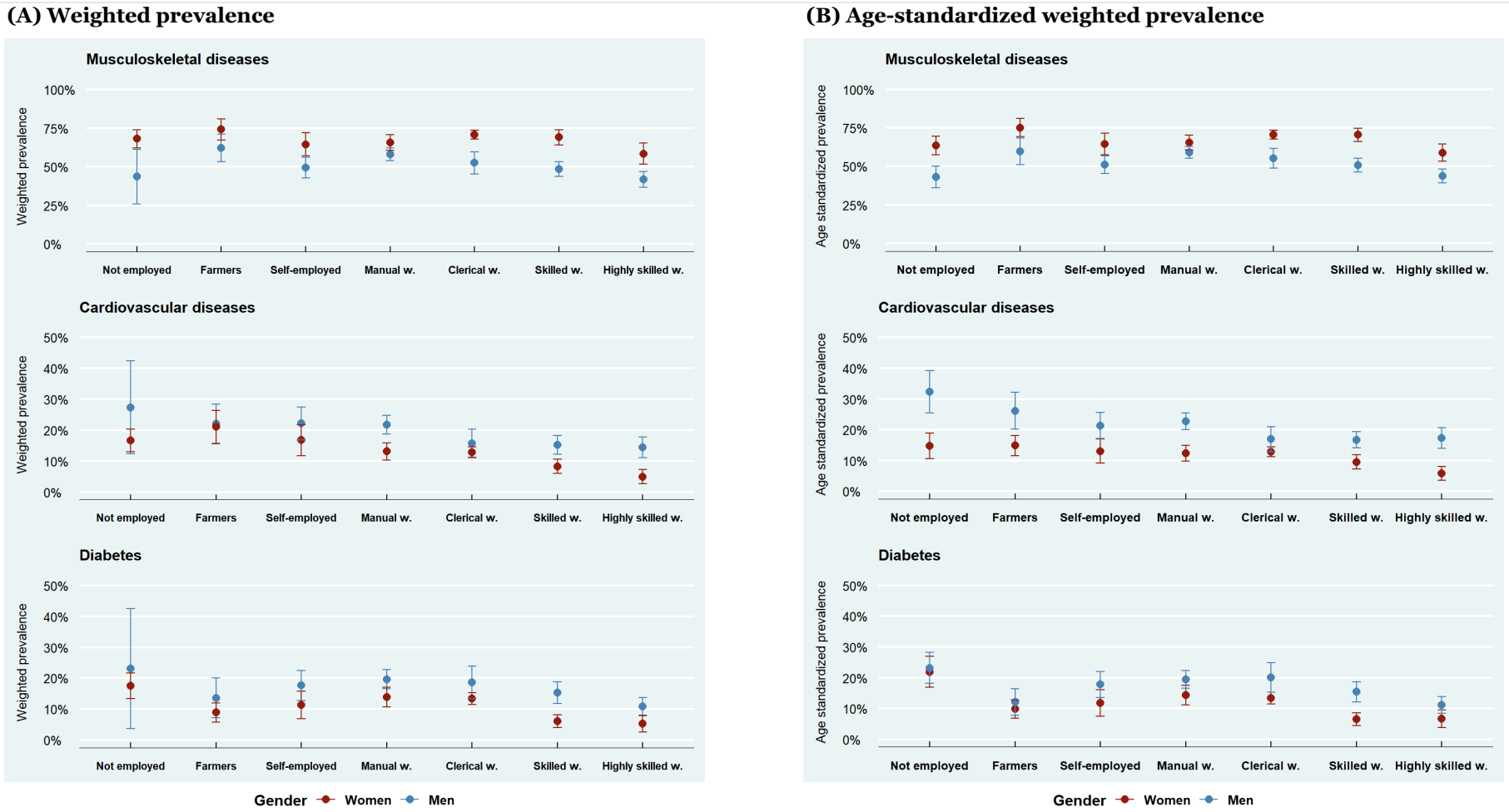
remained after age standardization). Besides, the prevalence of CVD, diabetes, and depression were significantly higher among the category not employed compared with the highly skilled, even in age-standardized prevalence, and MSD were significantly higher among women not employed compared to the highly skilled, but this was no longer the case after age-standardization, due to the higher representation of older women among the inactive. Differences also emerged between self-employed women and skilled and highly skilled: Self-employed women also showed higher prevalence of CVD, and diabetes compared with both skilled and highly skilled workers (which also remained after age-standardization).

Among men, self-employed workers reported higher prevalence of MSD and CVD compared with highly skilled workers, and higher prevalence of depression compared with skilled workers, although these patterns did not persist after age standardization. Another distinct pattern among men was detected for cancer: highly skilled workers reported a significantly higher prevalence compared with clerical workers, a difference that remained after age standardization.

Unlike other conditions, social gradients in the prevalence of NDD and macular degeneration were detected in weighted estimates but did were not always consistent with age-standardized estimates, and deserve special attention. Without age standardization, within women, NDD were more prevalent among the "Not employed", farmers, self-employed and clerical workers compared with highly-skilled women, and macular degeneration likewise more prevalent among the not employed, farmers, in addition to manual workers, compared to highly skilled women. After accounting for the older age distributions especially among the "Not employed", farmers, and the self-employed, these differences largely disappeared, suggesting that the higher prevalence of NDD and macular degeneration in these categories was partly explained by their older age structure, particularly among farmers and the category not employed. In contrast, NDD were more prevalent among women who had not been employed compared to self-employed women, a pattern which remained consistent in age-standardized estimates. For men, the detected gradient was for the higher prevalence of NDD among manual workers compared to highly skilled workers, which was also no longer detected in age

standardized prevalence. What remained after age standardization was a higher prevalence of NDD among men who were manual workers compared to men who were clerical workers (this was also observed before).

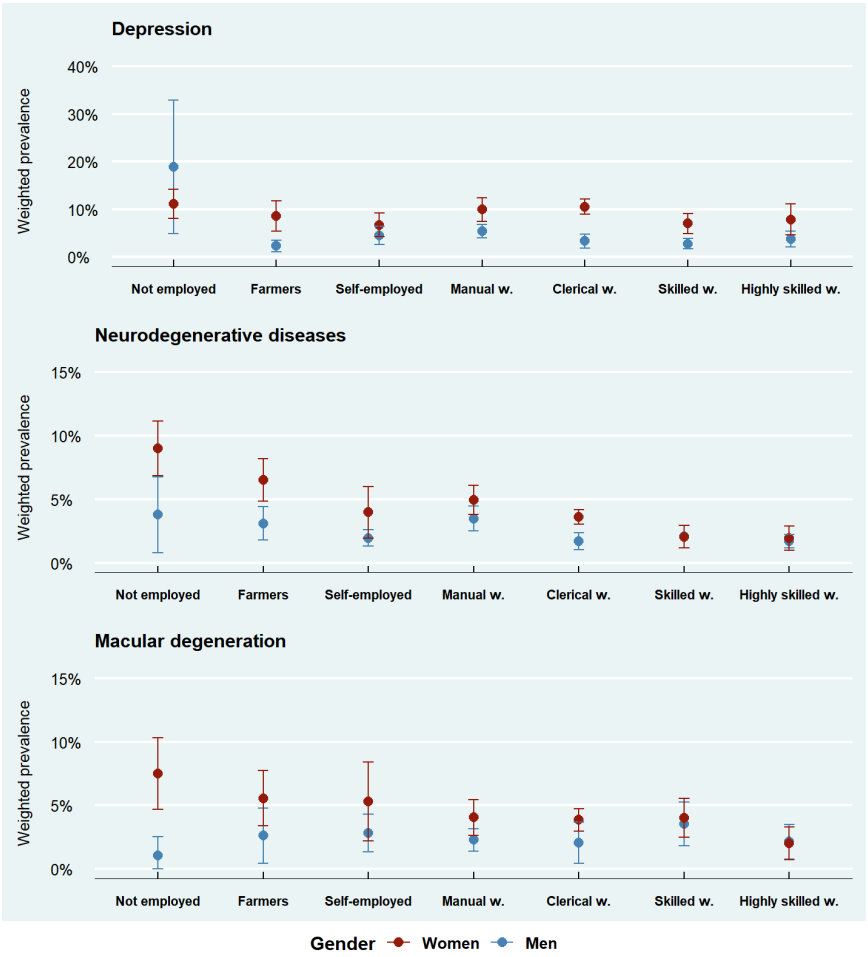
Figure.I.3. Prevalence of chronic diseases, without (A) and with (B) age standardization, with 95% confidence intervals, by gender and socio-occupational group (in merged sample from CARE-I and CARE-M).



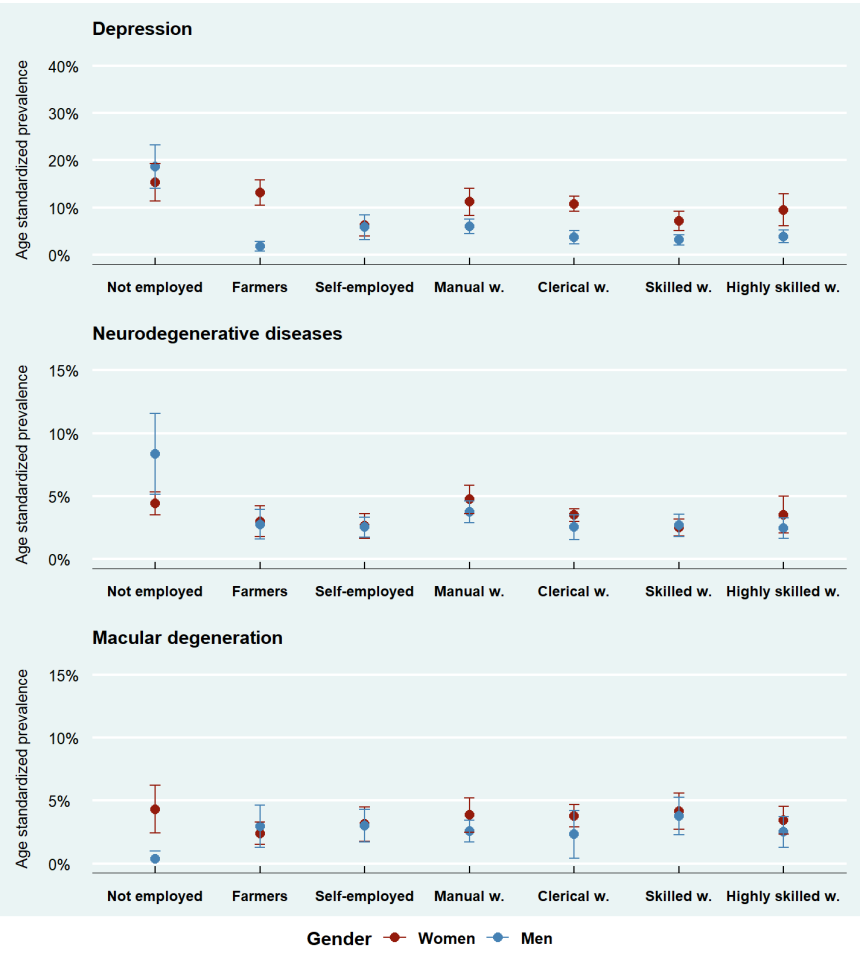
Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates) using the direct standardization method; Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom; Different scales are used for each graph.

Figure.I.3. ***(Continued)*** **Prevalence of chronic diseases, without (A) and with (B) age standardization, with 95% confidence intervals, by gender and socio-occupational group (in merged sample from CARE-I and CARE-M).**

(A) Weighted prevalence



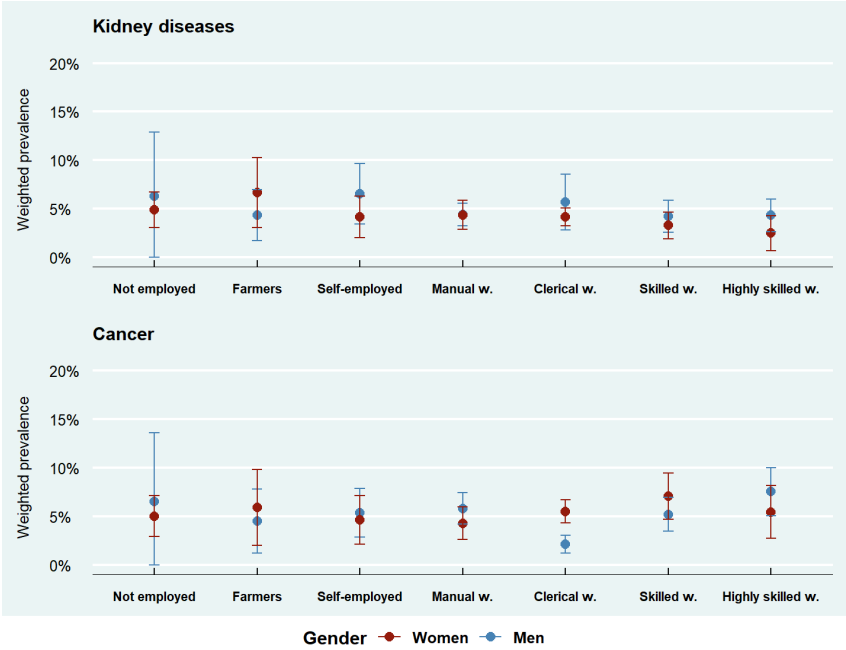
(B) Age-standardized weighted prevalence



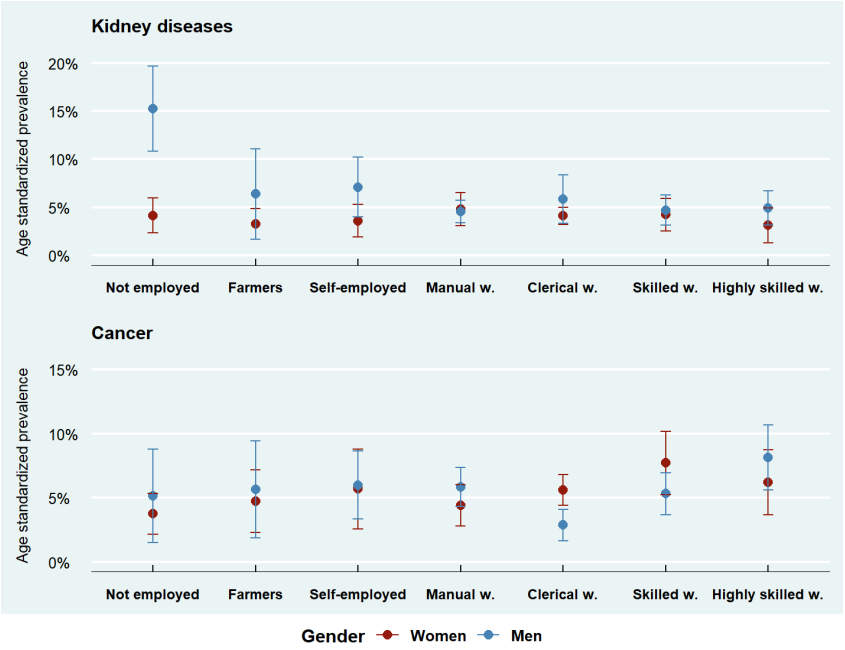
Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates) using the direct standardization method; Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom; Different scales are used for each graph.

Figure.I.3. ***(Continued)*** **Prevalence of chronic diseases without (A) and with (B) age standardization, with 95% confidence intervals in bars, by gender and socio-occupational group (in merged sample from CARE-I and CARE-M).**

(A) Weighted prevalence



(B) Age standardized weighted prevalence



Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates); Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom; Different scales are used for each graph.

IV. 3 Estimations from additive regression models (I): Disabling impacts of chronic diseases.

Estimated disabling impacts of chronic diseases based on additive regression models for the general population and by gender and socio-occupational groups are displayed in Figure.I.4 and Figure.I.5, with detailed coefficients reported in supplementary Table I.S.7 and Table I.S.8. Disabling impacts represent the estimated coefficients that proxy the associations between each group of chronic diseases and AL, accounting for comorbidities and for "background" factors such as age distributions, and other diseases not explicitly stated. In the fitted models' specification, the disabling impact of each disease can be interpreted as the disease-specific cumulative hazard rate of AL. They are used to estimate probabilities of AL for different profiles of comorbidities[5], that is done through a transformation using the exponential function as described in Methods (Section III.2. a). Cumulative hazard rated of AL assigned to the "Background" component across socio-occupational groups are additionally reported in Tables S.7 and S.8.

IV. 3. a. Estimated disabling impact of chronic diseases among men and women.

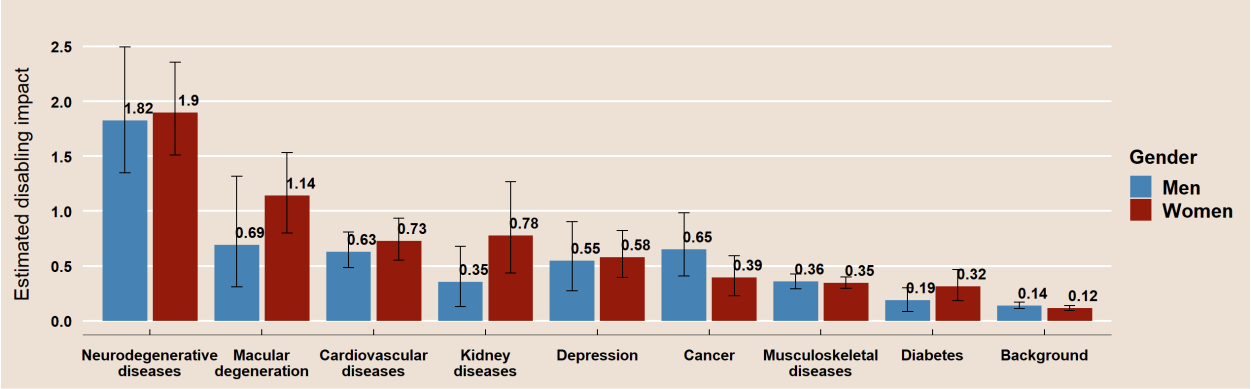
Results displayed in Figure.I.4 show that NDD and macular degeneration had the largest estimated disabling impacts for both women and men. For instance, the probabilities of reporting AL for women who only reported NDD or macular degeneration were estimated to be 86.7% and 71.6%, respectively[6]. Amon men, the probabilities of reporting AL when diagnosed with only NDD or macular degeneration were 85.9% and 56.4% respectively. In regards to other diseases, among women, kidney disease ranked third followed by CVD fourth, while among men, cancer ranked third, followed by CVD. Disabling impacts were consistently higher among women than men for all diseases except cancer ($\widehat{\beta}_{Cancer}$ = 0.65

[5] The estimated probabilities are not given here since there are 8 group of diseases and thus a total of 2^8 different possible profiles of diseases and comorbidities for men and women. Calculation of probabilities as illustration purposes are detailed for specific cases.

[6] For women who only reported NDD, the probability of AL was calculated following these steps: 1- Sum of cumulative hazard of AL for background (=0.12) + disabling impact attributed to NDD (=1.9); 2- Transformation with exponential function: 1 – exp(-2.02) = 0.867.

in men versus $\widehat{\beta}_{Cancer}$= 0.39 in women). However, none of the gender contrasts reached statistical significance at the 5% level. Notably, estimates of disabling impact of MSD were the most similar between women and men.

Figure.I.4. Estimated disabling impacts of chronic diseases, from additive regression models, with 95% confidence intervals, among men and women in merged sample from CARE-M and CARE-I.



Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Estimated disabling impacts represent the disease specific cumulative rate of AL estimated from the fitted binomial additive regression models, with the use of survey weights; 95% confidence intervals are based on 1000 bootstrapping simulations; Different scales are used for each group of diseases.

IV. 3. b. Estimated disabling impact of chronic diseases across gender and socio-occupational groups.

Estimations shown in Figure.I.5 show that within different socio-occupational groups most diseases consistently had higher, however not statistically significant, disabling impacts among women, except in two cases being: diabetes within clerical workers ($\widehat{\beta}_{diabetes}$ = 0.05 among women, and $\widehat{\beta}_{diabetes}$ = -0.03 among men, p<0.05) and kidney disease within the self-employed ($\widehat{\beta}_{kidney\ diseases}$ = 4.28 among women versus 0.14 among men, p<0.01). For other diseases, higher estimated disabling impacts for men compared with women were observed in selected categories. This was the case of NDD among skilled workers, macular degeneration among manual workers, CVD among farmers, depression and cancer among clerical workers, and MSD in all categories except

the skilled and highly skilled Nevertheless, none of these contrasts reached statistical significance[7].

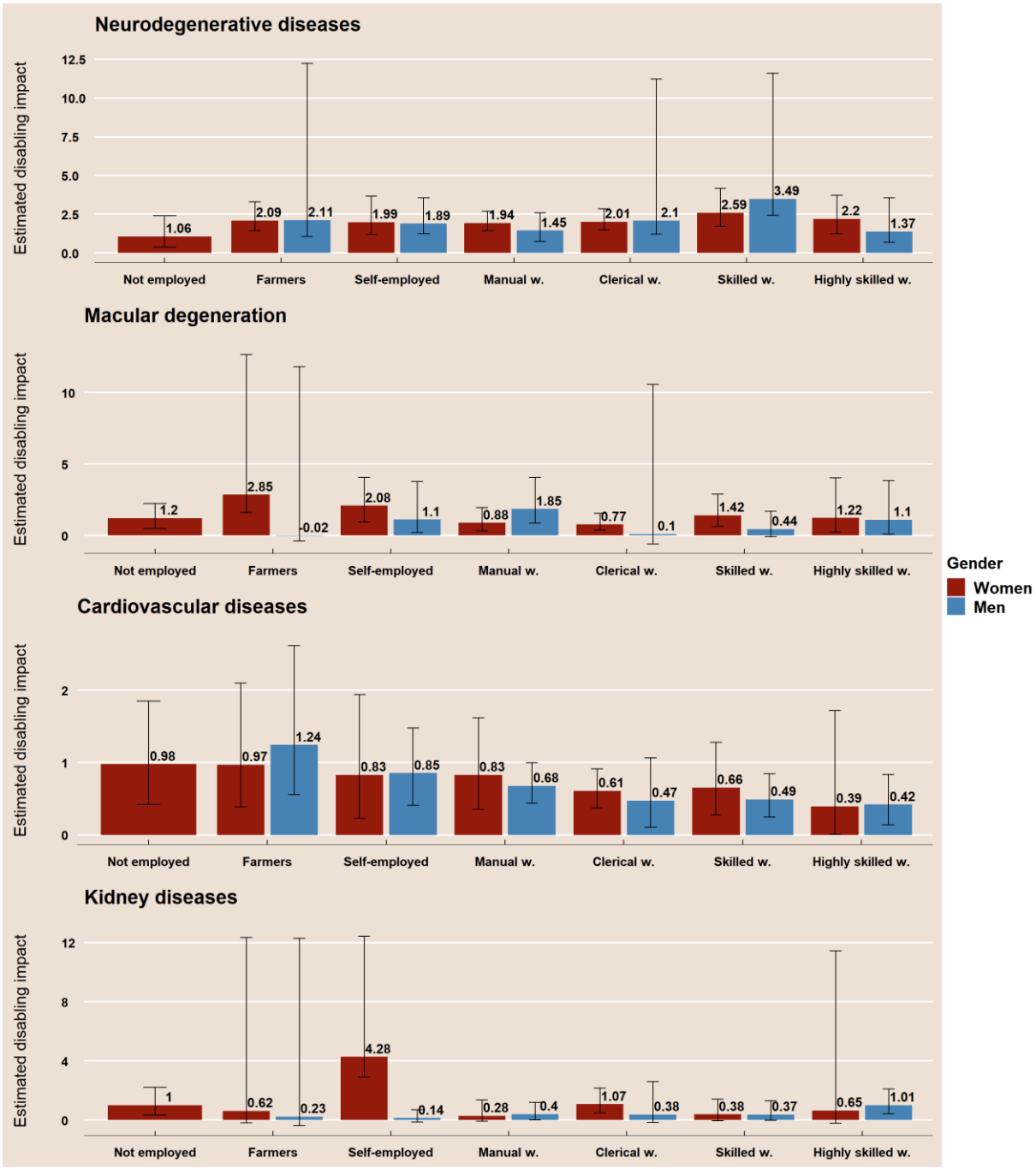
Across socio-occupational groups, NDD and macular degeneration generally had the highest disabling impacts, with the exception of self-employed women, for whom kidney diseases ranked first. Overall, between-category differences were limited, with only a few statistically significant contrasts. Nevertheless, for several diseases, there was a detected social gradient in estimated disabling impacts, which mirrored the social gradient in prevalence estimates. For both genders, the association of CVD with AL was lower among the highly skilled compared with manual workers, the self-employed, and farmers (and, for women, also compared with the not employed group). Among women, farmers also exhibited higher disabling impacts of macular degeneration, kidney diseases, and cancer, compared to the highly skilled. Among men, NDD impacts were higher among farmers, the self-employed, and manual workers than among the highly skilled.
Conversely, other patterns diverged from prevalence gradients. For instance, for both women and men, depression and kidney disease showed stronger associations with AL among the highly skilled compared with manual workers. Among women, higher disabling impacts in the highly skilled compared with manual workers were also observed for NDD, macular degeneration, and diabetes. Among men, macular degeneration and cancer were more associated with AL among farmers than among the highly skilled, while among women the association of MSD was more important in farmers than the highly skilled.

Beyond these descriptive differences, only two between-category differences reached statistical significance, both among women. This was the case of diabetes that had a stronger disabling impact among clerical workers compared with manual workers ($\widehat{\beta}_{diabetes}$ = 0.36, and 0.05, for manual and clerical workers, respectively; z= 2.24 and p = 0.025), and cancer had a higher disabling impact among clerical workers compared with skilled workers ($\widehat{\beta}_{Cancer}$ = 0.56, and 0.15, for clerical and skilled workers,

[7] Results from z-scores are not presented, as only the mentioned cases reached statistical significance. They are however available upon request.

respectively; p = 0.025). The lack of statistically significant differences in the disabling impacts of diseases across gender and socio-occupational groups largely reflected the wide 95% confidence intervals around several estimates. In many cases, this likely resulted from small sample sizes and the low prevalence of some conditions (Type II error; Bland, 2015), like the case of kidney diseases among farmers.

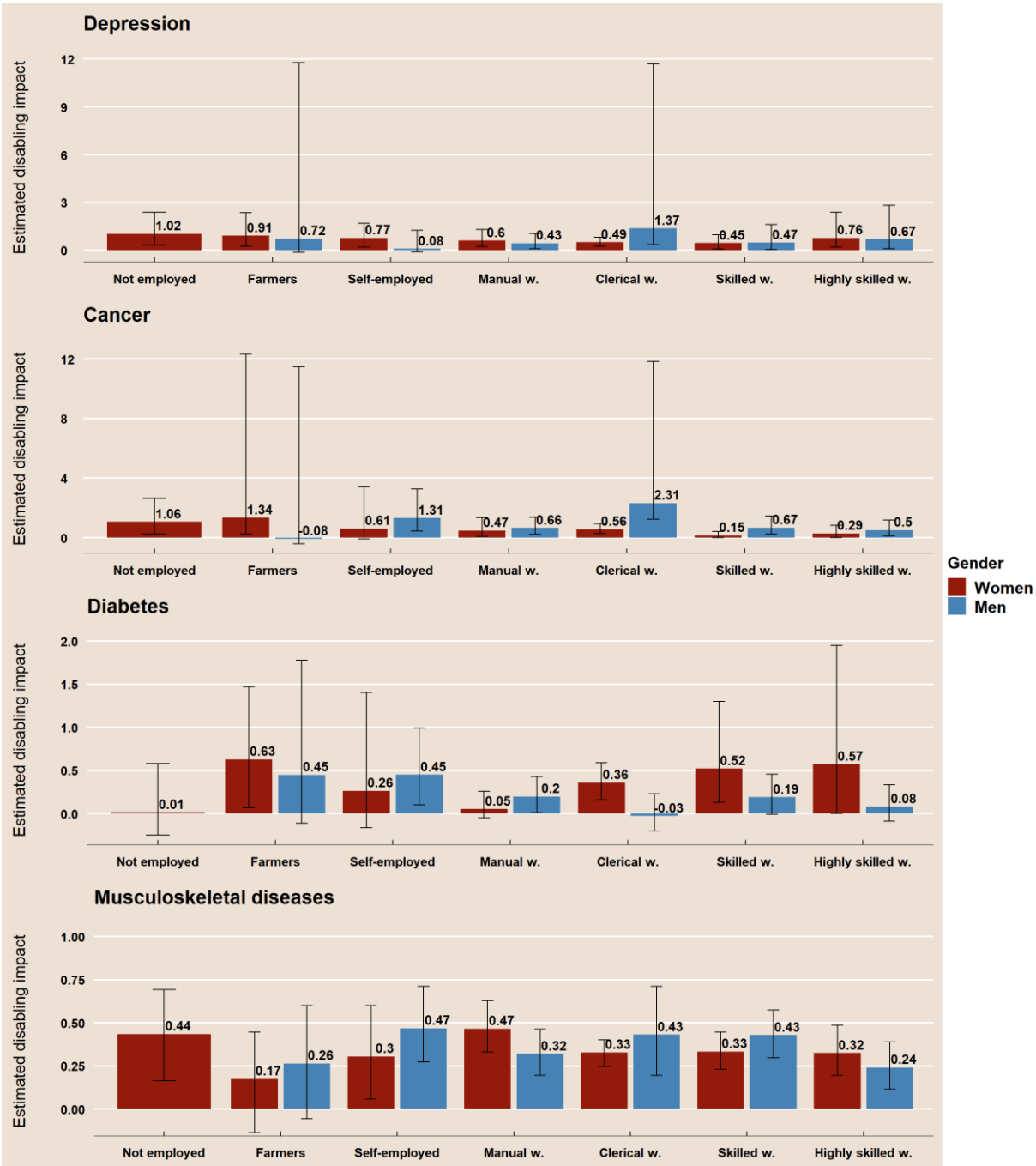
Figure.I.5. Estimated disabling impacts of chronic diseases with 95% confidence intervals, across gender and socio-occupational categories (in merged sample from CARE-M and CARE-I).



Source: Respondents aged 60 and over, except men not employed , from CARE-M (2015, N = 10,523) and CARE-I (2016, N = 2,928)

Notes: Estimated disabling impacts represent the cumulative rate of AL estimated from the fitted binomial additive regression models, with the use of survey weights; 95% confidence intervals are based on 1000 bootstrapping simulations; Different scales are used for each group of diseases.

Figure.I.5. ***(Continued)*** **Estimated disabling impacts of chronic diseases with 95% confidence intervals, across gender and socio-occupational categories (in merged sample from CARE-M and CARE-I).**



Source: Respondents aged 60 and over, except not employed men, from CARE-M (2015, N = 10,523) and CARE-I (2016, N = 2,928).

Notes: Estimated disabling impacts represent the cumulative rate of AL estimated from the fitted binomial additive regression models, with the use of survey weights; 95% confidence intervals are based on 1000 bootstrapping simulations; Different scales are used for each group of diseases.

IV. 4 Estimations from additive regression models (II): Attribution of chronic diseases to AL in CARE.

Building on the weighted prevalence of chronic diseases and their disabling impacts estimated with additive regression models, absolute contributions (AC) were computed by combining disease prevalence with the corresponding disabling impacts (as discussed in methods, section III.2. b). AC decompose the overall prevalence of AL into disease-specific components that sum to total AL prevalence. Relative contributions (RC) then express the share of AL prevalence attributable to each disease (that is, RC = AC / total AL prevalence).

IV. 4. a. Contributions of chronic diseases to AL prevalence among men and women.

Figure.I.6 displays the AC (panel A) and RC (panel B) of chronic diseases of interest along with the "background" component, in the 60+ population in CARE (Detailed in Table I.S.9 in supplementary materials). Model-based estimates of AL prevalence align with the present weighted estimates: 42.5% among women and 39.1% among men, with a significantly higher prevalence among women.

For both men and women, MSD and CVD were the leading contributors, together explaining around 50% of AL prevalence, which primarily reflected their higher prevalence relative to other conditions. NDD and macular degeneration exhibited the largest disabling impacts but, due to low prevalence, each explained less than 7% (together less than 12%) of AL prevalence for both women and men. Gender differences in contributions largely mirrored gender differences in disease prevalence. However, there were two exceptions which connected with differences in disabling impacts, though they were not significant: this was the case of kidney disease which contributed more among women, and cancer contributing more among men. The share attributed to the "background" part revealed that the set of included groups of chronic diseases explained a higher proportion of AL prevalence among women (around 79%), then among men.

Figure.I.6. Absolute (A) and relative (B) contributions of chronic diseases to AL prevalence among men and women (in merged sample from CARE-M and CARE-I).



Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Absolute (AC) and relative contributions (RC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases, which add up to 42.5% for women and 39.1% for men; RC of diseases quantify the percentage of AL prevalence that is attributed to chronic diseases, for instance, 38.9% of the prevalence of AL among women is attributed to musculoskeletal diseases (16.5/42.5).

IV. 4. b. Contributions of chronic diseases to AL prevalence across gender and socio-occupational groups.

Figure.I.7 and Figure.I.8 display the AC and RC of diseases to AL prevalence by gender and socio-occupational group (Detailed in Table I.S.10 and Table I.S.11 of supplementary materials). Figures S.5 and S.6, from supplementary materials, display results of z-statistics on differences in AC of diseases to AL prevalence across socio-occupational groups within men and women. In nearly all groups, CVD and MSD remained the top contributors to AL prevalence, while NDD and macular degeneration, despite their high disabling impacts, accounted for less than 15%. An exception was highly-skilled women, for whom depression contributed more to AL than MSD.

Occupational patterns in contributions to AL.

Across socio-occupational categories, the contributions of several diseases to AL prevalence followed the pattern observed in the general population with MSD and CVD contributing first, and NND and depression coming next. However, the magnitude of the contribution varies across occupational groups, with a contrasting gradient depending on the already observed differences in disease prevalence and, in some cases, in their disabling impacts. For both men and women, CVD contributed more among farmers, manual workers, and the self-employed (as well as the not employed for women) than among the highly-skilled workers. NDD showed a similar pattern, with higher contributions among farmers and manual workers; for men this was reinforced by differences in disabling impacts.

Occupational differences in disease-specific contributions to AL.

MSD had a significantly higher absolute contribution to AL among manual than highly-skilled workers for both men and women, reflecting higher prevalence among the former category. Yet in relative terms, MSD explained a similar share of women's AL among highly-skilled and manual workers, and a higher share of men's AL among highly-skilled workers than farmers. This pattern is explained by the importance of MSD in the scarcer situations of AL in highly-skilled workers, for whom MSD appear more disabling. In the same way, depression had a larger relative contribution in women's AL among the highly-

skilled workers than among the not employed, farmers, and manual workers (yet depression had similar absolute contribution across these groups). Among men, depression contributed relatively more to AL among the highly-skilled workers than among manual workers, despite similar absolute contribution. For other diseases, patterns were more heterogeneous and often gender specific. Diabetes contributed more to men's AL among farmers, the self-employed, and manual workers than among the highly-skilled, consistent with both higher prevalence and disabling impacts. Among women, diabetes contributed least in the not employed group and most among clerical workers. Regarding cancers among men, we found no contribution to AL in farmers and similar contributions across other categories; among women, cancers' contributions were higher in clerical workers, farmers, and the not employed group compared with skilled workers, consistently with differences in disabling impacts. Patterns for macular degeneration also differed by gender. Among women, contributions were higher among farmers and the self-employed than among the highly-skilled. Among men, macular degeneration contributed very little overall, with no detectable contribution among farmers and only 0.3% of AL among clerical workers. Kidney disease followed yet another pattern. Among women, contributions were highest in the self-employed, reflecting the strongest disabling impacts in this group. Among men, in contrast, kidney diseases contributed more among the highly-skilled than among farmers or the self-employed, consistent with the reverse gradient observed for their disabling impacts.

Gender differences in disease- specific contributions to AL within socio-occupational groups.

Several gender differences observed in the overall population were also apparent within occupational groups. CVD contributed more to AL among men, while depression contributed more among women. NDD and macular degeneration also contributed more to women's AL in most categories, with two exceptions: no significant gender difference was detected for NDD among skilled workers, and for macular degeneration among the highly-skilled. Other gender contrasts varied by occupational category and often reflected differences in disabling impacts rather than prevalence. MSD contributed more to men's AL among farmers and the self-employed, whereas no gender difference was detected among clerical workers ($Z=-0.62$; $p=0.49$). Kidney disease contributed more to women's

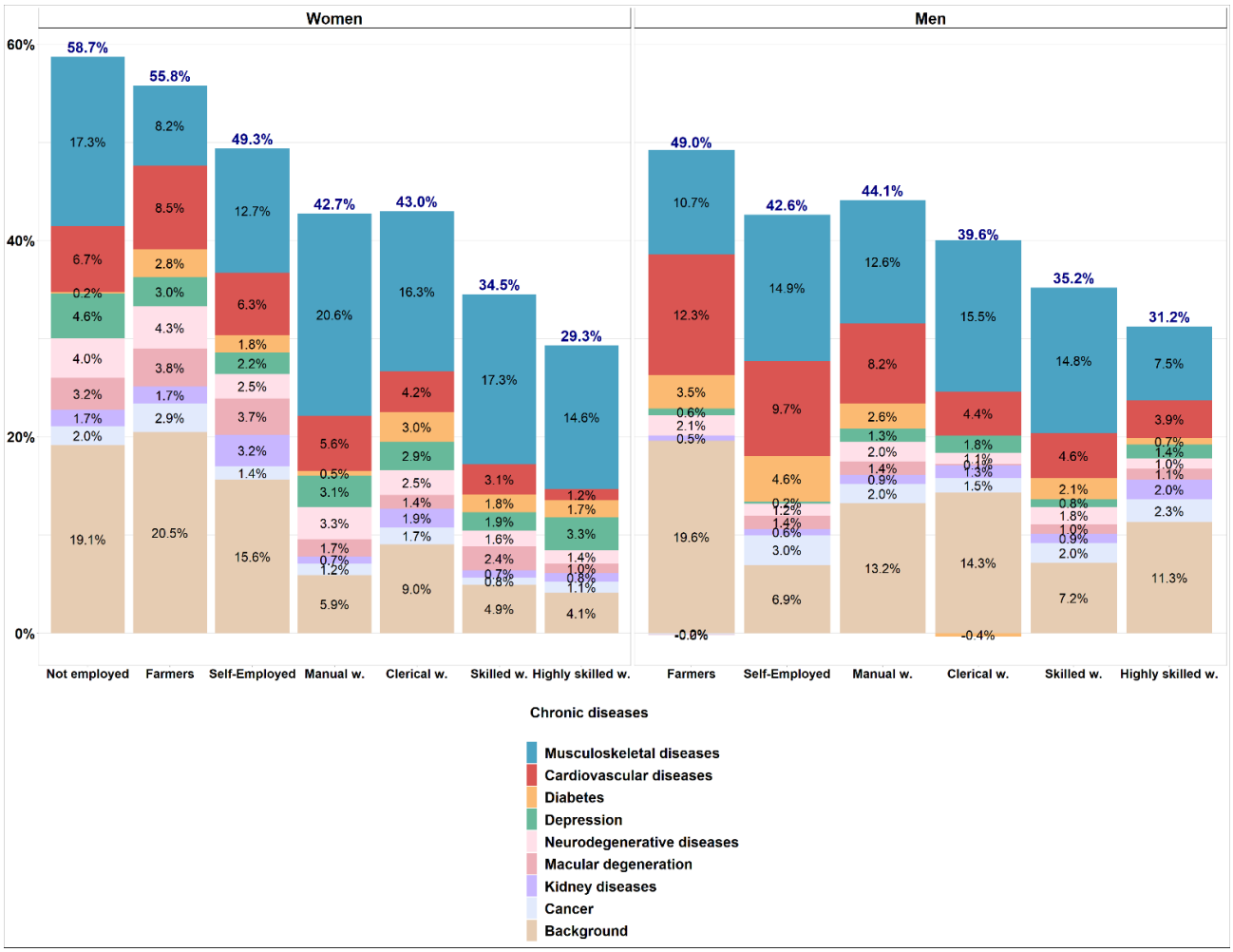
AL among farmers, the self-employed, and clerical workers. Cancer also showed a reversal of gender difference compared to the general population: among farmers, it contributed more to women's AL, reflecting a positive disabling impact in women and no evidence of a positive impact in men. Diabetes, which showed no overall gender difference in the general population, displayed heterogeneous patterns across groups. Its contribution was higher among men's AL in the self-employed and manual categories, reflecting higher prevalence, while it was higher among women in the highly-skilled and clerical categories, reflecting higher disabling impacts. Among clerical workers, diabetes contributed to women's AL and had no contributions among men.

The "background" component.

The background component varied across occupational categories. It was particularly important among farmers, exceeding the combined contributions of MSD and CVD among women and nearly matching them among men (40% versus 46.7%). By contrast, included diseases explained a larger share of AL prevalence among manual, skilled, and highly-skilled women, and among self-employed and skilled men.

Beyond differences across occupational groups, the background component also showed differences between men and women within these categories. Consistent with the general population, the background contribution was higher among men in all categories except for the self-employed, where differences in social characteristics such as education may have played a role (for example, nearly all self-employed women had low educational attainment, unlike men in this group.

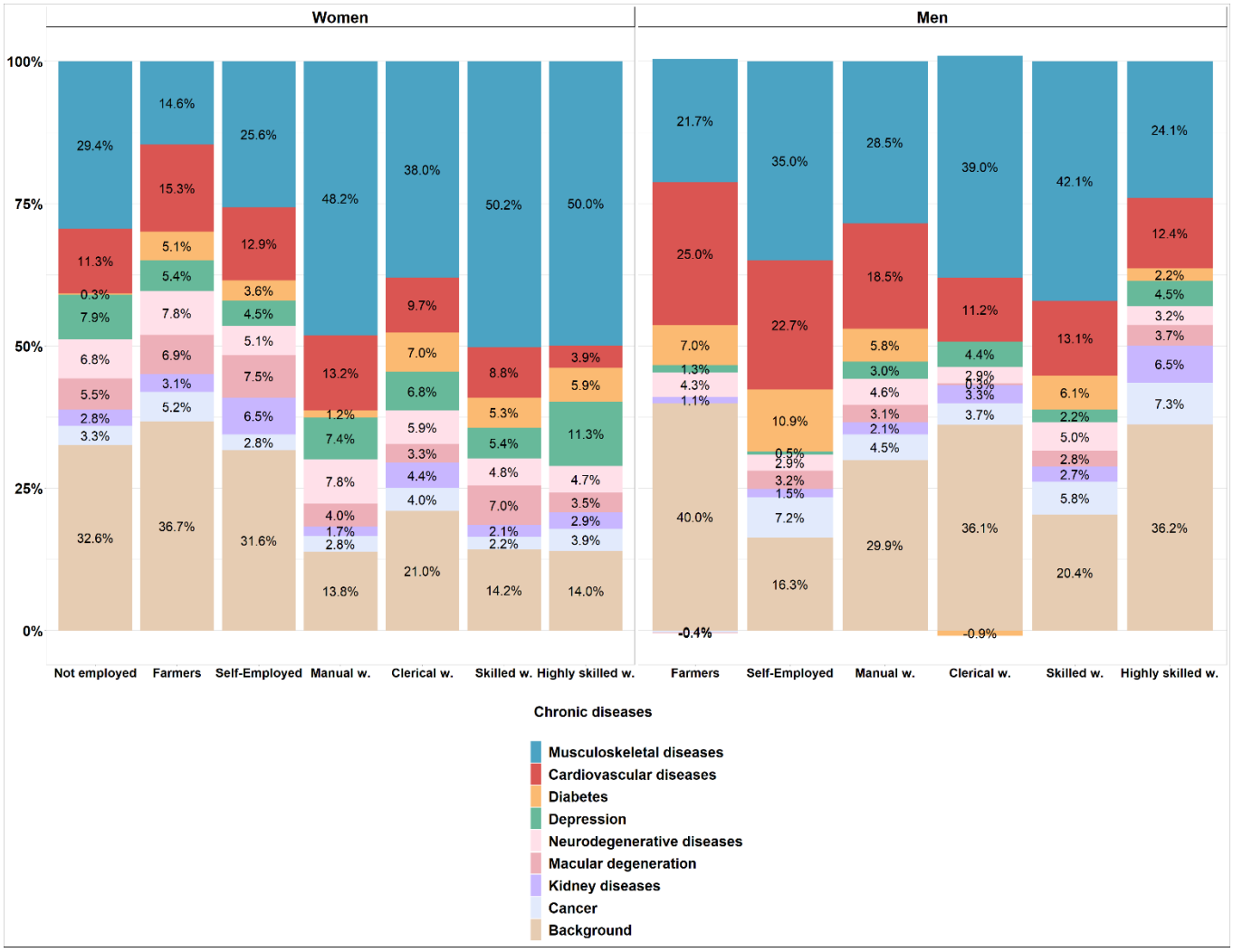
Figure.I.7. Absolute contributions of chronic diseases to AL prevalence across gender and socio-occupational groups (in merged sample from CARE-M and CARE-I).



Source: Respondents aged 60 and over, except the category of "Not employed" for men due to their low representation (N= 105), resulting in a selected sample of 10,523 respondents from CARE-M and 1928 respondents from CARE-I.

Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases, which add up to, for example, 58.7% for not employed women and 49% for men who are farmers; Within men, there is no positive AC of macular degeneration or cancer to AL prevalence among farmers, and no positive AC of diabetes among clerical workers, which results from the lack of evidence on a positive disabling impact of these conditions in the mentioned categories; Results of z-scores and p-values on gender and social differences are available in Supplementary materials, as they are not displayed here for graphs

Figure.I.8. Relative contributions of chronic diseases to AL prevalence across gender and socio-occupational groups (in merged sample from CARE-M and CARE-I).



Source: Respondents aged 60 and over, except the category of "Not employed" for men due to their low representation (N= 105), resulting in a selected sample of 10,523 respondents from CARE-M and 1928 respondents from CARE-I.
Notes: Relative contributions (RC) of diseases represent the ratio of estimated absolute contributions (AC), based on estimated disabling impacts and prevalence of diseases, to AL prevalence; For example, 29.4% of AL prevalence among inactive women is attributed to musculoskeletal diseases (17.3/58.7). Within men, there is no positive RC of macular degeneration or cancer to AL prevalence among farmers, and no positive RC of diabetes among clerical workers, which results from the lack of evidence on a positive disabling impact of these conditions in the mentioned categories.

IV. 5 Decomposition of differences in AL prevalence.

Building on the attribution analysis, the decomposition of differences in AL prevalence was applied to assess how disparities in the distribution and disabling impact of chronic diseases contributed to differences in AL prevalence. This method complements the previous results by disentangling whether inequalities in AL were primarily driven by higher disease prevalence or by stronger associations between diseases and AL. The decomposition further adjusts for age, highest educational attainment, geographical origin, marital status, thereby accounting for both different distributions across groups and their varying relationships with AL.

The analysis was first applied to gender differences in the overall 60+ population, where significant disparities in AL prevalence were observed. Next, socio-occupational differences within men and women were also examined, with a focus on the gradients highlighted earlier: the higher prevalence of AL among farmers and manual workers compared with the highly-skilled for both genders, and the higher prevalence among women in the "Not employed" category compared with their highly-skilled counterparts. Decomposition of gender differences within specific socio-occupational groups is not presented, as no significant gender differences in AL prevalence were previously detected among groups.

The distribution of social variables across socio-occupational groups previously revealed a strong correlation between highest educational attainment and socio-occupational status (Table I. 3, Table I. 4,). For instance, fewer than 2% of manual workers held an undergraduate or graduate diploma, compared to over 40% among the highly skilled. For this reason, highest educational attainment was not included as a control variable in the set of analyses on decomposition of differences in AL prevalence between socio-occupational groups. Moreover, to ensure sufficient category sizes and avoid estimation errors for these analysis, geographical origin along with marital status were recoded into binary variables: geographical origin classified as "French origins" versus "other" and marital status as "in a civil union" versus "other". Age categories were also regrouped into : "60-79", "80-89", and "90+".

IV. 5. 1. Decomposition of differences in AL prevalence between women and men in CARE.

Table I. 5 and Table I. 6, along with Table I.S.13 in Supplementary materials, present results from the decomposition analysis of gender differences in AL prevalence, controlling for age, highest educational attainment, geographical origin and marital status. To ensure sufficient observations within each group, individuals with a high school diploma and those with a vocational certificate were combined into one category, and those with undergraduate and graduate degrees into another. Besides, geographical origin was turned into a binary variable and classified as "French origins" versus "other". Respondents with missing values in the control variables (N = 435) were excluded, leaving 13,116 individuals (8,364 women and 4,752 men) in the analysis. Weighted prevalence estimates of AL in this subsample differed slightly from those in the full population, but the gender gap in AL prevalence remained statistically significant at the 5% level: 41.99% among women compared with 38.96% among men ($p < 0.01$). Moreover, the distributions of social variables across women and men in this restricted sample were consistent with the patterns observed in the full population.

Estimated average marginal effects (AMEs) from the fitted logistic regressions (Table I. 5) confirm that all included diseases were positively associated with AL for both genders, with NDD showing the strongest association (AME= 0.45 for women and AME= 0.47 for men). Regarding social variables, there were no detected significant associations between educational attainment and AL neither among men nor among women. For women, being of French origin decreased likelihood of declaring AL compared to foreigners from other countries (AME= -0.07, $p<0.01$). Further confirmed by results of Table I. 6, there was no significant gender difference in the associations between any disease and AL, consistent with results from the additive regression models. While not being significantly different across gender, it is worthy to note that the estimated AME of cancer on the likelihood of reporting AL was slightly higher among men than among women (AME=0.22 for men, and AME=0.20), which was also consistent with results from the additive regression models.

Table I. 5. Estimated average marginal effects (AMEs) of variables of interest on likelihood of AL, based on fitted logistic regressions across men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women	**Men**
Chronic diseases.		
Musculoskeletal diseases	**0.22***** (0.19, 0.26)	**0.19***** (0.16, 0.23)
Cardiovascular diseases	**0.20***** (0.15, 0.25)	**0.22***** (0.18, 0.27)
Diabetes	**0.14***** (0.09, 0.18)	**0.10***** (0.05, 0.15)
Kidney diseases	**0.23***** (0.14, 0.31)	**0.13***** (0.04, 0.22)
Neurodegenerative diseases	**0.45***** (0.35, 0.55)	**0.47***** (0.33, 0.61)
Depression	**0.22***** (0.16, 0.27)	**0.21***** (0.11, 0.30)
Macular degeneration	**0.27***** (0.18, 0.37)	**0.20***** (0.07, 0.33)
Cancer	**0.16***** (0.09, 0.24)	**0.26***** (0.17, 0.35)
Educational attainment. *Reference modality: "No diploma"*		
High school diploma or vocational certificate	-0.03 (-0.06, 0.01)	-0.01 (-0.06, 0.03)
Undergraduate or graduate studies	-0.05 (-0.11, 0.01)	-0.03 (-0.09, 0.03)
Marital status. *Reference modality: "In a civil union"*		
Divorced	0.05 (0.00, 0.10)	0.02 (-0.04, 0.08)
Widow (er)	0.03 (-0.01, 0.07)	0.05 (-0.01, 0.11)
Never in a civil union	**0.07*** (0.01, 0.13)	0.03 (-0.04, 0.11)
Age category. *Reference modality: "Age group: 60-69"*		
70-79	**0.06**** (0.03, 0.10)	0.03 (-0.02, 0.07)
80-89	**0.16***** (0.12, 0.20)	0.19 (0.14, 0.24)
90+	**0.34***** (0.27, 0.40)	0.36 (0.24, 0.49)
French origin.	**-0.07**** (-0.12, -0.02)	-0.01 (-0.06, 0.04)
Number of observations	N= 8364	N = 4752

Source: Respondents aged 60 and over with complete data on variables of interest, from CARE-M (2015, N = 10592) and CARE-I (2016, N = 2524).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I. 6. Breakdown of gender differences in AL prevalence, based on decomposition analysis (in merged sample with no missing data from CARE-M and CARE-I).

	Difference in AL prevalence (Women -Men) = 3.032 percentage points	
	Decomposition due to distributions	**Decomposition due to intensities**
Chronic diseases.		
Musculoskeletal diseases	**+3.78*****	+1.52
Cardiovascular diseases	**-1.17*****	-0.28
Diabetes	**-0.63*****	+0.60
Kidney diseases	**-0.15*****	+0.41
Neurodegenerative diseases	**+0.55*****	-0.03
Depression	**+1.08*****	+0.05
Macular degeneration	**+0.43*****	+0.18
Cancers	**-0.003*****	-0.44
Educational attainment. *Reference modality: "No diploma"*		
High school diploma or vocational certificate	+0.07	-0.46
Undergraduate or graduate studies	+0.30	-0.30
Marital status. *Reference modality: "In a civil union"*		
Divorced	+0.19	+0.25
Widow(er)	+0.61	-0.04
Never in a civil union	**-0.09***	+0.13
Age category. *Reference modality: "Age group: 60-69"*		
70-79	**-0.22*****	+1.09
80-89	**+0.88*****	-0.32
90+	**+1.15*****	-0.05
French origins.	**+0.15****	-4.9
Residual unexplained components		-1.25

Source: Respondents aged 60 and over with complete data on variables of interest, from CARE-M (2015, N = 10592) and CARE-I (2016, N = 2524).
General notes: The decomposition analysis follows the nonlinear extension of the Oaxaca-Blinder method (Blinder, 1973; Oaxaca, 1973) proposed by (Yun, 2004, 2008), implemented using R function adapted by Powers (Powers et al., 2011). Standard errors are obtained via the delta method (Yun, 2005). Stars denote significance: *p<0.05; **p<0.01; ***p<0.001.
Reading notes: Differences in the distribution of musculoskeletal diseases (MSD) between women and men significantly contributes with 3.84 percentage points to the gender gap in AL prevalence. Gender differences in the intensity of the association between MSD and AL contribute by an additional 1.54 percentage points, although this contribution is not statistically significant.

The contribution of the differences in distributions of chronic diseases to the gender gap in AL was statistically significant at the 5% level across all diseases (Table I. 6). This indicates that gender differences in AL prevalence were primarily driven by differences in disease prevalence, rather than differences in the associations of diseases with AL. In line with previous results from the attribution method, the prevalence of MSD, depression, NDD, and macular degeneration were significantly higher among women, positively contributing to the gender gap in AL. MSD, in particular, accounted for the largest share of this gap (3.78 out of 3.032 percentage points), exceeding the combined contribution of the other conditions. Therefore, MSD are not only the conditions that contribute the most to the reporting of AL, as demonstrated in results from the attribution method, but also the main drivers of gender differences in AL. Depression was previously found to be the third contributing condition to AL in women (4th one in men), and here we found that it is the second driver of gender differences in AL prevalence (with the higher prevalence of depression accounting for 1.08 percentage points of the gender gap in AL).

Conversely, CVD which are the second largest AL contributing conditions, as shown in the previous sections, and diabetes, were more prevalent among men, and therefore contributed negatively to the gender gap in AL, reducing it by approximately half. This suggests that a lower prevalence of CVD and diabetes would reduce AL prevalence for both women and men, but the reduction would be larger among men, thereby widening the gender gap in AL. Kidney diseases and cancers, which did not significantly differ in prevalence across gender (previously shown in Table I. 1), also contributed negatively to the gender gap in AL, although to a lesser extent.

The decomposition of the gender differences in AL prevalence brings new findings: whereas the attribution method showed the magnitude of contribution of each disease to AL within women and within men, the decomposition shows how these diseases contribute to the difference in AL prevalence between women and men, once accounting for age and social characteristics. Indeed, apart from diseases, the difference in age distribution between women and men had an important contribution to the gender gap in AL prevalence in the general population, a result that was consistent with the observed different gaps in weighted and age-standardized prevalence discussed earlier. The older

age distribution among women accounted for more than half of the observed difference (59.7%) in AL prevalence. This result connects with the earlier finding that while women still reported a higher prevalence of AL than men after age standardization in the general population, this difference was no longer statistically significant at the 5% level. In regards to social controls, differences in educational attainment between men and women had no significant contribution to the observed gap in AL. Regarding geographical origin, French individuals represented 87.81% of men and 87.63% of women, with this slightly higher proportion among men positively contributing to the gender gap in AL prevalence by 0.15 percentage points. Conversely, the higher proportion of men falling in the "never in a civil union" category (11% versus 8% among women), reduced the gender gap in AL by 0.09 percentage points.

IV. 5. 2. Decomposition of differences in AL prevalence between manual and highly skilled workers.

The decomposition method was also applied to analyze occupational differences in AL. The selected sample for this analysis included respondents who were manual and highly skilled workers, excluding those with missing observations in the variables of interest This resulted in a subsample of 4,249 individuals (1,824 women and 2,425 men). Results from the decomposition analysis of the difference in AL prevalence between manual and highly skilled workers are presented in Table I. 7 and Table I. 8, in addition to Table I.S.14 in Supplementary materials.

For women, the difference in AL prevalence between manual and highly skilled workers amounted to 13.27 percentage points (42.42% for manual workers and 31.05% for the highly skilled, $p < 0.01$). A substantial share of the gap was explained by the higher prevalence of MSD, CVD, and NDD among manual workers, which together accounted for approximately half of the observed difference. In contrast, diabetes and kidney diseases, did not significantly contribute to the gap (all $p>0.1$): results from logistic regressions showed that associations between diabetes and kidney diseases with AL were not significant at the 5% level within manual workers. Cancers contributed negatively to the gap in AL prevalence. Specifically, under a counterfactual scenario of equal cancers

prevalence across groups, the gap would have increased by 0.22 percentage points. The older age distribution of manual workers (ages 80+) explained 2.82 percentage points of the gap (21%), exceeding the individual contribution of all diseases. Beyond age, among social factors, being in a civil union had a negative association with AL (AME= -0.09, p=0.04) within manual workers. The lower proportion of individuals in a civil union in this category accounted for 0.19 percentage points of the gap in AL prevalence with highly skilled workers (1.3%).

For the case of men, the difference in AL prevalence between manual and highly skilled workers was 13.02 percentage points (44.07% for manual workers and 29.15% for the highly skilled, $p<0.01$). As with the case of women, MSD and CVD were the largest contributors, with their higher prevalence among manual workers explaining an important share of the gap (36%). Nonetheless, several patterns diverged from those observed among women. Within men, diabetes was positively associated with AL among manual workers and accounted for 7% of the gap in AL with the highly skilled, which is slightly equivalent to the contributions of NDD and depression, conditions that played a more prominent role among women. As with the case of women, cancers had a negative contribution to the gap in AL, however, the contribution was larger in magnitude than that of depression within men. In regards to age distributions, the higher proportion of 80+ individuals among manual workers explained 7% of the gap in AL prevalence across categories within men, which was a relatively smaller contribution compared to women (21%).

Overall, these results show that MSD are the main candidates for targeted prevention: Lowering the prevalence of MSD would lead reduce risks of AL in older ages for both men and women, and manual and highly skilled workers. In addition, lowering the prevalence of MSD would promote opportunities of reducing disparities in AL prevalence between manual and highly skilled workers. A decrease in the prevalence of CVD would also reduce unequal chances of healthy aging between manual workers and highly skilled ones, for both men and women.

Table I. 7. Estimated average marginal effects (AMEs) of variables of interest on likelihood of AL, based on fitted logistic regressions across manual and highly skilled workers within men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Manual	**Highly skilled**	**Manual**	**Highly skilled**
Chronic diseases.				
Musculoskeletal diseases	**0.31***** (0.23, 0.39)	**0.31** *** (0.20, 0.42)	**0.17***** (0.11, 0.24)	**0.12**** (0.04, 0.20)
Cardiovascular diseases	**0.30***** (0.18, 0.43)	**0.20*** (0.02, 0.37)	**0.25***** (0.17, 0.32)	**0.18***** (0.09, 0.28)
Diabetes	0.02 (-0.07, 0.11)	**0.28*** (0.03, 0.54)	**0.10*** (0.02, 0.19)	0.07 (-0.04, 0.17)
Kidney diseases	0.11 (-0.05, 0.26)	0.17 (-0.11, 0.46)	0.14 (-0.01, 0.30)	**0.27***** (0.12, 0.42)
Neurodegenerative diseases	**0.46***** (0.34, 0.57)	**0.57***** (0.35, 0.79)	**0.41***** (0.19, 0.63)	**0.33***** (0.11, 0.55)
Depression	**0.17**** (0.05, 0.29)	**0.32***** (0.17, 0.45)	**0.17*** (0.01, 0.32)	**0.27**** (0.08, 0.47)
Macular degeneration	**0.22**** (0.07, 0.37)	0.23 (-0.15, 0.61)	**0.43**** (0.15, 0.71)	**0.33**** (0.08, 0.58)
Cancer	**0.18*** (0.01, 0.34)	0.08 (-0.14, 0.30)	**0.25**** (0.08, 0.42)	**0.22***** (0.09, 0.35)
Age category. *Reference modality: "Age group: 60-79"*				
80-89	**0.16***** (0.07, 0.24)	0.04 (-0.09, 0.18)	**0.16***** (0.08, 0.25)	**0.26***** (0.16, 0.37)
90+	**0.18**** (0.06, 0.30)	**0.61***** (0.37, 0.86)	0.28 (-0.01, 0.58)	0.22 (0.08, 0.35)
French origins.	-0.04 (-0.16, 0.08)	-0.02 (-0.17, 0.13)	0.00 (-0.08, 0.09)	-0.04 (-0.16, 0.07)
In a civil union.	**-0.09*** (-0.17, -0.01)	0.04 (-0.07, 0.14)	-0.03 (-0.10, 0.05)	-0.06 (-0.15, 0.02)
Number of observations	N= 1340	N=484	N=1657	N=768

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 3,419) and CARE-I (2016, N = 832).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I. 8. Breakdown of differences in AL prevalence between manual and highly skilled workers, for both men and women, based on decomposition analysis (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Difference in AL prevalence (Manual – Highly skilled) = 13.27 percentage points		**Difference in AL prevalence (Manual – Highly skilled) = 13.02 percentage points**	
	Decomposition due to distributions	**Decomposition due to intensities**	**Decomposition due to distributions**	**Decomposition due to Intensities**
Chronic diseases.				
Musculoskeletal diseases	**+2.44*****	-2.88	**+2.88*****	+0.98
Cardiovascular diseases	**+2.73*****	+0.52	**+1.85*****	+0.24
Diabetes	+0.20	-2.00	**+0.95***	+0.22
Kidney diseases	+0.22	-0.29	+0.01	-0.78
Neurodegenerative diseases	**+1.53*****	-046	**+0.75*****	+0.00
Depression	**+0.39*****	-2.0	**+0.28***	-0.59
Macular degeneration	**+0.5*****	-0.10	**+0.06*****	+0.04
Cancer	**-0.22*****	+0.62	**-0.45*****	-0.20
Age category. *Reference modality: "Age group: 60-79"*				
80-89	**+1.98*****	+1.54	**+0.91*****	-1.60
90	**+0.84*****	-1.96	-0.09	+0.03
French origin.	+0.05	-1.86	-0.04	+5.73
In a civil union.	**+0.19***	-9.31	+0.17	+3.48
Residual unexplained components		+20.66		-0.84

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 3,419) and CARE-I (2016, N = 832).
General notes: The decomposition analysis follows the nonlinear extension of the Oaxaca-Blinder method (Blinder, 1973; Oaxaca, 1973) proposed by (Yun, 2004, 2008), implemented using R function adapted by Powers (Powers et al., 2011). Standard errors are obtained via the delta method (Yun, 2005). Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001. ***Reading notes:*** Within women, differences in the distribution of musculoskeletal diseases (MSD) across manual and highly skilled workers significantly contributed with 2.42 percentage points to the gap in AL prevalence. Differences in the intensity of the association between MSD and AL reduced the gap in AL by 0.46 percentage points, although this contribution was not statistically significant.

IV. 5. 3. Decomposition of differences in AL prevalence between farmers and highly skilled workers.

For this analysis, the sample was restricted to respondents identified as farmers or highly skilled workers, excluding those with missing observations in the variables of interest. In total, 2304 individuals were retained (1159 women and 1145 men). Prevalence estimates indicated that, within both women and men, farmers reported higher levels of AL than their highly skilled counterparts. Results of this decomposition analysis shown in Table I. 9 and Table I. 10, and Table I.S.15 in supplementary materials. Given that 98% of men farmers were of French origin, geographical origin was not included as a control variable in this analysis.

Within women of the selected sample, the difference in AL prevalence between farmers and the highly skilled amounted to 26.51 percentage points (55.65% for farmers and 29.15% for the highly skilled, $p<0.01$). This gap was primarily explained by differences in the distribution of diseases and age across groups, rather than by differences in their associations with AL. All conditions except diabetes and kidney disease were positively associated with AL and contributed positively to the gap due to their higher prevalence among farmers. MSD, CVD, NDD, and macular degeneration together accounted for 38% of the observed difference. Age emerged as the dominant factor in explaining the AL gap: the higher proportion of individuals aged over 80 years old among farmers explained 12 percentage points of the gap (45% of the total), exceeding the combined contribution of chronic diseases. Regarding social variables, there was no significant evidence of their contribution to differences in AL prevalence.

Within men, the prevalence of AL among farmers exceeded that of the highly skilled by 18.32 percentage points (AL prevalence of 49.2% for farmers and 31% for the highly skilled, $p<0.01$). Only the higher prevalence of MSD, CVD, and NDD among farmers was significant at the 5% level in explaining the gap in AL prevalence between the two groups, together accounting for 44% of the difference. Other conditions did not contribute, reflecting the absence of a significant association with AL in this subgroup. The older age distribution among farmers contributed to the gap in AL prevalence with 5.5 percentage

points (30% of the gap), yet, only the higher representation of 90+ individuals farmers was significant at the 5% level. Overall, the magnitude of the age contribution was smaller among men than among women, indicating that age differences played a more limited role in explaining the AL gap between groups within men.

Table I. 9. Estimated odds ratios (OR) representing associations of variables of interest with AL, based on fitted logistic regressions across farmers and highly skilled workers within men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Farmers	**Highly skilled**	**Farmers**	**Highly skilled**
Chronic diseases.				
Musculoskeletal diseases	**0.13*** (0.00, 0.26)	**0.31***** (0.20, 0.42)	**0.20**** (0.05, 0.35)	**0.12**** (0.04, 0.20)
Cardiovascular diseases	**0.23**** (0.09, 0.37)	**0.20*** (0.03, 0.37)	**0.38***** (0.24, 0.51)	**0.18***** (0.09, 0.28)
Diabetes	0.18 (-0.02, 0.38)	**0.28*** (0.03, 0.54)	0.18 (-0.05, 0.41)	0.07 (-0.04, 0.17)
Kidney diseases	0.12 (-0.12, 0.36)	0.17 (-0.11, 0.46)	0.14 (-0.22, 0.49)	**0.28***** (0.13, 0.42)
Neurodegenerative diseases	**0.42***** (0.24, 0.60)	**0.57***** (0.35, 0.79)	**0.58***** (0.27, 0.89)	**0.33***** (0.12, 0.55)
Depression	**0.22***** (0.05, 0.39)	**0.32***** (0.20, 0.45)	0.15 (-0.36, 0.67)	**0.27**** (0.08, 0.47)
Macular degeneration	**0.48***** (0.21, 0.76)	0.23 (-0.15, 0.61)	0.00 (-0.32, 0.32)	**0.34**** (0.09, 0.58)
Cancer	**0.31*** (0.07, 0.55)	0.08 (-0.14, 0.30)	-0.33 (-0.80, 0.15)	**0.22**** (0.09, 0.35)
Age category. *Reference modality: "Age group: 60-79"*				
80-89	**0.27***** (0.18, 0.36)	0.04 (-0.09, 0.18)	0.13 (-0.01, 0.26)	**0.26***** (0.15, 0.37)
90+	**0.19*** (0.04, 0.33)	**0.61***** (0.37, 0.86)	**0.56***** (0.36, 0.77)	**0.22**** (0.08, 0.35)
French origins.	0.01 (-0.23, 0.25)	-0.02 (-0.17, 0.13)	*Not applicable*	*Not applicable*
In a civil union.	-0.04 (-0.14, 0.07)	0.04 (-0.07, 0.14)	0.08 (-0.06, 0.21)	-0.06 (-0.15, 0.02)
Number of observations	N= 675	N=484	N=377	N=768

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 1,826) and CARE-I (2016, N = 478).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I. 10. Breakdown of differences in AL prevalence between manual and highly skilled workers, for both men and women, based on decomposition analysis (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Difference in AL prevalence (Farmers – Highly skilled) = 26.51 percentage points		**Difference in AL prevalence (Farmers – Highly skilled) = 18.32 percentage points**	
	Decomposition due to distributions	**Decomposition due to intensities**	**Decomposition due to distributions**	**Decomposition due to Intensities**
Chronic diseases.				
Musculoskeletal diseases	**+2.20***	-6.73	**+4.29****	+2.77
Cardiovascular diseases	**+4.00*****	+0.01	**+2.98*****	+2.51
Diabetes	+0.72	-0.38	+0.54	+1.19
Kidney diseases	+0.54	-0.1	+0.00	-0.81
Neurodegenerative diseases	**+2.09*****	-0.22	**+0.85*****	+0.35
Depression	**+0.17*****	-0.58	-0.23	-0.62
Macular degeneration	**+1.89*****	+0.25	+0.00	-0.87
Cancer	**+0.17****	+0.64	+1.03	-4.59
Age category. *Reference modality: "Age group: 60-79"*				
80-89	**+9.07*****	+1.28	+2.87	-1.93
90+	**+2.93*****	-0.77	**+2.61*****	+1.11
French origin.	+0.13	+1.62	*Not applicable*	*Not applicable*
In a civil Union.	+0.34	-2.20	-0.15	+12.15
Residual unexplained component		+9.44		-7.83

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 3,419) and CARE-I (2016, N = 832).
General notes: The decomposition analysis follows the nonlinear extension of the Oaxaca-Blinder method (Blinder, 1973; Oaxaca, 1973) proposed by (Yun, 2004, 2008), implemented using R function adapted by Powers (Powers et al., 2011). Standard errors are obtained via the delta method (Yun, 2005). Stars denote significance: *p<0.05; **p<0.01; ***p<0.001. ***Reading notes:*** Within women, differences in the distribution of musculoskeletal diseases (MSD) across farmers and highly skilled workers significantly contributed with 2.53 percentage points to the gap in AL prevalence. Differences in the intensity of the association between MSD and AL further increased the gap in AL by 0.46 percentage points, although this contribution was not statistically significance.

IV. 5. 4. Decomposition of differences in AL prevalence between the "Not employed" and highly skilled workers within women.

This analysis focuses on the decomposition of differences in AL prevalence between the "Not employed" category and the highly skilled within women. Following the same approach as in the previous subsections, the sample was restricted to these two groups, excluding individuals with missing observations in the variables of interest. In total, 1613 women were included. As previously shown, the prevalence of AL was significantly higher among women in the "Not employed" category (58.77%) compared with highly skilled women (29.14%), corresponding to a gap of 29.63 percentage points ($p<0.01$). Results from this decomposition analysis are presented in Table I. 11 and Table I. 12, and Table I.S.16 in supplementary materials.

Regarding diseases, all conditions except diabetes and kidney diseases, neither of which was significantly associated with AL in either group (except diabetes among the highly skilled), contributed to the difference in AL prevalence. The largest contributions came from the higher prevalence of CVD and NDD among women in the "Not employed" category, which together explained 15% of the gap in AL. A distinctive pattern emerged in this analysis compared with previous decompositions: differences in the intensity of association between MSD and AL contributed negatively to the gap in AL prevalence. Specifically, the AME of MSD on the likelihood of AL was higher among the highly skilled (AME = 0.31) than among women not employed (AME = 0.13), though the difference did not reach statistical significance at the 5% level. Under a counterfactual scenario where MSD prevalence was equal across groups, that is, if highly skilled women had the same prevalence of MSD as women in the "Not employed" category, the gap would have been reduced by 10.35 percentage points, representing 35.3% of the observed difference in AL prevalence. A similar, though much smaller, pattern was observed for NDD. While the higher prevalence of NDD among women not employed contributed positively to the gap in AL prevalence compared to the highly skilled, differences in the intensity of the association between

NDD and AL acted in the opposite direction (−0.77 percentage points), slightly reducing the observed difference between groups.

Age differences also contributed to the gap in AL prevalence between the two groups. The older age profile of not employed women increased the disparity, with the higher proportion of women aged 90 and over accounting for +3.28 percentage points of the gap (11.1%), while the higher share of individuals aged 80–89 contributed an additional +1.43 percentage points (4.8%), although this latter contribution was not statistically significant. In contrast, differences in the intensity of the association between age and AL slightly reduced the gap. The stronger marginal effect of being aged 90 or above among highly skilled women (AME = 0.61) than among women in the "Not employed" category (AME = 0.19) negatively contributed by 1.31 percentage points (4.4%) to the difference in AL prevalence. As a result, if the association between oldest ages and AL had been identical across the two groups, the observed difference in AL prevalence would have been slightly larger.

A notable feature of this decomposition is the magnitude of the residual unexplained component, which reached 33.4 percentage points (112.7% of the observed gap) and was statistically significant at the 1% level. This contribution exceeds the observed difference in AL prevalence between "Not employed" and highly skilled women (29.63 percentage points), indicating that the variables included in the model explain only a limited share of the disparity between the two groups. This pattern contrasts with the previous decompositions comparing manual workers or farmers with highly skilled workers, where a larger proportion of the gap could be attributed to differences in the distribution of diseases and age. The large and significant residual unexplained component suggests that substantial differences in AL prevalence between both categories remain unaccounted for by the observed characteristics included in the analysis.

Table I. 11. Estimated average marginal effects (AMEs) representing associations of variables of interest with AL, based on fitted logistic regressions across "Not employed" and highly skilled workers within women (in merged sample with no missing data from CARE-M and CARE-I).

	Not employed	**Highly skilled**
Chronic diseases.		
Musculoskeletal diseases	**0.13*** (0.00, 0.26)	**0.31***** (0.20, 0.42)
Cardiovascular diseases	**0.23**** (0.09, 0.37)	**0.20*** (0.03, 0.37)
Diabetes	0.18* (-0.02, 0.38)	**0.28*** (0.03, 0.54)
Kidney diseases	0.12 (-0.12, 0.36)	0.17 (-0.11, 0.46)
Neurodegenerative diseases	**0.42***** (0.24, 0.60)	**0.57***** (0.35, 0.79)
Depression	**0.22*** (0.05, 0.39)	**0.32***** (0.20, 0.45)
Macular degeneration	**0.48***** (0.21, 0.76)	0.23 (-0.15, 0.61)
Cancer	**0.31*** (0.07, 0.55)	0.08 (-0.14, 0.30)
Age category. *Reference modality: "Age group: 60-79"*		
80-89	**0.27***** (0.18, 0.36)	0.04 (-0.09, 0.18)
90+	**0.19*** (0.04, 0.33)	**0.61***** (0.37, 0.86)
French origin.	0.01 (-0.23, 0.25)	-0.02 (-0.17, 0.13)
In a civil union	-0.04 (-0.14, 0.07)	0.04 (-0.07, 0.14)
Number of observations	N= 1129	N = 484

Source: Subsample of women respondents aged 60 and over with complete data on variables of interest, from the categories of "Not employed" and highly skilled workers in CARE-M (2015, N = 1129) and CARE-I (2016, N = 484).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I. 12. Breakdown of differences in AL prevalence between "Not employed" and highly skilled workers, for women, based on decomposition analysis (in merged sample with no missing data from CARE-M and CARE-I).

	Difference in AL prevalence (Inactive -Highly skilled) = 29.63 percentage points	
	Decomposition due to distributions	**Decomposition due to intensities**
Chronic diseases.		
Musculoskeletal diseases	**+1.78*****	**-10.35***
Cardiovascular diseases	**+2.69*****	-0.07
Diabetes	+1.30	-1.17
Kidney diseases	+0.45	-0.06
Neurodegenerative diseases	**+1.85*****	**-0.77*****
Depression	**+0.94*****	-0.77
Macular degeneration	**+1.37****	-0.06
Cancer	-0.11	+0.94
Age category. *Reference modality: "Age group: 60-79"*		
80-89	+1.43	-0.05
90+	**+3.28*****	**-1.31*****
French origins.	+0.11	+1.47
In a civil union.	**+1.49*****	-8.21
Residual unexplained component		**+33.4*****

Source: Subsample of women respondents aged 60 and over with complete data on variables of interest, from the categories of "Not employed" and highly skilled workers in CARE-M (2015, N = 1129) and CARE-I (2016, N = 484).
General notes: The decomposition analysis follows the nonlinear extension of the Oaxaca-Blinder method (Blinder, 1973; Oaxaca, 1973) proposed by (Yun, 2004, 2008), implemented using R function adapted by Powers (Powers et al., 2011). Standard errors are obtained via the delta method (Yun, 2005). Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.
Reading notes: Differences in the distribution of musculoskeletal diseases (MSD) between women and men significantly contributes with 3.76 percentage points to the gender gap in AL prevalence. Gender differences in the intensity of the association between MSD and AL contribute by an additional 1.54 percentage points, although this contribution is not statistically significant.

V. Discussion.

This study investigated the contribution of chronic diseases to activity limitation (AL) in the 60+ population in France using data from the CARE surveys (2015-2016), representative of the French population. The ranking of diseases regarding their overall contribution to AL in the population reveals relevant targets for public schemes to prevent disabilities at old ages. Accounting for a large set of conditions, this work examined how the contribution of chronic diseases to AL varies across gender and socio-occupational groups, and assessed the extent to which variation in their prevalence and their associations with AL accounts for disparities in AL prevalence across different groups. The leading causes of AL are MSD and CVD, followed by diabetes, depression and NND with different ranking in men and women and across occupational groups.

This study analyzed which of these conditions contribute to gender and occupational differences in AL. Overall, in line with the literature, AL was more prevalent among women in the general population and among socially disadvantaged occupational groups, including the heterogeneous group of women not employed. The results of this study showed that, although age was an important factor contributing to disparities in AL prevalence across gender and occupational groups, these disparities were importantly driven by differences in disease prevalence (particularly musculoskeletal, cardiovascular, and neurodegenerative diseases) rather than by differences in the strength of their associations with AL. While the analysis generated a wide range of detailed findings, the discussion focuses on the most relevant insights regarding the contribution of diseases to AL prevalence across gender and social groups.

V. 1 Musculoskeletal diseases: Highly prevalent conditions and leading contributors to AL, with marked gender and social inequalities.

In this work, MSD emerged as highly prevalent conditions, relative to other diseases, and the leading contributors to AL prevalence, while not always having a high association with AL. They are more prevalent among women, and have a different distribution across socio-occupational groups, which contributes to disparities in AL prevalence between

different groups, coming in line with previous findings (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2019).

Our results showed that MSD were more prevalent among occupational groups in which physically demanding jobs are overrepresented, farmers and manual workers, compared to highly skilled workers; MSD positively contributed to the observed AL gap between them. Additionally, within women, MSD were more prevalent among the "Not employed" women compared to the highly skilled. These results provide important insights for policymakers. Reducing activity limitation among older adults through targeting MSD should prioritize prevention, given that their higher prevalence contributes to both overall levels of AL and to social inequalities in AL prevalence. Regarding the overall levels, our first set of analysis demonstrated that MSD are increasing AL by 16.5% in women (being associated with 39% of the AL they report) and 12.8% in men (33% of the AL they report); the decomposition of the overall gender gap in AL additionally confirms the crucial role of the different prevalence of these conditions in the gender gap in AL.

As highlighted in the literature, MSD are strongly linked to occupational exposures, particularly in manual and agricultural jobs involving repetitive movements, heavy physical loads, or awkward postures. The results of this study figure out that MSD contribution rise up to 20.6% of AL reported by women who are manual workers (48% of their AL); the lowest contribution being for farmers (however with the largest part of AL being not associated with any of the set of conditions). Interestingly, clerical, skilled and highly-skilled occupation as well as inactivity, show a large contribution of MSD. In men, the contribution of these conditions are a large contributor to AL across all groups; yet highly-skilled men show the lowest contribution of MSD to their AL.

Both women and men are exposed at work to physically-demanding tasks, yet women are more exposed to the more risky exposures of MSD than men in all occupations. Interestingly, in this study, MSD represent half of the AL reported by highly-skilled women. Improving working conditions by reducing ergonomic risks, strengthening occupational health surveillance, and promoting workplace adaptations are therefore central strategies to lessen the prevalence of MSD. In addition to a possible selection effect

based on poor health in the "Not employed" category also among women, patterns of exposure outside the labor market also deserve attention, including domestic responsibilities; this domestic exposure would also contribute to impact women across all occupational groups. Policies that encourage a more equal distribution of domestic work, expand access to preventive health services, and improve early detection and treatment of MSD among women could help reduce these inequalities.

V. 2 Cardiovascular diseases: Major contributors to AL and primary drivers of social disparities in AL prevalence.

In this study, CVD also emerged as highly prevalent conditions. While more common among men, they contributed substantially to AL prevalence for both genders, with stronger contributions among men. Socially, their prevalence and disabling impact displayed clear gradients: CVD were major contributors to disparities in AL prevalence between farmers, manual workers, and the highly skilled. Among women, they also explained an important share of the difference in AL prevalence between women who were not employed and their highly skilled counterparts. These findings are consistent with previous evidence showing the central role of CVD in generating health inequalities at older ages (Palazzo et al., 2019).

Although CVD are well known as leading causes of mortality, this study confirms their importance as contributors to activity restrictions. Their uneven distribution can reflect both occupational exposures, such as physically demanding work and psychosocial stressors, and behavioral risk factors, including smoking, poor diet, and limited physical activity, which are themselves unequally distributed across social groups. Disparities in access to preventive care and effective disease management could further reinforce these inequalities.

From a policy perspective, strategies to reduce the contribution of CVD to AL should combine prevention and improved management. Possible prevention could include workplace health promotion, reduction of occupational stress, and support for healthier lifestyles. At the same time, strengthening cardiovascular screening and ensuring equitable access to treatment and long-term disease management, particularly among

socially disadvantaged groups, could mitigate their contribution to inequalities in AL. Gains towards the CVD on AL would benefit more to men who show higher prevalence and larger contribution than women; as isolated policy target, it would improve AL in men more than in women and therefore increase the gender gap in AL.

It is worthy to acknowledge that the contribution of CVD to AL may be underestimated, rather than over estimated, in this cross-sectional setting, as severe cardiovascular events are a leading cause of premature mortality, particularly among men and lower socio-occupational groups (Cambois et al., 2008). Individuals with the most severe CVD are less likely to survive to the ages captured in the CARE surveys, potentially attenuating both the observed prevalence of CVD and its estimated disabling impact among these groups.

V. 3 Neurodegenerative diseases: Highly disabling but low prevalent conditions, yet shaping gender and social inequalities in AL.

NDD emerged in this study as the most disabling conditions in the 60+ French population (except among self-employed women). Despite their relatively lower prevalence and overall contribution to AL compared to MSD and CVD, NDD were important contributors to both gender and occupational disparities in AL, primarily through differences in their prevalence across groups. This was consistent with earlier findings (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2019). Yet, no evidence was found of significant differences in the strength of their association with AL, neither across gender nor socio-occupational categories. Their prevalence and disabling impacts were also closely linked to age.

As they are highly disabling diseases, targeting them remains a crucial objective for policymakers. Reducing the contribution of NDD to inequalities in AL requires strategies that address their differential prevalence across groups by acting on modifiable risk factors. For gender, women's higher prevalence of NDD partly reflects their longer life expectancy, but also social and biological factors, including hormonal changes and greater exposure to cumulative disadvantages across the life course. Policies that promote better cognitive health for women, through for instance, promotion of physical

activity, cognitive stimulation, continuous education and strong labor market engagement, could help reduce their elevated prevalence among them.

Across socio-occupational groups, the higher prevalence of NDD among disadvantaged populations could reflect lower educational attainment and occupational experiences with limited cognitive stimulation, as well as barriers to preventive healthcare. Strengthening policies that expand access to education and work opportunities that stimulate cognition earlier in life, alongside interventions that encourage social participation, mental engagement, and risk-factor control in later life, could highly help in narrowing social disparities in NDD prevalence.

Beside the cognition decline, NDD comprise Parkinson disease. The contribution of NDD to the gap between farmers and highly-skilled men is intriguing; as farmers are known to be more exposed than other groups to Parkinson diseases probably due to the pesticide use (Kab et al., 2017). This cannot be disentangled here due to the very small proportion of the sample concerned.

V. 4 Depression: contributor to the gender gap in AL, with mixed patterns across socio-occupational groups.

Alongside other diseases, depression also emerged as an important contributor to AL and to gender disparities in AL prevalence, though through a smaller extent, compared with MSD and CVD. Depression was more prevalent among women, ranked among the leading contributors to their AL prevalence, and played a notable role in explaining the gender gap in AL, largely through differences in prevalence rather than differences in disabling impact, in line with previous literature (Nusselder et al., 2019; Palazzo et al., 2019). Regarding socio-occupational differences, patterns were more nuanced. Depression was more prevalent among respondents who were in the “Not employed” category and among manual workers compared to highly skilled workers, while its prevalence was relatively low among farmers within men. Interestingly, it explained a relatively larger share of AL prevalence among highly skilled men and women, compared to other categories, despite not showing a higher disabling impact in this group. Finally, although depression

contributed positively to occupational gaps in AL between manual and highly skilled workers, and between women in the "Not employed" category and their highly skilled counterparts, their contribution was modest compared to other diseases. Overall, preventive measures for reducing the prevalence depression are crucial across various groups. Interventions that address social determinants of depression, such as caregiving responsibilities, occupational stress, and job insecurity, are particularly relevant for women and for socially disadvantaged groups, where exposure to such risks is more pronounced. On the other hand, the relatively higher contribution of depression to AL among highly skilled men and women points to the need for workplace-based interventions in more advantaged occupational groups, focusing on psychosocial stressors such as long working hours, performance pressures, and job strain.

V. 5 Diabetes: a relevant contributor to AL, with heterogeneous evidence on gender and socio-occupational differences.

In this study, diabetes was identified as a relevant contributor to AL, though its patterns were more heterogeneous than those observed for MSD, CVD, or NDD. It was more prevalent among men and contributed more to their AL prevalence across most occupational groups. Decomposition analyses indicated that if women had the same prevalence of diabetes as men, the gender gap in AL would have been even larger.

Socio-occupational differences revealed mixed patterns. Among men, the higher prevalence of diabetes among manual workers contributed to widening the gap with highly skilled workers, whereas this effect was not observed among women. Moreover, in certain cases, variations in the disabling impact of diabetes across occupational groups (although not significant) further influenced inequalities in its contribution to AL.

At older ages, diabetes frequently co-occurs with other chronic conditions, such as cardiovascular and kidney diseases. This comorbidity may explain why its contribution to AL appeared lower or more variable in some groups, as part of its impact may be captured through the role of other conditions. Despite this, diabetes remains an important

condition to address for reducing AL, particularly among men and socially disadvantaged groups where prevalence is higher.

From a policy perspective, reducing the contribution of diabetes to AL requires a combined focus on prevention and effective management. Prevention should involve promoting healthier lifestyles and ensuring equitable access to preventive care, especially for men and socially disadvantaged groups at higher risk. Improved management is equally essential, since complications and the burdens associated with diabetes treatment can themselves lead to fatigue and functional limitations that restrict daily activities.

V. 6 What insights on macular degeneration, kidney diseases, and cancers?

While MSD, CVD, NDD, depression, and diabetes emerged as the main contributors to AL and to gender and social gaps in AL, this study also provided some insights on macular degeneration, kidney diseases, and cancer. Although their contributions were generally smaller compared to the leading conditions, their role should not be overlooked, particularly given their impact in specific subgroups.

V. 6. a. Macular degeneration

In this study, macular degeneration was strongly associated with AL, particularly among women, and its (slightly) higher prevalence among them, combined with a higher disabling impact, contributed more to their AL prevalence compared to men's. Within women, it also explained social gaps in AL, given its higher prevalence among farmers, the "Not employed", and manual workers compared with the highly skilled.

The stronger impact among women can be explained by their longer life expectancy, which increases exposure to this age-related condition, biological factors such as hormonal changes, and higher risks of vision-related comorbidities. Social circumstances can also play a role, as women in older cohorts are less likely to be in a civil union (confirmed by differences in distributions) and face barriers to specialized care or assistive devices, making vision loss more disabling. Among disadvantaged groups, higher prevalence may reflect unequal access to preventive eye care and greater exposure

to behavioral risk factors such as smoking. Policy responses could focus on improving access to regular eye examinations and early detection, expanding preventive strategies such as limiting smoking and dietary improvements, and ensuring equitable access to treatment and rehabilitation services. These measures would help reduce both the prevalence and the disabling impact of macular degeneration, particularly among women and socially disadvantaged groups.

V. 6. b. Kidney diseases.

Regarding kidney diseases, our results showed no significant gender or overall social differences in the prevalence of these diseases. However, they ranked among the top disabling diseases for women and made a notable contribution to AL among self-employed women.

The literature has also showed that these conditions often co-occur with other health conditions, such as diabetes and hypertension (another risk factor for CVD), that are themselves also risk factors for kidney diseases (Ke et al., 2022; Lucas & Taal, 2023). Thus, just like the case of diabetes, the contribution of kidney diseases to AL gaps in AL prevalence could have been embedded under other conditions. The top disabling impact of kidney diseases among self-employed women may relate to the possible distribution of educational attainment in this category, as women with low educational attainments were overrepresented in this category, and research has already shown the link between low socio economic status and the disabling impact of kidney diseases which relate to dialysis. This highly demanding treatment can disrupt standard employment arrangements. If further studies confirm the specific finding regarding self-employed women, this could reflect reverse causation: rather than self-employment increasing the disabling impact of kidney diseases, women undergoing dialysis may shift toward self-employment to gain the flexibility needed to accommodate their treatment schedule. This interpretation is consistent with the fact that self-employment encompasses different types of activities for men and women, with self-employment among women more often involving forms of work that allow such adjustments.

V. 6. c. Cancers

In our work, cancers contributed more to AL prevalence among men, due to a more important disabling impact of cancer among them, although no overall gender difference in the prevalence of self-reported cancers was observed in this dataset, except within clerical workers. It also showed no clear contribution to the gender gap in AL. Social differences in prevalence were limited: cancers had a lower prevalence and contribution to AL in clerical men compared to other occupational groups (except for men farmers). Within men, decomposition results also indicated no positive contribution of cancers to the AL gap between farmers and manual workers, with highly skilled workers. For women, cancers were estimated with a significantly higher disabling impact among clerical compared to skilled workers, which resulted in a higher contribution of cancer to AL prevalence in clerical women. In decomposition results, it contributed modestly to the social gap in AL prevalence between farmers and highly skilled women only.

Overall, these results likely reflect the heterogeneity of cancer sites and stages, which are closely tied to disease severity. Gender differences in site-specific cancers, with some more common among women (e.g., breast cancer) and others among men (e.g., prostate cancer), may have offset each other, explaining the absence of an overall gender difference in prevalence. In addition, the fatal nature of certain cancers reduces their visibility in prevalence estimates, since more severe cancers often result in death before older ages, whereas others persist as chronic and disabling conditions. These dynamics help explain why cancers showed only modest contributions in decomposition results, despite being a major disease. Importantly, when cancers do not end in death, they often result in disability, which highlights the need for timely detection, equitable access to treatment, and sustained support for survivors across all population groups. This dynamic illustrates a broader pattern of selective mortality that applies, to varying degrees, across all lethal conditions examined in this study, whereby the most severe disease cases are underrepresented in cross-sectional surveys of older populations.

VI. Study limitations.

This study provided many evidence on the contributions of chronic diseases to AL across gender and socio-occupational groups in the French 60+ population. However, there are some limitations that are worthy of noting.

VI. 1. Cross-sectional design.

Our analysis relied on cross-sectional data. Guided by the disablement process model (Nagi, 1964; Verbrugge & Jette, 1994), we treated chronic diseases as precursors of AL, a direction supported by substantial clinical and epidemiological research. However, we acknowledge that cross-sectional data cannot establish firm causal inference, and reverse mechanisms may have reinforced the associations observed. For instance, reduced physical activity due to AL can lead to physical deconditioning, which is a known risk factor for musculoskeletal and cardiovascular diseases (Curtis et al., 2017; Sluka et al., 2013; Yusuf et al., 2004). Likewise, AL may increase the risk of depression through loss of independence, reduced social participation, and diminished engagement in meaningful activities (Peng & Wang, 2025; Xiong et al., 2024). This mechanism is particularly relevant for interpreting patterns among the "Not employed" category. For instance, among men, being outside of employment was associated with both high AL prevalence and high prevalence of depression, consistent with earlier findings that unemployment or weak labor attachment elevate risks of depression (Picchio & Ubaldi, 2024). Evidence also suggests that AL is linked to cognitive impairment and increased risks of dementia (Fauth et al., 2013; Makino et al., 2020). Overall, these findings highlight that part of the associations between chronic diseases and AL can be bidirectional. However, the predominant pathway documented in the literature runs from chronic disease to AL, supporting the rationale for prevention strategies that target disease onset and management to reduce functional decline and promote healthy ageing.

VI. 2. Selective mortality.

A further limitation of this cross-sectional study relates to selective mortality. Since CARE captures individuals who survived to age 60 and above, the observed population is shaped by differential survival, both across genders and across socio-occupational groups. This survival selection means that the individuals observed at the oldest ages, particularly men and disadvantaged occupational groups, might have represented a healthier subset of their original birth cohorts, the most vulnerable individuals having died before the survey.

For gender, the proportion of men and women within each cohort in the CARE data reveals that the sex composition was quite balanced for cohorts aged 60–79, but the proportion of women exceeded 62% starting at ages 80 and above (Table I.S.17), consistent with the gender gap in life expectancy of approximately six years in France in 2015 (INSEE, 2016). This pattern implies that within-age-group comparisons may be affected by health selection, particularly among the oldest cohorts. The age standardization performed in our analyses addresses the overrepresentation of women at older ages, but cannot fully correct for this selection within age groups. Nevertheless, several observations suggest that selective mortality is unlikely to fundamentally alter the gender-related findings of this study. First, the sex ratio remains close to parity among individuals aged 60–79, who represent the largest share of the weighted sample, limiting the extent of health selection for the bulk of the analysis. Second, for cardiovascular diseases, selective mortality would work in the opposite direction: by removing men with the most severe cardiovascular events before older ages, it likely leads to an underestimation rather than an overestimation of CVD's contribution among men. Third, the decomposition analyses, which controlled for age categories, yielded patterns consistent with the attribution results, supporting the robustness of the disease-specific contributions to the gender gap in AL prevalence.

The occupational dimension of selective mortality cannot be directly isolated from the CARE data, as the age distributions of occupational groups also reflect historical changes in the French occupational structure across cohorts. However, longitudinal mortality follow-up data document substantial occupational differentials: among men, life expectancy at age 35 for manual workers was approximately 6.4 years shorter than for

managers during 2009–2013, and 18% of manual workers would die before age 65, compared to only 7% of managers (Blanpain, 2016; Cambois et al., 2008). These differentials imply that the most vulnerable individuals from disadvantaged groups are likely to be disproportionately absent from the observed sample, producing conservative estimates of social inequalities in disease prevalence and activity limitation. The true gaps between occupational groups are thus likely to be larger than the ones we found.

VI. 3. Other data limitations.

CARE surveys provide rich and a large dataset that allowed us to stratify by both gender and socio-occupational group, and provided us with survey weights to have a representation of the French population. However, there are some limitations that need to be acknowledged.

To begin with, our results revealed that age was an important factor in explaining differences in AL prevalence across various groups. A limitation of our work stemmed from the lack of further stratification by age categories which has been done in previous works (Palazzo et al., 2019). The small sample size of some strata did not allow for more stratifications (like for example, men farmers, n=377). Since the 60+ population is very heterogeneous, we acknowledge that this is a limitation, as age-specific patterns could not be examined. Nevertheless, it is worthy to note that several differences in disease prevalence remained significant after age-standardization. Moreover, results from decomposition analysis that controlled for age, revealed similar insights then results of the attribution analysis showing different contributions of diseases to AL. With a similar reasoning, separate analyses for household (CARE-M) and institutional (CARE-I) respondents were not possible. Institutionalized older adults may differ in many aspects from those living in private households, but splitting the data by this status would have reduced the precision of estimates in several strata. For this reason, the two datasets were merged. However, we compared distributions of key social and health variables across CARE-M and CARE-I and found no patterns contradicting the main results.

An additional limitation relates to the classification of occupational groups adapted in our work which was based on CARE's classification in line with the "French National Institute of Statistics and Economic Studies" (INSEE, 2020). Other studies have used alternative groupings that distinguish unskilled and skilled manual or clerical/office workers (Amossé & Chardon, 2006; Beaufils, 2022; Desrosières & Thévenot, 2002). Due to high non-response (about 80%) to the question asking for detailed occupational descriptions, we were not able to apply such classifications or further divide some groups. We encourage future works to adapt both classifications, upon data availability, and compare the findings.

Finally, the self-reporting nature of variables is also an acknowledged limitation of our data. Chronic diseases in CARE were self-reported but based on a physician diagnosis and/or treatment in the past 12 months, which reduces but does not fully remove bias. Under-reporting due to undiagnosed conditions and recall problems, especially among the oldest or institutionalized respondents, was still possible. For AL, the GALI indicator is validated and widely used (Berger et al., 2015; Bogaert et al., 2018), but as remains a subjective measure that may be affected by differences in reporting norms, thus misclassification is possible. In CARE's GALI version, there were three response categories assessing AL ("strongly limited," "limited but not strongly," and "not limited at all"). These could have been analyzed with a multinomial model to account for separate profiles. However, once stratified by gender and socio-occupational group, some categories had too few respondents for reliable estimates. As a consequence, the GALI variable was dichotomized, which entails a loss of information on the severity gradient of activity limitation. Future work with larger samples could exploit the full ordinal structure of the GALI by applying extensions of the Yun decomposition framework to multinomial or ordered response models, as implemented by Powers, Yoshioka, and Yun (Powers et al., 2011). This would allow decomposing group gaps separately for each severity level, revealing whether disparities in disease prevalence and associations drive transitions into mild versus severe limitation differently.

VII. Conclusion.

Beyond their substantial public and economic costs, chronic diseases are key contributors to activity limitation and restrictions in later life. This study showed that AL was more prevalent among women and socially disadvantaged occupational groups, with farmers and manual workers (both men and women), and "Not employed" women, more affected compared to highly skilled workers. Musculoskeletal and cardiovascular diseases emerged as the leading contributors to AL prevalence, and their unequal distribution across gender and socio-occupational groups explained a large share of the observed inequalities. Neurodegenerative diseases, though less prevalent, had strong disabling effects and made important contributions to gender and social gaps.

Other conditions also played meaningful roles. Depression contributed to the gender gap due to its higher prevalence among women, but also affected advantaged groups. Diabetes and kidney diseases were relevant in certain subgroups, while cancers and macular degeneration showed smaller yet non-negligible contributions in specific populations. These results highlight that the different chronic diseases display distinct profiles in their contribution to AL and inequalities.

Overall, the findings underline that reducing AL in ageing populations requires a twofold approach. First, policymakers should prioritize the prevention of musculoskeletal, cardiovascular, and neurodegenerative diseases, given their central role in driving gender and occupational inequalities in healthy ageing. Prevention efforts need to consider occupational and social risk factors, like job strain and risky physical tasks (like repetitive movements), that shape the distribution of these chronic diseases. Second, improving the management of the broader range of chronic diseases, including neurodegenerative diseases and macular degeneration, is also crucial to reduce their disabling impacts in specific groups. This includes ensuring equitable access to healthcare, strengthening treatment options, and expanding rehabilitation services to support those already affected. Finally, tailoring prevention and management strategies to the specific profiles of gender and socio-occupational groups is essential to lower the overall burden of AL and to reduce persistent health inequalities at older ages.

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Chapter 1. Supplementary materials.

A. Estimated prevalence of AL and chronic diseases across gender and socio-occupational groups.

Table I.S.1. Weighted prevalence of AL and chronic diseases, with 95% confidence intervals, across socio-occupational groups within <u>women</u> (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Activity Limitation	58.8 (52.5-65.2)	55.7 (47.7-63.6)	49.3 (41.6-57)	42.4 (37.6-47.2)	42.8 (40-45.7)	34.6 (30.1-39.2)	29.1 (23.5-34.8)
Musculoskeletal diseases	68.1 (62.2-74)	74.1 (67.1-81)	64.5 (56.9-72)	65.6 (60.5-70.7)	70.7 (67.9-73.6)	69.0 (64.2-73.9)	58.4 (51.7-65.2)
Depression	11.1 (8.1-14.1)	8.5 (5.4-11.7)	6.7 (4.2-9.2)	9.9 (7.5-12.3)	10.5 (8.9-12.1)	7.0 (4.9-9.1)	7.8 (4.6-11.1)
Diabetes	17.6 (13.5-21.7)	8.9 (5.8-12)	11.4 (6.9-15.8)	13.9 (10.8-17.1)	13.4 (11.5-15.4)	6.1 (4-8.2)	5.2 (2.6-7.9)
Cardiovascular diseases	16.7 (12.9-20.4)	21.1 (15.7-26.4)	16.8 (11.8-21.8)	13.1 (10.3-15.9)	12.9 (11.2-14.6)	8.3 (6-10.6)	5.0 (2.6-7.3)
Kidney diseases	4.9 (3-6.7)	6.6 (3-10.3)	4.2 (2-6.3)	4.3 (2.9-5.8)	4.1 (3.2-5.1)	3.3 (1.9-4.6)	2.5 (0.7-4.3)
Neurodegenerative diseases	9.0 (6.8-11.2)	6.5 (4.8-8.2)	4.0 (2-6)	5.0 (3.8-6.1)	3.6 (3.1-4.2)	2.1 (1.2-2.9)	1.9 (1-2.9)
Macular degeneration	7.5 (4.7-10.3)	5.6 (3.4-7.7)	5.3 (2.2-8.4)	4.0 (2.6-5.5)	3.8 (3-4.7)	4.0 (2.5-5.5)	2.0 (0.7-3.3)
Cancer	5.0 (2.9-7.1)	5.9 (2-9.8)	4.6 (2.1-7.1)	4.3 (2.6-5.9)	5.5 (4.3-6.7)	7.1 (4.7-9.4)	5.4 (2.7-8.1)

Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

Table I.S.2. Age standardized weighted prevalence of AL and chronic diseases, with 95% confidence intervals, across socio-occupational groups within <u>women</u> (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Activity Limitation	52.5 (45.6-59.4)	40.1 (35.4-44.8)	41.1 (34.8-47.4)	42.2 (37.6-46.8)	42.9 (40.2-45.7)	37.8 (33.3-42.3)	34.1 (29-39.2)
Musculoskeletal diseases	63.7 (57.6-69.8)	75.1 (69.3-81)	64.5 (57.6-71.5)	65.5 (60.7-70.2)	70.7 (67.8-73.5)	70.5 (66.1-74.8)	58.9 (53.3-64.5)
Depression	15.3 (11.3-19.3)	13.1 (10.4-15.8)	6.2 (3.9-8.5)	11.2 (8.4-14)	10.8 (9.2-12.3)	7.1 (5-9.2)	9.5 (6.1-12.9)
Diabetes	21.9 (16.8-27)	9.8 (6.8-12.8)	11.8 (7.5-16)	14.4 (11.2-17.6)	13.3 (11.5-15.2)	6.5 (4.5-8.6)	6.6 (3.8-9.5)
Cardiovascular diseases	14.8 (10.7-18.8)	14.9 (11.6-18.1)	13.0 (9.1-16.9)	12.4 (9.9-14.9)	12.8 (11.2-14.4)	9.5 (7.2-11.8)	5.8 (3.6-8)
Kidney diseases	4.2 (2.4-6)	3.3 (1.7-4.9)	3.6 (1.9-5.3)	4.8 (3.1-6.5)	4.1 (3.2-5)	4.2 (2.6-5.9)	3.1 (1.3-5)
Neurodegenerative diseases	4.4 (3.5-5.3)	3.0 (1.8-4.2)	2.6 (1.7-3.6)	4.7 (3.6-5.9)	3.5 (3-4)	2.5 (1.9-3.2)	3.5 (2.1-5)
Macular degeneration	4.3 (2.4-6.2)	2.4 (1.5-3.3)	3.1 (1.8-4.5)	3.9 (2.5-5.2)	3.8 (2.9-4.7)	4.2 (2.7-5.6)	3.4 (2.3-4.5)
Cancer	3.8 (2.2-5.3)	4.8 (2.3-7.2)	5.7 (2.6-8.8)	4.4 (2.8-6)	5.6 (4.4-6.8)	7.7 (5.3-10.2)	6.2 (3.7-8.8)

Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates); Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

Table I.S.3. Weighted prevalence of AL and chronic diseases, with 95% confidence intervals, across socio-occupational groups within men (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Health conditions.							
Activity Limitation	64.3 (45.9-82.6)	49.3 (40.3-58.3)	42.9 (36.4-49.4)	44.1 (40.1-48)	39.5 (32.8-46.1)	35.1 (30.7-39.5)	31.0 (26.6-35.5)
Musculoskeletal diseases	43.6 (25.8-61.3)	62.1 (53.1-71.1)	49.5 (42.7-56.2)	57.9 (53.8-62)	52.6 (45.4-59.7)	48.4 (43.6-53.3)	41.7 (36.7-46.8)
Depression	18.9 (4.9-32.8)	2.3 (1.1-3.5)	4.5 (2.6-6.4)	5.3 (4-6.7)	3.3 (1.9-4.8)	2.7 (1.7-3.8)	3.7 (2.1-5.3)
Diabetes	23.1 (3.7-42.5)	13.6 (7.2-20)	17.7 (12.8-22.5)	19.6 (16.6-22.7)	18.6 (13.4-23.8)	15.2 (11.8-18.7)	10.8 (7.8-13.8)
Cardiovascular diseases	27.3 (12.3-42.4)	22.0 (15.5-28.4)	22.2 (16.9-27.5)	21.7 (18.7-24.7)	15.8 (11.2-20.3)	15.2 (12.1-18.2)	14.4 (11.1-17.7)
Kidney diseases	6.3 (-0.3-12.9)	4.3 (1.7-7)	6.5 (3.4-9.6)	4.4 (3.2-5.5)	5.7 (2.8-8.6)	4.2 (2.6-5.8)	4.3 (2.6-6)
Neurodegenerative diseases	3.8 (0.8-6.8)	3.1 (1.8-4.4)	2.0 (1.3-2.6)	3.5 (2.5-4.5)	1.7 (1.1-2.4)	2.1 (1.2-3)	1.7 (1.2-2.2)
Macular degeneration	1.0 (-0.5-2.6)	2.6 (0.5-4.8)	2.8 (1.4-4.3)	2.3 (1.4-3.2)	2.1 (0.4-3.7)	3.5 (1.8-5.2)	2.1 (0.8-3.5)
Cancer	6.5 (-0.6-13.6)	4.5 (1.2-7.8)	5.3 (2.9-7.8)	5.8 (4.2-7.4)	2.1 (1.2-3)	5.2 (3.4-6.9)	7.5 (5-10)

Source: Men aged 60 and over from CARE-M (2015, N = 4,100) and CARE-I (2016, N = 756)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

Table I.S.4. Age standardized weighted prevalence of AL and chronic diseases, with 95% confidence intervals, across socio-occupational groups within men (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Health conditions.							
Activity Limitation	69.1 (62.9-75.4)	51.6 (44-59.2)	45.3 (39.5-51.2)	46.5 (42.9-50.1)	43.1 (37.5-48.7)	38.6 (34.7-42.6)	36.2 (32.2-40.2)
Musculoskeletal diseases	43.1 (36.1-50)	59.7 (51.2-68.3)	51.1 (45.4-56.7)	59.1 (55.3-62.9)	55.3 (48.9-61.7)	50.8 (46.4-55.3)	43.9 (39.4-48.3)
Depression	18.7 (14-23.3)	1.7 (0.7-2.8)	5.8 (3.2-8.4)	6.0 (4.5-7.5)	3.7 (2.2-5.1)	3.1 (2-4.2)	3.9 (2.5-5.2)
Diabetes	23.2 (18.2-28.2)	12.1 (7.8-16.5)	17.8 (13.6-22.1)	19.4 (16.5-22.3)	20.1 (15.3-24.9)	15.4 (12.2-18.6)	11.1 (8.4-13.9)
Cardiovascular diseases	32.3 (25.5-39.1)	26.1 (20.1-32.1)	21.4 (17.1-25.6)	22.7 (20.1-25.4)	16.9 (12.9-21)	16.7 (14.1-19.4)	17.3 (14-20.6)
Kidney diseases	15.3 (10.9-19.7)	6.4 (1.7-11.1)	7.1 (4-10.2)	4.6 (3.4-5.7)	5.8 (3.3-8.4)	4.7 (3.1-6.3)	4.9 (3.2-6.7)
Neurodegenerative diseases	8.4 (5.1-11.6)	2.8 (1.6-3.9)	2.5 (1.8-3.3)	3.7 (2.9-4.6)	2.5 (1.6-3.5)	2.7 (1.8-3.6)	2.4 (1.6-3.3)
Macular degeneration	0.4 (-0.3-1)	2.9 (1.3-4.6)	3.0 (1.7-4.3)	2.6 (1.7-3.4)	2.3 (0.4-4.2)	3.8 (2.3-5.2)	2.5 (1.3-3.7)
Cancer	5.2 (1.5-8.8)	5.7 (1.9-9.5)	6.0 (3.4-8.6)	5.8 (4.3-7.4)	2.9 (1.7-4.1)	5.3 (3.7-7)	8.1 (5.6-10.7)

Source: Men aged 60 and over from CARE-M (2015, N = 4,100) and CARE-I (2016, N = 756)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates); Standard errors were estimated by Taylor linearization, and confidence intervals were constructed as Wald intervals using a t-distribution with design-based degrees of freedom.

B. Results of z test statistics on gender differences in prevalence of AL and chronic diseases within socio-occupational groups.

Table I.S.5. Estimates Z-scores and p-values, testing gender differences (women – men) in weighted prevalence of AL and chronic diseases within socio-occupational categories (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Health conditions.							
Activity Limitation	Z=-0.55; p=0.58	Z=1.04; p=0.30	Z=1.25; p=0.21	Z=-0.52; p=0.60	Z = 0.91; p=0.36	Z=-0.14; p=0.89	Z= -0.52; p=0.60
Musculoskeletal diseases	Z=2.57; **p=0.01**	Z=2.07; **p=0.04**	Z=2.90; **p=0**	Z=2.31; **p=0.02**	Z = 4.62; **p=0**	Z=5.86; **p=0**	Z = 3.89; **p=0**
Cardiovascular diseases	Z=-1.35; p=0.18	Z=-0.22; p=0.83	Z=-1.45; p=0.15	Z=-4.11; **p=0.00**	Z = -1.17; p=0.24	Z=5.86; **p=0**	Z = -4.60 ; **p=0**
Depression	Z=-1.07; p=0.29	Z=3.63; **p=0**	Z=1.37; p=0.17	Z=3.20; **p=0.00**	Z = 6.47; **p=0**	Z=3.55; **p=0**	Z = 2.21; p=**0.03**
Diabetes	Z=-0.55; p=0.58	Z=-1.29; p=0.20	Z=-1.88; p=0.06	Z=-2.54; **p=0.01**	Z = -1.84; p=0.07	Z=-4.42; **p=0**	Z = -2.69; **p=0.01**
Kidney diseases	Z=-0.41; p=0.68	Z=1.01; p=0.31	Z=-1.22; p=0.22	Z=-0.04; p=0.96	Z = -1.00; p=0.32	Z=-0.86; p=0.39	Z = -1.47; p=0.14
Neurodegenerative diseases	Z=2.78; **p=0.01**	Z=3.14; **p=0**	Z=1.86; p=0.06	Z=1.90; p=0.06	Z=4.34; **p=0**	Z=-0.04; p=0.97	Z = 0.43; p=0.67
Macular degeneration	Z=3.69; **p=0.0**	Z=1.88; p=0.06	Z=1.42; p=0.16	Z=2.10; **p=0.04**	Z =1.92; p=0.05	Z=0.39; p=0.69	Z=-0.15; p=0.88
Cancer	Z=-0.40; p=0.69	Z=0.54; p=0.59	Z=-0.40; p=0.69	Z=-1.27; p=0.20	Z=4.44; **p=0**	Z=1.24; p=0.21	Z =-1.11; p=0.27

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.
Example of interpretation: Within farmers, the prevalence of musculoskeletal diseases is significantly higher among women compared to men, at the 5% level, based on the z-score = 2.90 and p=0.04.

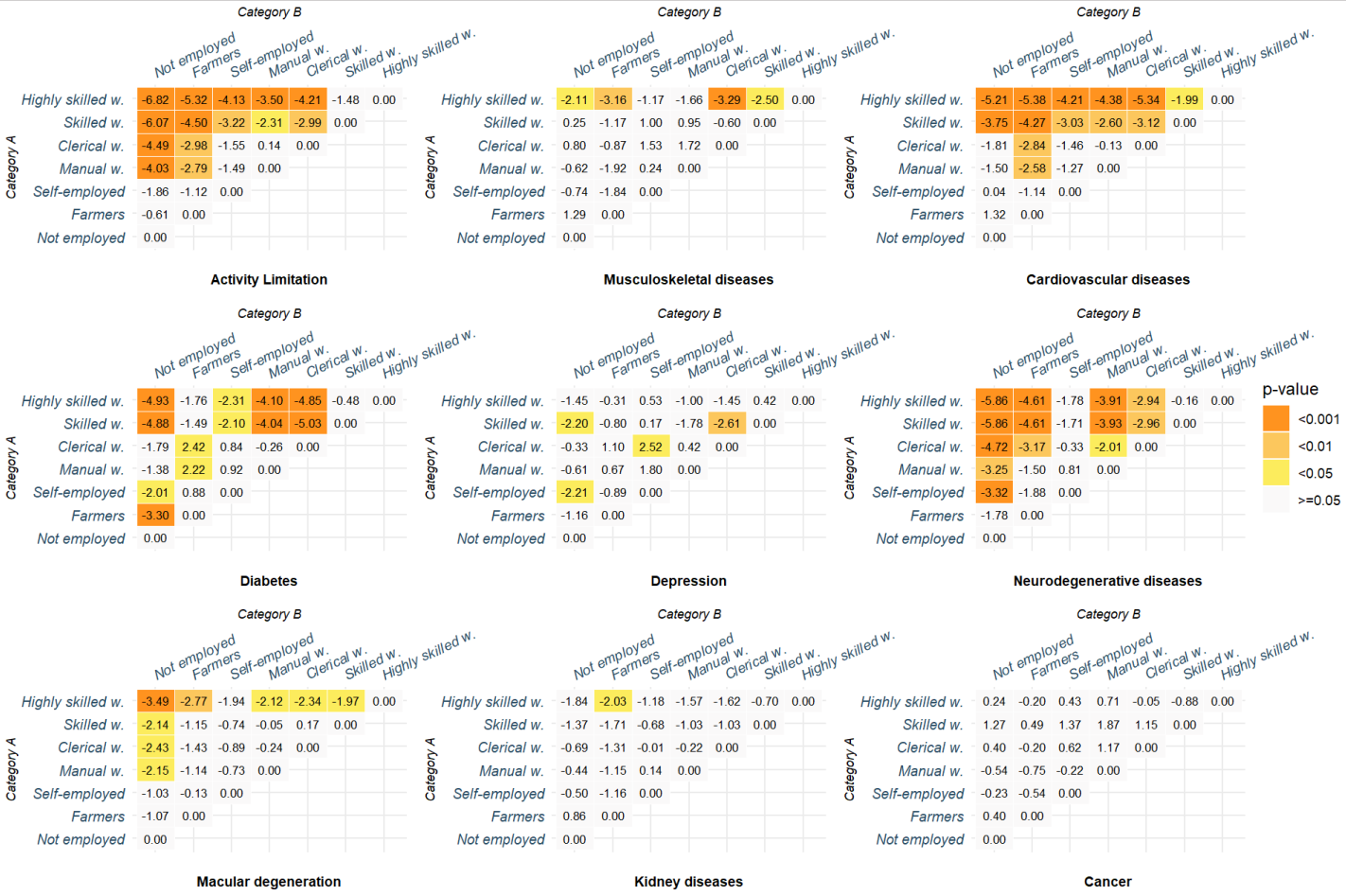
Table I.S.6. Estimates Z-scores and p-values, testing gender differences (women – men) in <u>age – standardized</u> weighted prevalence of AL and chronic diseases within socio-occupational categories (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Health conditions.							
Activity Limitation	Z=-3.51; **p<0.01**	Z=-2.55; **p=0.01**	Z=-0.97; p=0.33	Z=-1.43; p=0.15	Z = -0.05; p=0.96	Z=-0.28; p=0.78	Z= -0.65; p=0.52
Musculoskeletal diseases	Z=4.36; **p<0.01**	Z=2.91; **p<0.01**	Z=2.94; **p<0.01**	Z=2.05; **p=0.04**	Z = 4.30; **p<0.01**	Z=6.19; **p<0.01**	Z = 4.11; **p<0.01**
Cardiovascular diseases	Z=-4.33; **p<0.01**	Z=-3.24; **p<0.01**	Z=-2.84; **p<0.01**	Z=-5.51; **p<0.01**	Z = -1.86; p=0.06	Z=-4.02; **p<0.01**	Z = -5.72 ; **p<0.01**
Depression	Z=-1.06; p=0.29	Z=7.76; **p<0.01**	Z=0.22; p=0.83	Z=3.18; **p<0.01**	Z = 6.47; **p<0.01**	Z=3.31; **p<0.01**	Z = 3.01; **p<0.01**
Diabetes	Z=-0.35; p=0.73	Z=-0.87; p=0.39	Z=-1.97; **p=0.05**	Z=-2.28; **p=0.02**	Z = -2.58; **p<0.01**	Z=-4.53; **p<0.01**	Z = -2.21; **p=0.03**
Kidney diseases	Z=-4.55; **p<0.01**	Z=-1.23; p=0.22	Z=-1.94; p=0.052	Z=0.24; p=0.81	Z = -1.26; p=0.21	Z=-0.41; p=0.68	Z = -1.39; p=0.16
Neurodegenerative diseases	Z=-2.31; **p=0.02**	Z=0.26; p=0.79	Z=0.17; p=0.86	Z=1.37; p=0.17	Z=1.71; p=0.09	Z=-0.31; p=0.75	Z = 1.27; p=0.20
Macular degeneration	Z=3.89; **p<0.01**	Z=-0.56; p=0.57	Z=0.12; p=0.89	Z=1.57; p=0.12	Z =1.38; p=0.17	Z=0.37; p=0.71	Z=1.08; p=0.27
Cancer	Z=-0.69; p=0.48	Z=-0.40; p=0.69	Z=-0.15; p=0.87	Z=-1.26; p=0.21	Z=3.12; **p<0.01**	Z=1.57; p=0.11	Z =-1.04; p=0.29

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Age standardization is applied based on the 2015 French population structure (taking the 2016 French population structure did not change estimates); Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.
Example of interpretation: Within farmers, the prevalence of musculoskeletal diseases is significantly higher among women compared to men, at the 5% level, based on the z-score = 2.90 and p=0.04.

C. Results of z test statistics on socio-occupational differences in prevalence of AL and chronic diseases within men and women.

Figure I.S.1. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in <u>weighted</u> prevalence of AL and chronic diseases within <u>women</u> (in merged sample from CARE-M and CARE-I).

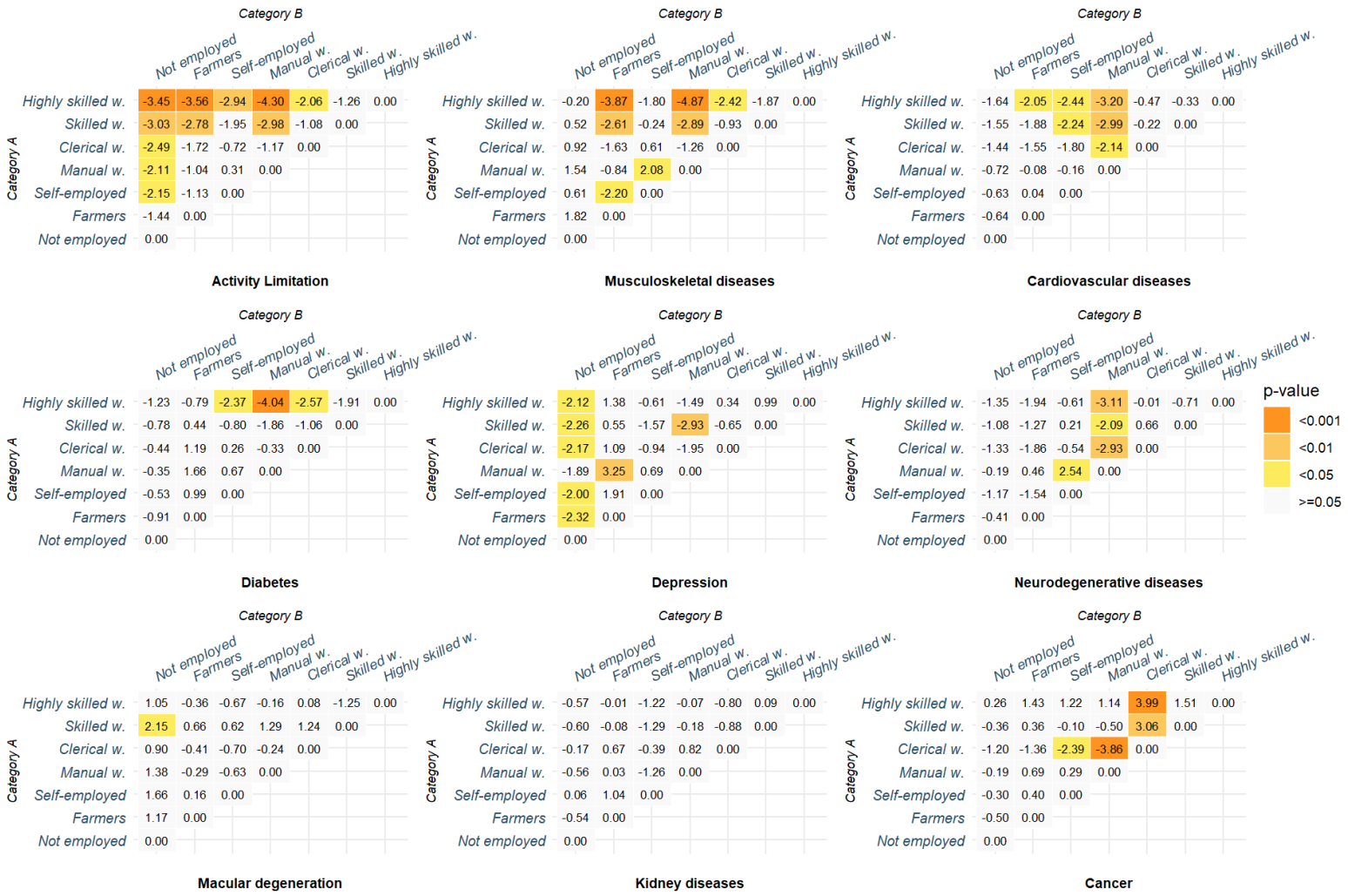


Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)

Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.

Example of interpretation: The prevalence of activity limitation is significantly lower among the highly skilled compared to farmers, at the 1% level, based on the z-score = -5.32 and p<0.001.

Figure I.S.2. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in weighted prevalence of AL and chronic diseases within men (in merged sample from CARE-M and CARE-I).

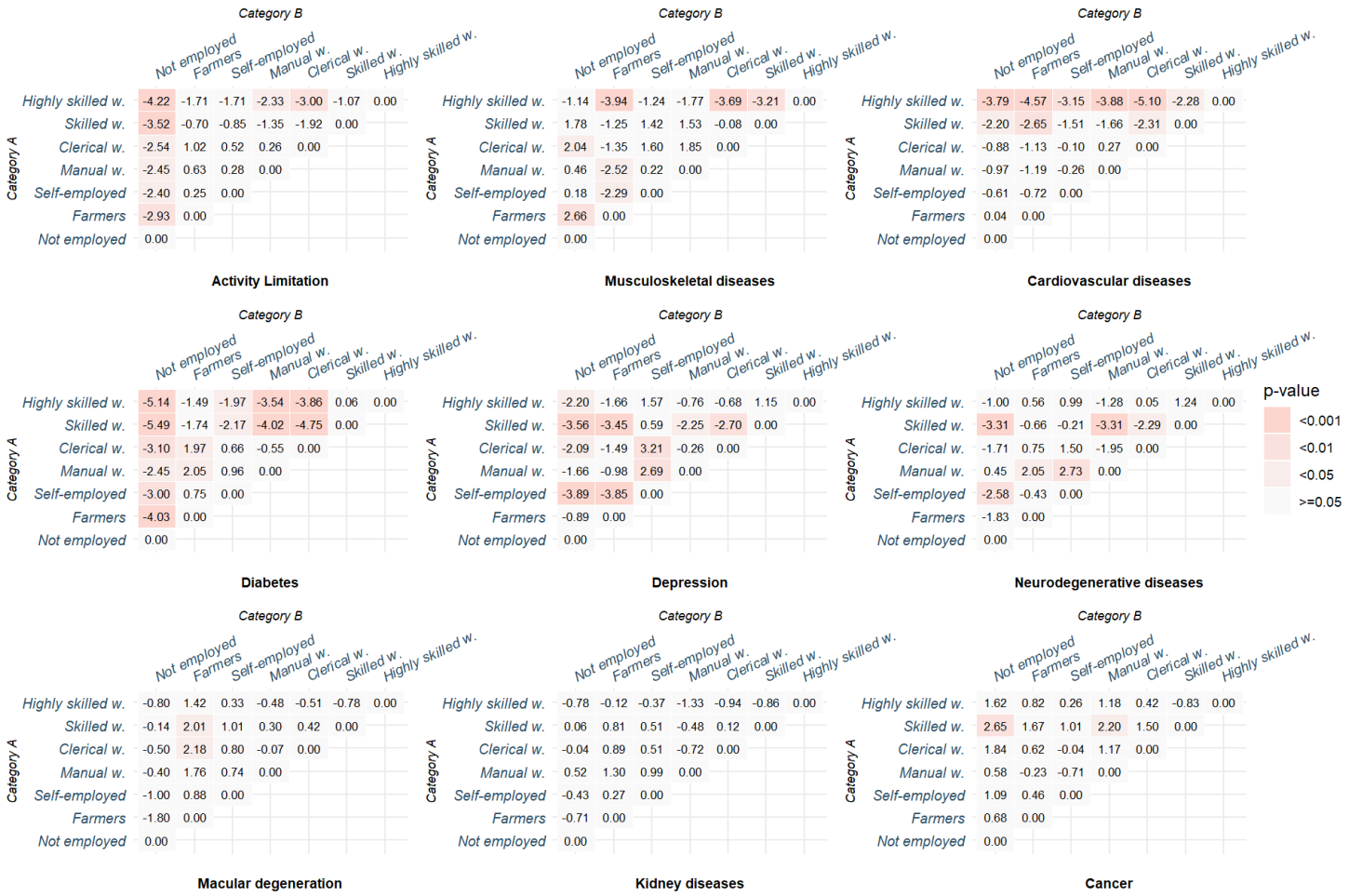


Source: Men aged 60 and over from CARE-M (2015, N = 4,100) and CARE-I (2016, N = 756)

Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.

Example of interpretation: The prevalence of activity limitation is significantly lower among the highly skilled compared to farmers, at the 1% level, based on the z-score = -3.56 and p<0.001.

Figure I.S.3. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in <u>age-standardized</u> weighted prevalence of AL and chronic diseases within <u>women</u> (in merged sample from CARE-M and CARE-I).

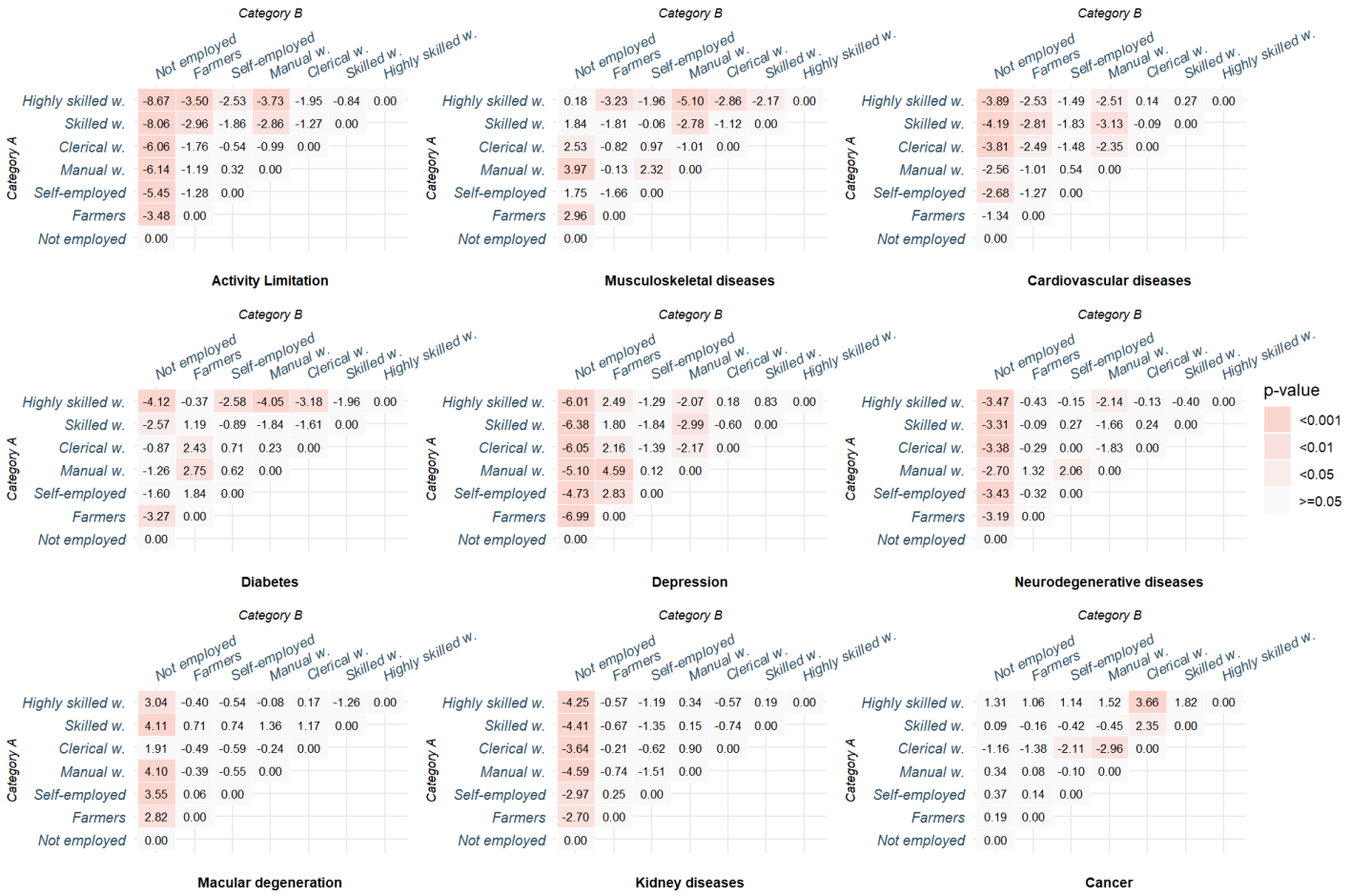


Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)

Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization. Age standardization was based on the French population structure of 2015.

Example of interpretation: The age standardized prevalence of activity limitation is significantly lower among the highly skilled compared to "Not employed" women, at the 1% level, based on the z-score = -4.22 and p<0.001.

Figure I.S.4. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in weighted age-standardized prevalence of AL and chronic diseases within men (in merged sample from CARE-M and CARE-I).



Source: Men aged 60 and over from CARE-M (2015, N = 4,100) and CARE-I (2016, N = 756)

Notes: Weighted prevalence and 95% confidence intervals were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization. Age standardization was based on the French population structure of 2015.

Example of interpretation: The age standardized prevalence of activity limitation is significantly lower among the highly skilled compared to farmers, at the 1% level, based on the z-score = -3.50 and p<0.001.

D. Estimations from additive regression models (I): Disabling impacts.

Table I.S.7. Estimated disabling impacts (β coefficients), with 95% confidence intervals, from fitted additive hazard models across socio-occupational categories within women.

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Chronic diseases.							
Musculoskeletal diseases	0.44 (0.16, 0.69)	0.17 (-0.14, 0.45)	0.30 (0.06, 0.60)	0.47 (0.33, 0.63)	0.33 (0.25, 0.40)	0.33 (0.23, 0.45)	0.32 (0.20, 0.49)
Depression	1.02 (0.32, 2.39)	0.91 (0.25, 2.35)	0.77 (0.19, 1.68)	0.60 (0.21, 1.30)	0.49 (0.26, 0.82)	0.45 (0.07, 0.97)	0.76 (0.20, 2.39)
Diabetes	0.01 (-0.25, 0.58)	0.63 (0.07, 1.47)	0.26 (-0.16, 1.40)	0.05 (-0.05, 0.26)	0.36 (0.16, 0.59)	0.52 (0.13, 1.30)	0.57 (0.00, 1.95)
Cardiovascular diseases	0.98 (0.42, 1.85)	0.97 (0.39, 2.10)	0.83 (0.23, 1.94)	0.83 (0.35, 1.62)	0.61 (0.37, 0.91)	0.66 (0.28, 1.28)	0.39 (0.01, 1.72)
Kidney diseases	1.00 (0.34, 2.22)	0.62 (-0.18, 12.35)	4.28 (2.89, 12.42)	0.28 (-0.08, 1.35)	1.07 (0.49, 2.16)	0.38 (-0.05, 1.41)	0.65 (-0.20, 11.43)
Neurodegenerative diseases	1.06 (0.38, 2.41)	2.09 (1.42, 3.30)	1.99 (1.20, 3.68)	1.94 (1.43, 2.70)	2.01 (1.48, 2.85)	2.59 (1.73, 4.17)	2.20 (1.25, 3.72)
Macular degeneration	1.20 (0.50, 2.23)	2.85 (1.61, 12.67)	2.08 (0.93, 4.06)	0.88 (0.33, 1.93)	0.77 (0.37, 1.53)	1.42 (0.62, 2.89)	1.22 (0.23, 4.02)
Cancer	1.06 (0.25, 2.64)	1.34 (0.26, 12.35)	0.61 (-0.08, 3.41)	0.47 (0.08, 1.36)	0.56 (0.27, 0.95)	0.15 (0.01, 0.42)	0.29 (0.00, 0.83)
Background	0.30 (0.18, 0.49)	0.31 (0.17, 0.59)	0.22 (0.10, 0.41)	0.08 (0.05, 0.13)	0.12 (0.08, 0.16)	0.06 (0.03, 0.11)	0.05 (0.01, 0.10)

Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)
Notes: Estimated disabling impacts represent the cumulative rate of AL estimated from the fitted binomial additive regression models, with the use of survey weights; 95% confidence intervals are based on 1000 bootstrapping simulations.

Table I.S.8. Estimated disabling impacts (β coefficients), with 95% confidence intervals, from fitted additive hazard models across socio-occupational categories within men.

	Socio-occupational group					
	Not employed	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Chronic diseases.						
Musculoskeletal diseases	0.26 (-0.06, 0.60)	0.47 (0.27, 0.71)	0.32 (0.20, 0.46)	0.43 (0.20, 0.71)	0.43 (0.30, 0.57)	0.24 (0.11, 0.39)
Depression	0.72 (-0.14, 11.78)	0.08 (-0.11, 1.24)	0.43 (0.09, 1.05)	1.37 (0.36, 11.71)	0.47 (0.04, 1.62)	0.67 (0.10, 2.81)
Diabetes	0.45 (-0.11, 1.78)	0.45 (0.10, 0.99)	0.20 (0.01, 0.43)	-0.03 (-0.20, 0.23)	0.19 (-0.01, 0.46)	0.08 (-0.09, 0.33)
Cardiovascular diseases	1.24 (0.56, 2.62)	0.85 (0.41, 1.48)	0.68 (0.44, 1.00)	0.47 (0.10, 1.06)	0.49 (0.25, 0.85)	0.42 (0.14, 0.83)
Kidney diseases	0.23 (-0.39, 12.30)	0.14 (-0.12, 0.69)	0.40 (0.02, 1.21)	0.38 (-0.15, 2.61)	0.37 (-0.01, 1.30)	1.01 (0.43, 2.11)
Neurodegenerative diseases	2.11 (1.07, 12.23)	1.89 (1.24, 3.57)	1.45 (0.74, 2.58)	2.10 (1.21, 11.23)	3.49 (2.44, 11.60)	1.37 (0.69, 3.57)
Macular degeneration	-0.02 (-0.41, 11.81)	1.10 (0.19, 3.76)	1.85 (0.85, 4.06)	0.10 (-0.60, 10.57)	0.44 (-0.07, 1.68)	1.10 (0.10, 3.83)
Cancer	-0.08 (-0.41, 11.48)	1.31 (0.44, 3.28)	0.66 (0.21, 1.37)	2.31 (1.24, 11.84)	0.67 (0.26, 1.46)	0.50 (0.10, 1.17)
Background	0.28 (0.11, 0.58)	0.09 (0.04, 0.17)	0.18 (0.12, 0.25)	0.19 (0.10, 0.31)	0.09 (0.05, 0.14)	0.14 (0.08, 0.20)

Source: Men aged 60 and over, except the inactive group, from CARE-M (2015, N = 4,030) and CARE-I (2016, N = 721)
Notes: Estimated disabling impacts represent the cumulative rate of AL estimated from the fitted binomial additive regression models, with the use of survey weights; 95% confidence intervals are based on 1000 bootstrapping simulations.

E. Estimations from additive regression models (II): Absolute contributions of chronic diseases to AL.

Table I.S.9. Estimated absolute contributions of chronic diseases to AL (in %) with 95% confidence intervals, from fitted additive hazard models among men and women (in merged sample from CARE-M and CARE-I).

	Women	Men	p-values
Chronic diseases			
Musculoskeletal diseases	16.51 (15.99, 17.00)	12.77 (12.18, 13.37)	P<0.01
Cardiovascular diseases	4.57 (4.15, 4.94)	6.58 (5.94, 7.19)	P<0.01
Diabetes	2.23 (2.00, 2.48)	2.08 (1.85, 2.30)	P=0.35
Depression	2.87 (2.57, 3.17)	1.23 (1.00, 1.47)	P<0.01
Neurodegenerative diseases	2.66 (2.38, 2.95)	1.61 (1.36, 1.91)	P<0.01
Macular degeneration	2.05 (1.75, 2.38)	0.94 (0.71, 1.18)	P<0.01
Kidney diseases	1.46 (1.25, 1.71)	0.97 (0.80, 1.14)	P<0.01
Cancer	1.30 (1.12, 1.50)	2.00 (1.66, 2.36)	P<0.01
Background	8.81 (8.74, 8.87)	10.95 (10.86, 11.03)	P<0.01

Source: Respondents aged 60 and over, from CARE-M (2015, N = 10,593) and CARE-I (2016, N = 2,958)
Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases, which add up to 42.5% for women and 39.1% for men; 95% confidence intervals are based on 1000 bootstrapping simulations; p-values are based on z-test statistics with standard errors estimated by Taylor linearization.

Table I.S.10. Estimated absolute contributions of chronic diseases to AL (in %) with 95% confidence intervals, from fitted additive hazard models for <u>women</u> (in merged sample from CARE-M and CARE-I).

	Socio-occupational group						
	Not employed	**Farmers**	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Chronic diseases.							
Musculoskeletal diseases	17.26 (15.58, 18.92)	8.17 (7.24, 9.10)	12.65 (10.91, 14.33)	20.60 (18.85, 22.25)	16.32 (15.60, 17.09)	17.34 (16.06, 18.63)	14.65 (12.91, 16.38)
Cardiovascular diseases	6.65 (5.40, 8.30)	8.53 (6.59, 10.79)	6.34 (4.52, 8.38)	5.63 (4.39, 7.13)	4.16 (3.57, 4.75)	3.05 (2.20, 4.00)	1.16 (0.66, 1.78)
Diabetes	0.15 (0.11, 0.19)	2.82 (1.87, 3.98)	1.75 (1.06, 2.59)	0.52 (0.40, 0.66)	2.99 (2.54, 3.44)	1.82 (1.18, 2.58)	1.72 (0.84, 2.72)
Depression	4.61 (3.34, 6.10)	2.99 (2.03, 4.09)	2.20 (1.42, 3.11)	3.15 (2.40, 3.99)	2.92 (2.48, 3.42)	1.86 (1.30, 2.49)	3.32 (1.84, 4.96)
Neurodegenerative diseases	4.02 (3.12, 5.37)	4.33 (3.19, 5.60)	2.50 (1.52, 3.98)	3.32 (2.58, 4.22)	2.52 (2.11, 2.98)	1.65 (1.05, 2.62)	1.37 (0.76, 2.22)
Macular degeneration	3.24 (2.12, 4.55)	3.85 (2.41, 5.50)	3.69 (1.77, 6.70)	1.72 (1.15, 2.47)	1.42 (1.09, 1.79)	2.40 (1.50, 3.43)	1.02 (0.42, 1.86)
Kidney diseases	1.67 (1.15, 2.29)	1.72 (0.81, 2.84)	3.22 (1.78, 5.10)	0.71 (0.48, 1.00)	1.90 (1.45, 2.38)	0.73 (0.44, 1.08)	0.84 (0.25, 1.58)
Cancer	1.96 (1.29, 2.89)	2.91 (1.20, 5.04)	1.38 (0.66, 2.41)	1.18 (0.75, 1.71)	1.74 (1.34, 2.12)	0.76 (0.52, 1.06)	1.14 (0.60, 1.78)
Background	19.12 (18.50, 19.71)	20.47 (19.63, 21.30)	15.61 (15.00, 16.17)	5.91 (5.79, 6.04)	9.01 (8.92, 9.11)	4.90 (4.82, 4.99)	4.09 (4.01, 4.18)

Source: Women aged 60 and over from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202)
Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases 95% confidence intervals are based on 1000 bootstrapping simulations.

Table I.S.11. Estimated absolute contributions of chronic diseases to AL (in %) with 95% confidence intervals, from fitted additive hazard models for men (in merged sample from CARE-M and CARE-I).

	Socio-occupational group					
	Farmers	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Chronic diseases.						
Musculoskeletal diseases	10.66 (9.02, 12.27)	14.91 (12.68, 17.13)	12.57 (11.63, 13.55)	15.45 (13.23, 17.79)	14.82 (13.26, 16.41)	7.51 (6.55, 8.44)
Cardiovascular diseases	12.26 (9.01, 15.84)	9.66 (7.27, 12.25)	8.16 (6.91, 9.43)	4.44 (3.17, 5.84)	4.59 (3.68, 5.59)	3.86 (2.96, 4.82)
Diabetes	3.45 (1.92, 5.19)	4.64 (3.37, 6.05)	2.56 (2.14, 3.02)	-0.37 (-0.49, -0.27)	2.13 (1.63, 2.69)	0.68 (0.48, 0.89)
Depression	0.64 (0.33, 0.99)	0.22 (0.13, 0.32)	1.31 (0.96, 1.76)	1.76 (1.09, 2.69)	0.77 (0.47, 1.17)	1.40 (0.79, 2.21)
Neurodegenerative diseases	2.08 (1.21, 3.05)	1.23 (0.87, 1.65)	2.01 (1.46, 2.68)	1.14 (0.73, 1.66)	1.76 (1.11, 2.60)	1.00 (0.69, 1.35)
Macular degeneration	-0.03 (-0.07, -0.01)	1.35 (0.68, 2.25)	1.35 (0.82, 1.98)	0.13 (0.03, 0.24)	0.97 (0.51, 1.50)	1.15 (0.46, 1.98)
Kidney diseases	0.54 (0.22, 0.98)	0.63 (0.33, 0.98)	0.94 (0.68, 1.22)	1.30 (0.62, 2.07)	0.94 (0.57, 1.34)	2.03 (1.30, 2.90)
Cancer	-0.18 (-0.32, -0.08)	3.05 (1.64, 4.68)	2.00 (1.42, 2.57)	1.48 (0.92, 2.20)	2.03 (1.37, 2.78)	2.29 (1.56, 3.16)
Background	19.58 (18.84, 20.27)	6.93 (6.71, 7.15)	13.20 (12.99, 13.40)	14.32 (14.01, 14.62)	7.16 (7.05, 7.28)	11.30 (11.11, 11.47)

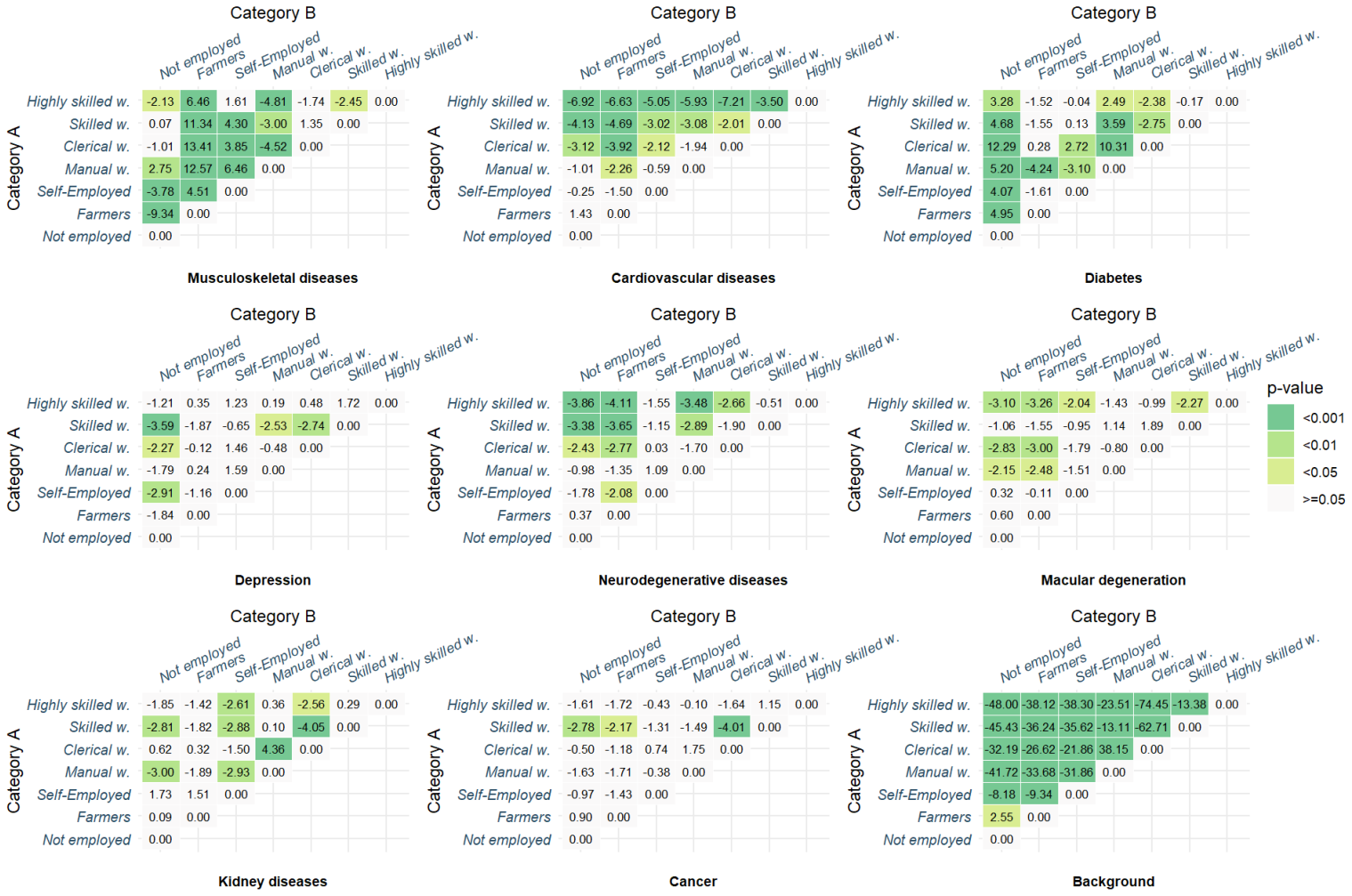
Source: Men aged 60 and over, except men in the category "Not employed", from CARE-M (2015, N = 4,030) and CARE-I (2016, N = 721)
Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases 95% confidence intervals are based on 1000 bootstrapping simulations.

Table I.S.12. Estimated Z-scores and p-values, testing gender differences (women – men) in absolute contribution of chronic diseases to AL prevalence within socio-occupational categories (in merged sample from CARE-M and CARE-I).

	Socio-occupational group					
	Farmers	**Self-Employed**	**Manual w.**	**Clerical w.**	**Skilled w.**	**Highly skilled w.**
Chronic diseases.						
Musculoskeletal diseases	**Z=2.62; p<0.01**	Z=1.59; p=0.11	**Z= -8.19; p<0.01**	Z=-0.62; p=0.49	**Z=-2.41; p=0.02**	**Z=-7.12; p<0.01**
Cardiovascular diseases	Z=1.73; p=0.084	**Z=1.97; p=0.05**	**Z=2.51; p=0.02**	Z=0.37; p=0.71	**Z=2.19; p=0.03**	**Z=4.62; p<0.01**
Diabetes	Z=0.59; p=0.55	**Z=3.44; p<0.01**	**Z=8.35; p<0.01**	**Z=-14.24; p<0.01**	Z=0.64; p=0.52	**Z=-2.01; p=0.04**
Depression	**Z=-3.98; p<0.01**	**Z=-4.24; p<0.01**	**Z=-3.77; p<0.01**	**Z=-2.16; p=0.03**	**Z=-2.82; p<0.01**	**Z=-2.06; p=0.04**
Neurodegenerative diseases	**Z=-2.75; p<0.01**	Z=-1.62; p=0.10	**Z=-2.28; p=0.02**	**Z=-3.9; p<0.01**	Z=0.17; p=0.86	Z=-0.77; p=0.44
Macular degeneration	**Z=-4.61; p<0.01**	Z=-1.45; p=0.14	Z=-0.75; p=0.45	**Z=-6.55; p<0.01**	**Z=-2.43; p=0.02**	Z=0.22; p=0.83
Kidney diseases	Z=-1.91; p=0.56	**Z=-2.64; p<0.01**	Z=1.10; p=0.27	Z=-1.29; p=0.19	Z=0.77; p=0.44	**Z=2.05; p=0.04**
Cancer	**Z=-2.85; p<0.01**	Z=1.70; p=0.09	**Z=2.04; p=0.04**	Z=-0.61; p=0.54	**Z=3.05; p<0.01**	**Z=2.10; p=0.04**
Background	Z=-1.62; p=0.11	**Z=-28.21; p<0.01**	**Z=61.37; p=0**	**Z=32.93; p<0.01**	**Z=30.64; p<0.01**	**Z=77.12; p=0**

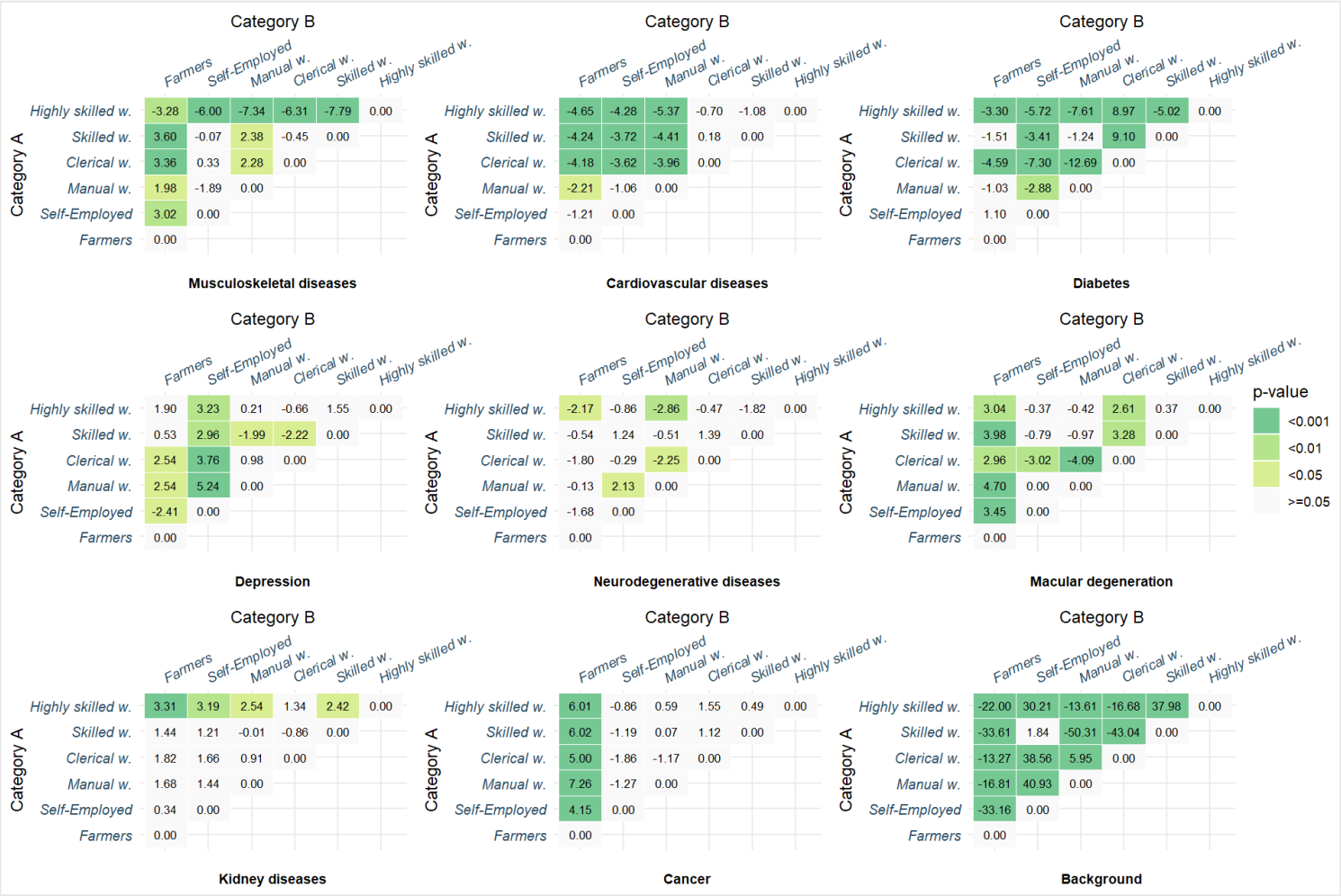
Source: Respondents aged 60 and over, except men in the category "Not employed", from CARE-M (2015, N = 10,523) and CARE-I (2016, N = 2,923)
Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases 95% confidence intervals are based on 1000 bootstrapping simulations; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.
Example of interpretation: Within farmers, the absolute contribution of musculoskeletal diseases to AL prevalence is significantly higher among women compared to men, at the 1% level, based on the z-score = 2.62 and p<0.01.

Figure I.S.5. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in absolute contributions of chronic diseases to AL within <u>women</u> (in merged sample from CARE-M and CARE-I).



Source: Women aged 60 and over, from CARE-M (2015, N = 6,493) and CARE-I (2016, N = 2,202).
Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases 95% confidence intervals are based on 1000 bootstrapping simulations; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.
Example of interpretation: The AC of depression to AL prevalence is significantly lower among skilled workers compared to inactive women at the 1% level, based on a z-score = -3.59, and p<0.01.

Figure I.S.6. Estimates Z-scores and p-values, testing socio-occupational differences (Category A – Category B) in absolute contributions of chronic diseases to AL within men (in merged sample from CARE-M and CARE-I).



Source:
Men aged 60 and over, except inactive men, from CARE-M (2015, N = 4,030) and CARE-I (2016, N = 721).

Notes: Absolute contributions (AC) were derived from both estimated disabling impact of diseases and their weighted prevalence, with the use of survey weighted provided in CARE-M and CARE-I; AC represent the decomposed components of the prevalence of AL attributed to chronic diseases 95% confidence intervals are based on 1000 bootstrapping simulations; Z-scores were based on z-test statistics with standard errors estimated by Taylor linearization.

Example of interpretation: The AC of diabetes to AL prevalence is significantly lower among highly skilled workers compared to farmers at the 1% level, based on a z-score = -3.30, and p<0.01.

F. Estimations from decomposition analysis.

Table I.S.13. Estimated odds ratios (ORs) representing associations of variables of interest with AL, based on fitted logistic regressions across men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women	Men
Chronic diseases.		
Musculoskeletal diseases	**3.63***** (2.98, 4.43)	**2.99***** (2.41, 3.72)
Cardiovascular diseases	**3.21***** (2.38, 4.34)	**3.55***** (2.67, 4.70)
Diabetes	**2.19***** (1.64, 2.91)	**1.72***** (1.29, 2.29)
Kidney diseases	**3.67***** (2.24, 6.01)	**2.08**** (1.26, 3.42)
Neurodegenerative diseases	**13.14***** (7.34, 23.53)	**14.46***** (6.54, 32.77)
Depression	**3.47***** (2.52, 4.77)	**3.23***** (1.90, 5.49)
Macular degeneration	**4.82***** (2.80, 8.29)	**3.10*** (1.44, 6.68)
Cancer	**2.53***** (1.64, 3.92)	**4.25***** (2.50, 7.23)
Educational attainment. *Reference modality: "No diploma"*		
High school diploma or vocational certificate	0.86 (0.71, 1.04)	0.92 (0.72, 1.16)
Undergraduate or graduate studies	0.74 (0.54, 1.03)	0.83 (0.60, 1.15)
Marital status. *Reference modality: "In a civil union"*		
Divorced	1.33 (0.99, 1.77)	1.11 (0.79, 1.54)
Widow (er)	1.17 (0.93, 1.47)	1.21 (0.80, 1.82)
Never in a civil union	**1.49*** (1.06, 2.09)	1.35 (0.95, 1.90)
Age *Reference modality: "Age group: 60-69"*		
70-79	**1.45**** (1.15, 1.82)	1.16 (0.90, 1.48)
80-89	**2.53***** (1.94, 3.29)	**2.89***** (2.12, 3.93)
90+	**6.96***** (4.77, 10.17)	**7.71***** (3.72, 15.96)
French origin.	**0.67***** (0.50, 0.88)	0.95 (0.71, 1.29)
Number of observations	N= 8364	N = 4752

Source: Respondents aged 60 and over with complete data on variables of interest, from CARE-M (2015, N = 10592) and CARE-I (2016, N = 2524).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I.S.14. Estimated odds ratios (OR) representing associations of variables of interest with AL, based on fitted logistic regressions across manual and highly skilled workers within men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Manual	**Highly skilled**	**Manual**	**Highly skilled**
Chronic diseases.				
Musculoskeletal diseases	**6.84***** (3.95, 11.84)	**8.86***** (3.76, 20.85)	**2.47***** (1.67, 3.64)	**2.09**** (1.25, 3.51)
Cardiovascular diseases	**6.66***** (2.91, 15.21)	**4.20*** (1.21, 14.66)	**3.54***** (2.22, 5.66)	**3.13**** (1.64, 5.94)
Diabetes	1.13 (0.64, 2.02)	**7.47*** (1.19, 46.85)	**1.73*** (1.10, 2.71)	1.45 (0.72, 2.90)
Kidney diseases	2.01 (0.77, 5.29)	3.39 (0.45, 25.66)	2.12 (0.92, 4.86)	**6.36***** (2.27, 17.85)
Neurodegenerative diseases	**17.52***** (8.36, 36.70)	**55.15***** (11.21, 271.45)	**8.05***** (2.53, 25.56)	**8.53***** (2.29, 31.77)
Depression	**2.95**** (1.39, 6.25)	**9.76***** (3.65, 26.06)	**2.56*** (1.12, 5.85)	**5.75**** (1.66, 19.98)
Macular degeneration	**3.89**** (1.46, 10.41)	5.18 (0.32, 83.57)	**9.16**** (1.99, 42.16)	**8.52**** (1.83, 39.57)
Cancer	**2.98*** (1.03, 8.65)	1.77 (0.38, 8.35)	**3.67*** (1.40, 9.64)	**4.14**** (1.62, 10.57)
Age.				
70-79	1.17 (0.63, 2.17)	0.91 (0.42, 1.98)	1.25 (0.79, 1.98)	**1.84*** (1.04, 3.25)
80-89	**2.87**** (1.48, 5.57)	1.30 (0.46, 3.69)	**2.57**** (1.58, 4.19)	**7.33***** (3.26, 16.46)
90+	**3.28**** (1.41, 7.64)	72.43*** (10.94, 479.36)	4.86 (0.98, 23.97)	**5.32***** (2.08, 13.61)
French origins.	0.79 (0.36, 1.73)	0.85 (0.30, 2.45)	1.01 (0.64, 1.59)	0.84 (0.37, 1.89)
In a civil union.	**0.57*** (0.33, 0.98)	1.29 (0.62, 2.70)	0.87 (0.58, 1.29)	0.64 (0.37, 1.10)
Number of observations	N= 1340	N=484	N=1657	N=768

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 3,419) and CARE-I (2016, N = 832).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I.S.15. Estimated odds ratios (OR) representing associations of variables of interest with AL, based on fitted logistic regressions across farmers and highly skilled workers within men and women (in merged sample with no missing data from CARE-M and CARE-I).

	Women		**Men**	
	Farmers	**Highly skilled**	**Farmers**	**Highly skilled**
Chronic diseases.				
Musculoskeletal diseases	2.30 (0.97, 5.45)	**8.86***** (3.76, 20.86)	**3.16*** (1.22, 8.15)	**2.11**** (1.26, 3.51)
Cardiovascular diseases	**3.70**** (1.39, 9.86)	**4.20*** (1.20, 14.66)	**8.56***** (3.30, 22.23)	**3.11**** (1.64, 5.92)
Diabetes	**2.82*** (0.86, 9.26)	**7.47*** (1.19, 46.87)	2.79 (0.70, 11.13)	1.45 (0.72, 2.89)
Kidney diseases	2.08 (0.44, 9.80)	3.39 (0.45, 25.67)	2.15 (0.27, 17.02)	**6.42***** (2.29, 17.97)
Neurodegenerative diseases	**13.52***** (4.09, 44.63)	**55.15***** (11.20, 271.52)	**27.34***** (4.34, 172.14)	**8.64***** (2.35, 31.76)
Depression	**5.21***** (2.13, 12.74)	**9.76***** (3.65, 26.06)	2.41 (0.12, 47.08)	**5.73*** (1.65, 19.88)
Macular degeneration	**21.04***** (3.83, 115.60)	5.18 (0.32, 83.61)	0.98 (0.15, 6.19)	**8.76*** (1.87, 41.03)
Cancer	**6.64*** (1.16, 38.14)	1.77 (0.38, 8.36)	0.16 (0.01, 2.36)	**4.13**** (1.61, 10.60)
Age.				
70-79	**5.15**** (1.57, 16.92)	0.91 (0.42, 1.98)	1.03 (0.29, 3.60)	**1.85*** (1.06, 3.25)
80-89	**20.60***** (6.70, 63.36)	1.30 (0.46, 3.69)	2.09 (0.81, 5.37)	**7.34***** (3.27, 16.49)
90+	**12.28***** (3.41, 44.26)	**72.43***** (10.94, 479.50)	**25.55***** (6.01, 108.58)	**5.27***** (2.06, 13.46)
French origins.	1.15 (0.22, 5.94)	0.85 (0.30, 2.45)	*Not applicable*	*Not applicable*
In a civil union.	0.79 (0.40, 1.59)	1.29 (0.62, 2.70)	1.55 (0.73, 3.29)	0.63 (0.36, 1.09)
Number of observations	N= 675	N=484	N=377	N=768

Source: Respondents aged 60 and over with complete data on variables of interest, from the categories of manual and highly skilled workers in CARE-M (2015, N = 1,826) and CARE-I (2016, N = 478).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I.S.16. Estimated odds ratios (OR) representing associations of variables of interest with AL, based on fitted logistic regressions across inactive and highly skilled workers within women (in merged sample with no missing data from CARE-M and CARE-I).

	Not employed	**Highly skilled**
Chronic diseases.		
Musculoskeletal diseases	**2.88** (1.58, 5.28)**	**8.86*** (3.76, 20.85)**
Cardiovascular diseases	**3.79** (1.70, 8.47)**	**4.20* (1.21, 14.66)**
Diabetes	1.84 (0.89, 3.81)	**7.47*** (1.19, 46.86)
Kidney diseases	3.04 (0.92, 10.03)	3.39 (0.45, 25.66)
Neurodegenerative diseases	**4.52* (1.31, 15.57)**	**55.15***** (11.21, 271.47)
Depression	**5.38** (1.85, 15.62)**	**9.76***** (3.65, 26.06)
Macular degeneration	**4.23* (1.27, 14.11)**	5.18 (0.32, 83.58)
Cancer	5.07 (0.71, 36.11)	1.77 (0.38, 8.35)
Age		
70-79	1.26 (0.50, 3.13)	0.91 (0.42, 1.98)
80-89	1.52 (0.64, 3.60)	1.30 (0.46, 3.69)
90+	**5.16** (1.85, 14.37)**	**72.43*** (10.94, 479.39)**
French origin.	0.95 (0.51, 1.76)	0.85 (0.30, 2.45)
In a civil union	0.49 (0.26, 0.91)	1.29 (0.62, 2.70)
Number of observations	N= 1129	N = 484

Source: Subsample of women respondents aged 60 and over with complete data on variables of interest, from the categories of "Not employed" and highly skilled workers in CARE-M (2015, N = 1129) and CARE-I (2016, N = 484).
Notes: Results are based on fitted logistic regression models that accounted for survey weights with the *svyglm function* with the R *survey* package. Stars denote significance: ∗p<0.05; ∗∗p<0.01; ∗∗∗p<0.001.

Table I.S.17. Proportion of men and women within each age group in the merged CARE sample (CARE-M 2015 and CARE-I 2016, 2016, N = 13,551).

Cohort	Age in CARE	N Men	N Women	N Total	% Men (weighted)	% Women (weighted)
1947–1956	60–69	1,439	1,583	3,022	47.4%	52.6%
1937–1946	70–79	1,398	1,914	3,312	46.7%	53.3%
1927–1936	80–89	1,422	3,140	4,562	38.0%	62.0%
1917–1926	90–99	585	1,985	2,570	28.5%	71.5%
1907–1916	99+	12	73	85	11.8%	88.2%
Total 60+		**4,856**	**8,695**	**13,551**	**43.8%**	**56.2%**

Source: Respondents aged 60 and over from CARE-M (2015, N = 10,593) and CARE-I (2016, N=2,958).
Notes: Weighted distributions were estimated with the *svymean* function in the R *survey* package, using survey weights provided in CARE-M and CARE-I; p-values are obtained from z-scores that compare weighted distributions across women and men.

Chapter 2. Impact of musculoskeletal conditions and depressive symptoms on activity restrictions among men and women in mid-adulthood: Evidence from CONSTANCES.

Co-authored with Emmanuelle Cambois and Pierre-Yves Geoffard

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Extended abstract.

Building on the results from Chapter 1, which examined the associations between chronic diseases and activity limitation (AL), this chapter focuses specifically on musculoskeletal conditions (MSC), including diagnosed osteoarticular diseases and related pain disorders, and depressive symptoms (DS). According to the 2019 Global Burden of Disease Study, musculoskeletal and mental disorders were the two leading causes of years lived with disability in France, underscoring the relevance of examining these conditions. Both conditions also have been identified as major contributors to the gender survival paradox, that is, the well-established observation that women live longer than men but spend more years with activity restrictions. Evidence from the literature, together with the findings from Chapter 1, indicates that gender disparities in the prevalence of MSC and poor mental health contribute to gender gaps in activity restrictions.

The conceptual framework of disability situates activity restrictions as the final stage of the disablement process, often measured through limitations in elementary activities of daily living (ADL) and instrumental activities of daily living (IADL). However, focusing solely on severe forms of disability overlooks earlier limitations that typically emerge in mid-adulthood and may foreshadow subsequent disability. More general indicators of activity restrictions are therefore relevant, and in particular the well documented Global activity limitation indicator (GALI), which will be used in this work. Moreover, restrictions related to work and employment, key components of activity in this age group, have received limited attention, despite evidence that health problems strongly influence the ability to remain employed before retirement. For employment restrictions, we focus on the risk of leaving work prior to retirement and falling into the "Neither Employed Nor Retired" (NENR) category.

In light of this, this chapter investigates the associations of MSC and DS with both general activity limitations and employment restrictions among individuals aged 50–69, a crucial group for policies aiming to extend working lives.
Most previous studies have relied on cross-sectional data, leaving the dynamics of transitions into and out of AL or employment restrictions underexplored. In addition, few studies have assessed these processes separately for men and women. This is an important gap, since gender differences in prevalence of activity restrictions may stem not only from differences in the distribution of diseases but also from differences in their disabling impact. Assessing whether MSC and DS affect men and women differently provides insights into whether gender inequalities in disability reflect differences in exposure, in impact, or both, an essential distinction for public policy.

We use data from the French CONSTANCES cohort, a large population-based study of adults in France. Analyses are based on data from inclusion (t_0), corresponding to the time of enrolment (CONSTANCES respondents were recruited in yearly sample from 2012 to 2019), and the first subsequent follow-up questionnaire (t_1), completed one year later. Two study samples are used depending on the availability of the outcome and other variables of interest. For the analysis of AL, the study sample focuses on 33590 individuals at t_0 among whom 20197 had available data in the variables of interest at t_1. It is worthy to note that the 2016 and 2017 CONSTANCES' follow up questionnaires did not include the question assessing AL, thus, individuals selected in this analysis (n=33590) are those who's baseline questionnaire did not occur during 2015 nor 2016. For the analysis focusing on employment restrictions, all inclusion waves were suitable. The selected sample consisted of individuals who were between 50 and 69 years of age at t_0, **not** retired at that time, and had no missing information in variables of interest: this resulted in a sample of 32003 at t_0, among whom 18869 had data in our variables of interest at t_1.

We first conduct cross-sectional analyses at t_0 to examine the associations between MSC, DS, and both AL and being NENR, using simple logistic regression models. We then assess the impact of MSC and DS at t_0 on transitions in the outcomes of interest over the one-year period. For AL, we analyze the risk of onset and persistence at t_1 using simple logistic regression models. For employment restriction, we examine the risk of transitioning from employment into NENR at t_1, as well as the likelihood of returning to employment at $t_1$among those classified as NENR at t_0. These employment transitions are modeled using multinomial logistic regression, as three employment states are possible at t_1: employed, NENR (including unemployment), or retired. All models are adjusted for age, educational attainment, marital status, and the presence of other chronic conditions, and are stratified by gender.

Results show that at inclusion (t_0), both diseases, MSC and DS, and restrictions, AL and NENR status (among non-retired respondents), were more prevalent among women. Cross-sectional results confirm strong associations in both men and women between DS or MSC and AL. The likelihood of being NENR at t_0 is associated with both MSC and DS among non-retired women and only with DS among non-retired men. Regarding transitions, for both genders, MSC and DS at t_0 increased probabilities of AL onset and persistence at t_1 while MSC and DS were associated with increased risks of becoming NENR after one year, for men and women initially non-retired; DS also predicted reduced chances of employment re-entry. There are no detected evidence of a gender difference in the associations of MSC and DS with transitions in restrictions.

This work remains limited by several shortcomings, including the short follow-up period and the observational design. Further longitudinal research is needed to assess long-term effects of these conditions of interest on activity restrictions and labor force participation. However, overall, this chapter provides new evidence that MSC and DS are strongly associated with both AL and employment restrictions in the pre-retirement period, and that their higher prevalence among women likely contributes to gender disparities in being either restricted in general activities or employment. Our findings point out the need for early interventions targeting musculoskeletal and mental health conditions to prevent the accumulation of disadvantages in mid- and later ages, including economic ones.

I. Introduction.

Life expectancy has increased over recent decades and is projected to continue rising, although at a slower pace (United Nations, 2024). Yet, gains in life expectancy have not always been matched by gains in years lived in good health. In France, the early 2000s saw an expansion of years lived with activity restrictions during mid-adulthood (Cambois et al., 2013). Activity restrictions refer to difficulties or inabilities, because of functional impairments, to perform activities that individuals are expected to carry out in their daily lives and within their community. Several spheres of activity define these limitations. A first sphere concerns self-care, or "Activities of Daily Living" (ADL), which ensure basic needs are met, such as dressing, using the toilet, eating, or moving from bed to chair. A second sphere includes domestic and organizational tasks, or "Instrumental Activities of Daily Living" (IADL), which allow individuals to live independently in a household, for example preparing meals, shopping, managing medications, administrative tasks, or using public transportation. Some studies extend this scope to limitations in general daily activities without specifying a domain, enabling individuals to consider restrictions that matter to them, such as social participation, cultural and leisure activities, physical activities, or grand-parenthood. This broader perspective is particularly relevant in mid-adulthood, when restrictions in ADL and IADL remain relatively rare. At these ages, limitations in work activities also represent a key aspect of restricted functioning. Activity restrictions come against the process of healthy ageing, defined by the World health organization (WHO) as "the process of developing and maintaining the functional ability that enables well-being in older age" (World Health Organization, 2020).

Even when they appear in the early phases of ageing, activity restrictions are costly. For individuals, they lower quality of life and increase the risk of dependency later in life. For governments, they create higher needs for long-term care, assistive devices, and medical services (OECD, 2023a). When restrictions affect employment, they reduce productivity, increase unemployment, and can lead to transitions to disability pensions, all of which add pressure on social protection systems (Meyer & Mok, 2013; Okamoto et al., 2023). Overall, activity restrictions are a major concern for policymakers and deserve targeted prevention.

A large body of research has shown that activity restrictions are closely tied to a number of chronic diseases, which therefore constitute key targets for public health and social policies (Jagger et al., 2020; Nusselder, Wapperom, et al., 2019; Verbrugge & Jette, 1994). Neurodegenerative diseases, such as Alzheimer's disease and Parkinson's disease, have become increasingly relevant targets with rising longevity. Although they are generally present at older ages, they have a strong disabling impact on cognitive and mobility functions and often lead to substantial dependency in daily life (Bloem et al., 2021; C. A. Lane et al., 2018; Waldman et al., 2024). Other chronic diseases with more moderate disabling impacts but higher prevalence starting mid-adulthood, have also been examined in the literature due to their link with limiting the number of activities people are able to do. Their high prevalence means they contribute significantly to the overall disability burden, both through impacts on daily functioning and through economic effects related to reduced social and work participation and the costs of treatment.

Musculoskeletal conditions (MSC) are recognized as leading cause of disability worldwide (consistent with findings from Chapter 1) (Al-Ajlouni et al., 2023; Briggs et al., 2018; Guan et al., 2025; Nusselder, Wapperom, et al., 2019; World Health Organization, 2022). In the field of mental health, depression and anxiety disorders are also widely recognized as risk factors for activity restrictions (Rehm & Shield, 2019). In the French context, results from the 2019 global burden of disease study found that mental and musculoskeletal disorders were the two leading causes of years lived with disabilities (YLDs) (Francis-Oliviero et al., 2024). Both conditions are widely present in the population: In 2021, 60% of French women and 50% of men declared a musculoskeletal pain, and 12.5% of 18 to 85 year olds had experienced a depressive episode in the 12 months preceding their data collection (Santé publique France, 2023, 2024).

MSC and mental disorders have also been extensively mentioned in works investigating gender inequalities in healthy ageing. While women generally outlive men, they spend more of their additional years with restrictions (Crimmins et al., 2011; OECD & European Observatory on Health Systems and Policies, 2023; Oksuzyan et al., 2009). In the literature, this paradox has been partly attributed to women's higher prevalence of disabling conditions namely MSC and poor mental health, while men are more likely to

face lethal diseases, reducing their lifespans, such as cardiovascular diseases or aggressive cancers. Examining how MSC and mental health shape activity restrictions, for men and women, is therefore important both for improving healthy ageing starting mid-adulthood and for understanding gender inequalities in restrictions experienced at old ages.

This introductory section is divided into three parts. The first part explains, drawing on theoretical frameworks and empirical evidence, how MSC and poor mental health can contribute to activity restrictions. The second part examines gender disparities in the distribution of MSC, and poor mental health. The third part presents the objectives of this chapter in light of its contribution to the literature.

I. 1. How do musculoskeletal conditions and poor mental health lead to activity restrictions ?

Theoretically, activity restrictions portray disabilities that result from a process that starts with diseases, that is the "disablement process" (Nagi, 1964). This conceptual framework has been referenced across many disciplines including sociology, medicine, epidemiology, and demography, to describe the link between chronic diseases and disabilities at old ages. The process goes as follows: Diseases lead to bodily impairments, which in turn affect physical, sensory, and cognitive functions that can reduce abilities of holding objects, climbing stairs, doing long walks, seeing and hearing clearly, orienting oneself in space, or recalling memories. These limitations can then restrict individuals' participation in various activities, from essential daily tasks, like feeding oneself, bathing, and fulfilling housework or preparing meals, to broader social engagements, such as paid and voluntary work, cultural activities, care for relatives, physical activities, social gatherings... While diseases are recognized as the primary drivers of the disablement process, treatments or technical aids, as well as social and environmental factors critically influence how diseases translate into disabilities, shaping the overall trajectory of disablement (Verbrugge & Jette, 1994).

While several chronic diseases are risk factors for disability at older ages, they do not follow the same trajectories toward activity restrictions. Some conditions, such as

Alzheimer's and Parkinson's diseases, directly impair cognition and autonomy and are particularly difficult to treat once advanced (Bloem et al., 2021; Martin, Prince et al., 2015). However, these conditions remain far less prevalent than others and become more frequent mainly at the oldest ages, which limits their overall contribution to the prevalence of activity restrictions at the population level. Other conditions or disorders that are more common can sometimes be effectively prevented, and others can be treated, controlled, or monitored, which mitigates their role in driving activity restrictions, like for example, presbyopia. Some other diseases are linked to high mortality, such as aggressive cancers, and may therefore lead to fewer restrictions being reported, as they shorten life expectancy before limitations appear. In contrast to these cases, MSC and poor mental health stand out because they are highly prevalent, more difficult to manage over time, and strongly associated with activity restrictions.

For MSC, they include arthritis, osteoporosis, carpal tunnel syndrome, and chronic pain disorders affecting different parts of the body such as the neck, back, shoulders, or elbows. By reducing mobility, they restrict participation in work and social activities (Briggs et al., 2016, 2018; Shah et al., 2011b; Walker & Littlejohn, 2007). In the labor market, MSC are among the most frequent causes of disability pension eligibility (Badarin et al., 2023; Briggs et al., 2016; Holland & Clayton, 2020; Polvinen et al., 2014; Ropponen et al., 2011; Vahtera et al., 2010). Even when comorbidities are considered, MSC remain the top contributors to activity restrictions (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2019).

As for poor mental health, in particular depression and anxiety disorders, they are also major contributors to activity restrictions. These conditions limit daily and social engagement by reducing energy, concentration, and motivation (American Psychiatric Association, 2013; Buss et al., 2022; Covinsky et al., 2010b; Cronin-Stubbs et al., 2000; Kazama et al., 2011; Mezuk et al., 2012). In the labor market, evidence has shown that depression is not only a consequence of unemployment but also a cause of it (Andreeva et al., 2015; Jefferis et al., 2011). Individuals with poor mental health face lower chances of re-employment after job loss, higher risks of transitioning to disability pensions, and greater likelihood of early retirement (Olesen et al., 2012; van Rijn et al., 2014). In

Australia, for example, poor mental health has been linked to early retirement among men and premature workforce exit among women (Olesen et al., 2012a).

I. 2. Gender disparities in the distribution of musculoskeletal conditions and poor mental health.

Women generally outlive men, but evidence shows they are more likely to experience and report activity restrictions. This paradox has often been explained by gender differences in the disease patterns (Crimmins et al., 2011; Kingston et al., 2014; Oksuzyan et al., 2009): Men are more likely to experience lethal diseases such as cardiovascular conditions and cancers, while women live longer with disabling conditions such MSC and poor mental health.

Some studies suggest that women are disadvantaged both by the higher prevalence of MSC and a greater severity of these diseases, shaped by social and biological factors. Occupational experiences are relevant factors in explaining gender differences in risks of MSC: while men are more often employed in physically strenuous jobs, women are concentrated in lower-skilled occupations involving repetitive tasks, prolonged postures, and manual handling, all of which elevate MSC risks (Briard, 2022; Guignon, 2008; Madsen et al., 2018; Srinivasan et al., 2016; Yung et al., 2020). Beyond employment, women frequently combine paid work with domestic and caregiving responsibilities, creating a "double exposure" to musculoskeletal strain (Campos-Serna et al., 2013; Fagan & Norman, 2021; Osinuga et al., 2021). Biological differences further compound this vulnerability. Women's stronger immune responses, while protective in many respects, heighten susceptibility to autoimmune joint disorders (J.-R. Kim & Kim, 2020; Overstreet et al., 2023). In addition, hormonal changes around menopause, including declining estrogen levels, increase pain sensitivity and accelerate joint degeneration, contributing to higher risks of osteoarthritis and rheumatoid arthritis in mid and late adulthood for women (Felson & Cummings, 2005; Khadilkar, 2019; Mei et al., 2022).

Poor mental health is also more commonly found among women and often more disabling. This also reflects an interplay of biological factors, such as hormonal

fluctuations, and social exposures, including caregiving responsibilities, occupational trajectories, and gender discrimination (Alblooshi et al., 2023; Cambois et al., 2017, p. 201; Freeman et al., 2006; Girgus & Yang, 2015; Rantanen et al., 2021). Women are more likely than men to report adverse psychosocial work conditions, such as low job control, insecure employment, and limited career progression (Beaufils et al., 2023b; Cambois, 2016; Clausen et al., 2022). Gender wage inequalities also contribute to women's higher experience of chronic stress and poorer mental health outcomes (Platt et al., 2016). Beyond the labor market, women more frequently assume unpaid caregiving roles, and in the absence of employment, these duties can intensify risks of depression (Beaumont & Gulliford, 2023; Rexhaj et al., 2023; Scheuermann et al., 2024). When combined with MSC, depressive symptoms (DS) have been shown to exacerbate restrictions by reducing motivation for physical activity and complicating symptom management (Moussavi et al., 2007; Stubbs et al., 2017). This interaction places women at a higher risk of limitations in both daily activities and employment, further deepening gender inequalities in activity restrictions (Christofaro et al., 2022; Newman et al., 2024).

I. 3. This work: Motivation and objectives.

Previous research has consistently shown strong links between MSC, poor mental health, and activity restrictions in later life, often beginning in mid-adulthood. However, most studies have relied on cross-sectional data and on measures of restrictions that primarily capture severe limitations in daily living, such as ADL and IADL. While these studies align with theoretical expectations, cross-sectional designs are known to be limited, as they are better suited to studying associations rather than impacts. Besides, cross-sectional data cannot capture whether health conditions lead to a later onset of restrictions, or whether individuals recover from restrictions over time, which is essential to better understanding diseases' disabling impacts. Moreover, the narrow focus on severe restrictions (i.e ADL and IADL indicators) overlooks earlier limitations in general activities that often appear in mid-adulthood, reduce social participation of the persons, impact their quality of life, and may signal subsequent disability.

When considering limitations in general activities, a focus on health-related restrictions in employment are also essential to consider. Evidence shows that MSC and depression

are associated with unemployment, disability pensions, and early retirement, but most studies examine these conditions separately rather than together. Besides, to our knowledge, no work has done so in the French context. This gap is particularly important given the high prevalence of these conditions in France and the policy environment shaped by pension reforms that have raised statutory retirement ages, requesting to protect health and participation in mid-adulthood to be efficient. The relevance of the issue is illustrated by the fact that in 2021, 80% of occupational diseases recognized by the French social security system were musculoskeletal diseases, which remain highly costly for both individuals and the system (Assurance Maladie, 2022).

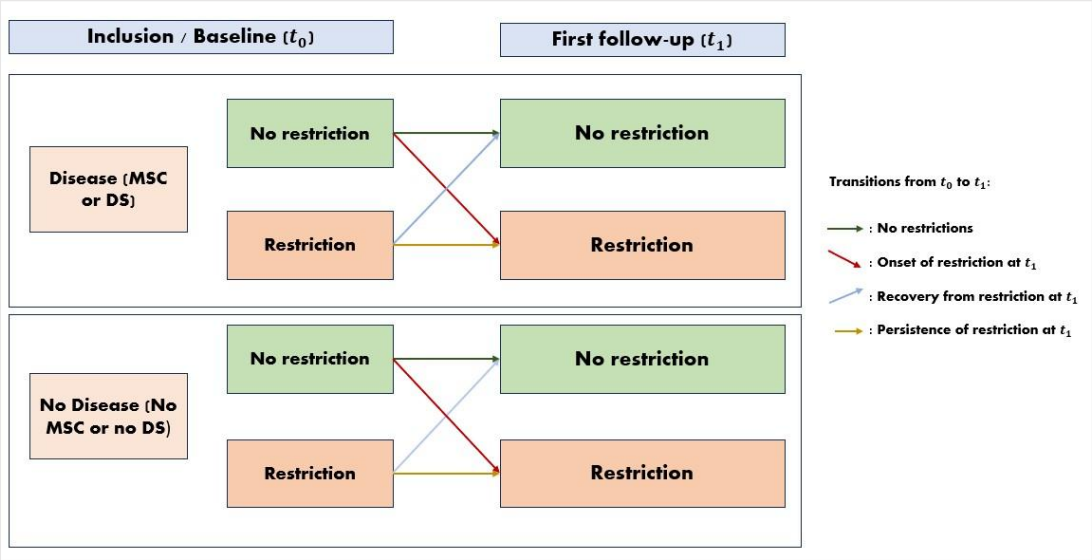
Additionnally, few works have examined the dynamics between these diseases and activity restrictions separately for men and women. This is an important gap, as part of the gender differences observed in the prevalence of activity restrictions at older ages reflects differences in the distributions of MSC and poor mental health. Examining their impacts for each gender makes it possible to test whether MSC and poor mental health have similar effects for men and women, or whether the effects differ, which would suggest that gender inequalities in activity restrictions are linked not only to differences in prevalence but also to differences in the impact of diseases in the risk of being limited in general activities, along with being restricted in work activites. This would be informative for public policy makers in their planned strategies.

Leveraging data from the French CONSTANCES cohort, a large population-based study with follow-up information, we examine the impact of indicators of MSC and DS on activity restrictions among men and women in mid-adulthood. Activity restrictions are assessed along two dimensions. First, we consider general activity limitations (AL), captured by self-reported question about *being limited in activities people usually do because of a health problem* (respondents can think of work, house chores, leisure, social activities). Second, we examine the risk of being out of employment before retirement, a status we refer to as “Neither employed nor retired” (NENR). This category is of growing importance in the context of ongoing pension reforms that postpone the minimum retirement age, exposing individuals with health problems to a longer period of potential income loss before pensions become available.

We begin with cross-sectional analyses using data of the inclusion waves of the CONSTANCES cohort, to measure the associations between MSC and DS with the risk of AL and with the risks of being NENR. We then assess the disabling impact of these conditions over a one-year period, focusing on the risks of onset and persistence of AL, and then on the risks of becoming NENR, the chances of re-entry into employment or the transition to retirement. The transitions of interest over the one-year follow-up period are illustrated in Box A below.

CONSTANCES' large dataset allows us to focus on mid-adulthood, stratify by gender, and look at gender specific patterns. Besides, the dataset allows to adjust for a wide range of sociodemographic factors and other health conditions.

Box II.A. Illustration of types of transitions in activity restrictions over the one-year follow-up in CONSTANCES.



II. Data.

II.1 French CONSTANCES cohort.

This work is based on the French CONSTANCES cohort, a large population-based study based on the overall French population (CONSTANCES team et al., 2015), that recruits individuals aged 18 to 69 at inclusion waves. Recruitment was proceeded annually among people registered in the national disease insurance fund (CNAM), which covers more than 85% of the French population (excluding agricultural workers), and who are

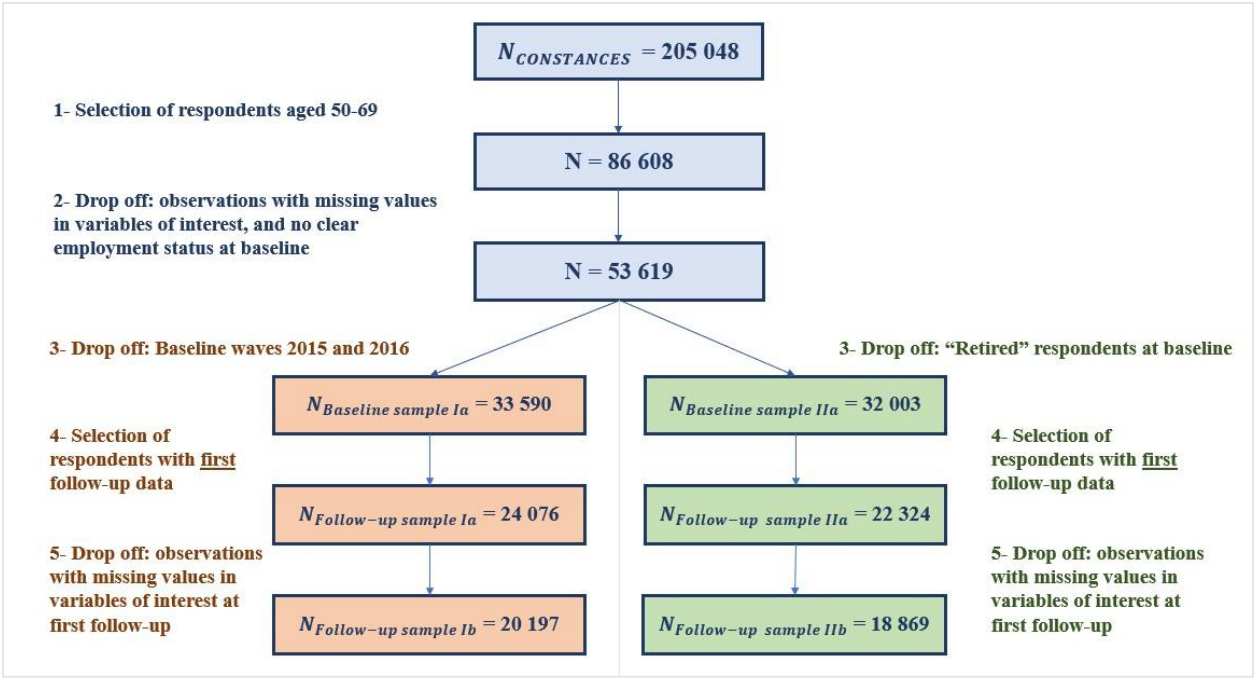
administratively attached to one of the CNAM Health Examination Centers participating in the study. The recruitment began in 2012 and continued until 2020 to reach the planned 200,000 participants, with additional recruitment in 2021. Each year, individuals were randomly selected with respect to a stratification by age, sex, occupational status, and region to optimize representativeness and invited to participate in the study by mail. At inclusion waves (also referred to as baseline waves), participants filled in questionnaires on lifestyle, health, physical limitations, and social and personal characteristics, and went to an examination center where they underwent a standardized medical examination including physiological, and biological measures, with additional cognitive tests for those aged 45 years or older. Information on socioeconomic characteristics, occupations, and family medical history was also collected. Participants received annual follow-up questionnaires that repeated a selection of questions on health and employment status, enabling a number of longitudinal measurements. However, not all variables were repeatedly measured in follow-up questionnaires, which prevented advanced panel data analysis with multiple time points.

Although CONSTANCES was designed to sample from the general population of CNAM beneficiaries, participation required attending a health examination at a participating center among 21 health centers that were part of the CONSTANCES project. This requirement led to a low participation rate, around 8% (Launay, 2024), resulting in a volunteer cohort that is not fully representative of the French population. As documented in several works that have used data from the CONSTANCES cohort (Goldberg et al., 2017b; Neufcourt et al., 2020), as well as the cohort's protocol, volunteers tend to be more educated and in better health than non-participants. These selection patterns reflect well-known gradients in participation in health surveys. Despite this, the cohort includes a broad diversity of social positions, occupations, and health conditions, enabling the study of associations between chronic diseases and activity restrictions.

For this study, we selected participants aged 50 to 69 at the time of inclusion (t_0), and excluded those with missing data in our variables of interest. Participants identified as students or apprentices were also excluded due to their small numbers (N=175), which

made it impractical to analyze them as a distinct group regarding employment status. This selection leads to a total of 53 619 respondents. As the objectives of this work were twofold, one with a focus on activity restrictions related to AL and transitions in AL status; and one with a focus on employment status, and transitions in it, two different subsamples were selected, as presented in the flowchart shown in Figure II. 1. Because of the selection mechanism that is not fully captured by the cohort's sampling weights, and because the objective of the analysis is to estimate associations rather than population prevalence, weights are not applied in this work.

Figure II. 1. Flowchart of sample selections from CONSTANCES data (N=205 048).



For the analyses focused on AL, respondents recruited in the 2015 and 2016 waves were excluded from the study sample, as the 2016 and 2017 CONSTANCES follow-up waves did not collect information on AL. Consequently, it was not possible to follow AL status for this group of respondents. The resulting sample for the analysis on AL comprised 33,590 respondents (Sample Ia: 17,972 women and 15,618 men). Among these, 20,197 individuals (Sample Ib: 10,999 women and 9,198 men) were included in the analysis of

transitions in AL status, based on the non-missingness of variables of interest at the first follow-up (t_1).

As for the analysis focused on employment status, from the initial sample of individuals aged 50–69 (N = 53,619), those who were retired at baseline (t_0) were excluded, resulting in a sample of 32,003 respondents (Sample IIa: 17,480 women and 14,523 men). Among these, 18,869 individuals (Sample IIb: 10,564 women and 8,305 men) had complete information on the variables of interest at the first follow-up. Robustness checks were performed to account for those lost to follow-up.

II.2 Variables.

II.2. a. Outcomes: activity restrictions.

Activity Limitation (AL).

In CONSTANCES, across all waves, respondents were asked: "*For the past 6 months, have you been limited, that is, have had difficulties due to a health problem, in performing routine activities (at home, at work, during leisure time) compared to people your age*". This is one version of the Global Activity limitation Indicator (GALI), often used in the literature to identify the form of disability related to activity limitation (Berger et al., 2015). Answer options were "Yes, strongly limited", "Yes, limited", "Yes, lightly limited" and "No". A dummy variable was constructed where we considered respondents who answered with a "Yes" in any form, as experiencing AL.

Status of "Neither Employed Nor Retired" (NENR).

In all questionnaires, respondents were asked to specify their current employment status. We summarized employment status into three categories: "*Employed* " for those who reported being employed (including those temporarly off work), "*Retired* " for those who identified themselves as retired, and "*Neither Employed Nor Retired*" (*NENR*) for those who were either out of labor force or job seekers. The NENR category was of particular interest as it portrayed scenarios of employment restrictions, which could stem from barriers related to health, discrimination, or other structural factors that keep individuals out of the labor force. Job seekers were also included in this category, as they might be

facing employment restrictions by not being matched with available jobs, possibly due to the same barriers (Kampfe et al., 2008).

II.2. b. Variables of interest:

Musculoskeletal conditions (MSC).

MSC were identified when individuals either self-reported a diagnosis of an osteoarticular disease in the last 12 months (e.g., osteoporosis, osteoarthritis, carpal tunnel syndrome, rheumatoid arthritis) or reported experiencing frequent pain in one or more body parts, such as the wrist, elbow, shoulder, neck, back, or knee, for at least 30 days in the preceding year. The information about pain location and duration, which followed the structure of the Nordic questionnaire for analyzing musculoskeletal symptoms (Carton et al., 2016; Kuorinka et al., 1987), was only captured in a specific section of CONSTANCES' inclusion questionnaire (t_0), and not repeated in the follow-up questionnaire, which imposed its consideration only at t_0.

Depressive Symptoms (DS).

To detect DS, we used scores from the 20-item Center for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977) available in the CONSTANCES baseline questionnaire (t_0). The CES-D measures the frequency of 20 depressive symptoms experienced in the preceding week, with a total score ranging from 0 to 60, where a higher score indicates greater levels of depressive symptomatology. Based on recommendations from the literature (Morin et al., 2011), we applied gender-specific thresholds to identify depressive symptoms: a minimum score of 20 for women and 16 for men. Using gender-specific cut-offs is recommended because women generally report higher frequencies of affective and somatic symptoms, such as sadness, fatigue, worry, and irritability, which are captured by several CES-D items. Studies have shown that these differences can arise even when underlying depressive severity is comparable, suggesting the potential for gender-related differences in symptom expression or reporting (Morin et al., 2011; Salk et al., 2017). A single threshold may therefore over-identify depressive symptoms in women and under-identify them in men, making gender-specific cut-offs preferable for epidemiological analyses.

The decision to use a binary variable for DS, based on CES-D threshold scores rather than a continuous measure, is supported by studies demonstrating that this approach is a widely accepted practice for identifying individuals with clinically significant depressive symptoms (Vilagut et al., 2016). Similarly to MSC, DS are considered as baseline characteristics as the CES-D quessionnaire was additionnally available only in two follow-up waves (2015 and 2018).

Other health variables to control for co-morbidity.

At inclusion (t_0), and in all follow-up questionnaires (t_1, t_2, …), respondents were provided with a list of chronic diseases and asked whether they had ever experienced or been diagnosed by a doctor with any of them. Known as major disabling diseases, we selected cancers, diabetes, cardiovascular, and respiratory diseases as other health conditions. Diabetes, cardiovascular, and respiratory diseases were grouped into a signle binary indicator, labeled 'Other chronic conditions', which was coded as 1 for respondents reporting any of these conditions, and 0 otherwise. A history with a cancer was modeled as a separate binary covariate, as recommended by the CONSTANCES team, due to its more heterogenous trajectory toward disablement which depends on site and treatment. To avoid reducing the power of planned empirical models (due to low distribution of certain cancer types), cancers were pooled into one indicator while remaining analytically distinct from the non-cancer conditions.

Sociodemographic variables.

We selected various dimensions of the social status which are known to be related to diseases and disability, and to be differently distributed in men and women. We used information on highest educational attainement categorized into: "No diploma", "High-school diploma", "Vocational certificate", "Undergraduate degree", and "Graduate or Post-graduate degree". This followed common practice in French surveys and was consistent with the international standard classification of education (ISCED, 2011) (UNESCO, 2012). Besides, we accounted for partnership status, distinguishing between those who were married or in a civil union, and those who were single, separated, divorced, or widowed at inclusion. Additionnaly, along with age, we considered birth cohorts as they were affected by different health context, labour market dynamics and

retirement policies, grouping them into four cohorts: those born in 1943-1948, 1949-1954, 1955-1960, and 1961-1971.

Although CONSTANCES collected information on household income at baseline, we did not use this variable as an indicator of socioeconomic status. Respondents were asked to report total household income, rather than individual income, by choosing from seven broad income brackets (ranging from "less than 450 euros" to "more than 4200 euros"), with the option to select "prefer not to answer". Interpreting household income in the age group of interest in this study is challenging, particularly for respondents living with partners or other household members, and for those already receiving pension income. In addition, the proportion of missing and non-response categories was non-negligible (around 7% among respondents aged 50–69 at inclusion) which would have reduced oursample size. For these reasons, educational attainment was retained as a more stable and comparable indicator of socioeconomic position and one that aligns more closely with indicators commonly used in the literature.

III. Empirical Strategies.

We firstly examined the distributions of variables of interest by gender at inclusion (t_0), and examined the associations between MSC, DS, with AL and the status of NENR at t_0, using cross-sectional analysis. Next, we used inclusion and first subsequent follow-up waves (t_1) and examined the distribution of transitions between t_0 and t_1 in AL status ($GALI_{t_0} \rightarrow GALI_{t_1}$) and across the employment status ($Employment\ status_{t_0} \rightarrow Employment\ status_{t_1}$) for each gender. Due to the available data, we could not use advanced panel data analysis to increase the robustness of our estimations by using repeated waves. Statistical tests were used to identify potential differences in variables' distributions between women and men: a "two-proportion z-test" was used for categorical and binary variables, and "t-tests" were used for age.

We used logistic models to estimate the associations between MSC and DS with our outcomes of interest at t_0, and to investigate the role of MCS and DS in the risks of onset and persistence of restrictions at t_1, for each gender. Pooled logistic regression models including Gender as an explanatory variable and interaction terms with MSC and DS were

additionally estimated to assess gender heterogeneity. Both targeted interaction (with MSC and DS only) and fully interacted specifications were considered. However, stratified models are presented in the main analysis for clarity of gender-specific estimates, while pooled interaction models are examined in the robustness section.

III.1 Cross-sectional analysis at t_0.

To investigate associations between both diseases (MSC, DS) and activity restrictions at t_0, simple logistic regressions (Equation 1) were initially fitted, for each gender. Information on sociodemographic and other diseases were used as controls. An interaction term between MSC and DS was included to account for the possibility that their co-occurrence may be associated with a different risk of AL than their independent associations would suggest. That is, DS may amplify the functional consequences of MSC, and chronic pain may in turn intensify the disabling impact of DS.

Equation 1. Model specification for simple logistic regressions at baseline (t_0) , fitted separately for each gender (Outcome A: AL; Outcome B: being NENR).

$$\log\left(\frac{P(Restriction=1)_i}{P(Restriction=0)_i}\right)^{A,B} = \beta_0^{A,B} + \beta_1^{A,B}\text{MSC}_i + \beta_2^{A,B}\text{DS}_i + \beta_3^{A,B}(\text{MSC}_i \times \text{DS}_i) + \gamma_1^{A,B}\text{Age}_i + \sum_{l=1}^{3}\gamma_{2,l}^{A,B}\text{Cohort}_{li} + \sum_{k=1}^{4}\gamma_{3,l}^{A,B}\text{Education}_{ki} + \gamma_4^{A,B}\text{Partnership}_i + \theta_1^{A,B}\text{Cancer}_i + \theta_2^{A,B}\text{Other chronic conditions}_i$$

Results are presented as average marginal effects (AMEs), which quantify absolute changes in predicted probabilities and are more interpretable than log-odds coefficients in nonlinear models. Given the nonlinearity of logistic regression, coefficients and odds ratios cannot be interpreted as changes in outcome probabilities; AMEs allow meaningful comparison of effect magnitudes across genders (Hanmer & Ozan Kalkan, 2013; Mood, 2010; Norton et al., 2018, 2024). Analysis were done using the *glm()* function from the *stats* package in R, which applies maximum likelihood estimation to fit logistic regression

models (Venables & Ripley, 2002), and marginal effects were computed using the *marginaleffects* package.

III.2 Analysis on transitions between t_0 and t_1.

To examine effects of MSC and DS at t_0 on transitions in AL and across employment status between t_0 and t_1, simple and multinomial logistic regression models were applied on the relevant samples, conditional on statuses at t_0, for each gender. Models were adjusted on birth cohort and highest educational attainment fixed from baseline t_0. For chronic conditions and partnership status, the models use status at t_1 to reflect any developments that have occurred during the follow-up period, such as newly diagnosed health conditions or changes in relationship status. In line with our research objectives, we focused on specific transition scenarios.

III.2. a. Risks of onset and persistence of AL at t_1.

For transition into AL, two simple logistic models were estimated as AL was measured with a binary variable (Equation 2). For those who were "Not-limited at t_0", a model was fitted to investigate risks of "**onset**" of global activity limitation in at t_1, where the outcome of interest was "Being Limited" at t_1. For those who were "Limited" at t_0, a model was fitted to investigate the risk of "**persistence**" of a limitation, with the same outcome of interest of "Being Limited" at t_1. Odds ratios (ORs), average marginal effects (AMEs) and their 95% confidence intervals (CIs) were estimated using the "*marginal effects*" R package. Similarly to the case of cross-sectional analysis, a focus is given to AME.

Equation 2. Model specification for simple logistic regressions estimated for transition into AL, fitted separately for each gender.

$$\log\left(\frac{P(\text{Outcome of interest}_{t_1}=1 \mid GALI_{t_0})_i}{P(\text{Outcome of interest}_{t_1}=0 \mid GALI_{t_0})_i}\right) = \beta_0 + \beta_1 \text{MSC}_{i,t_0} + \beta_2 \text{DS}_{i,t_0} + \beta_3(\text{MSC}_{i,t_0} \times \text{DS}_{i,t_0}) + \gamma_1 \text{Age}_{i,t_1} + \sum_{l=1}^{3} \gamma_{2,l} \text{Cohort}_{li} + \sum_{k=1}^{4} \gamma_{3,l} \text{Education}_{ki} + \gamma_4 \text{Partnership}_{i,t_1} + \theta_1 \text{Cancer}_{i,t_1} + \theta_2 \text{Other chronic conditions}_{i,t_1}$$

III.2. b. Transitions across employment statuses.

Regarding transitions across employment status, there were three possible states at t_1 ("Employed", "Retired", or "NENR"), which required multinomial models to be fitted, conditional on each status at t_0 (Equation 3). Generally, in multinomial logistic regressions, each outcome modality is compared individually to a chosen reference modality, requiring separate logistic regressions for each comparison (Greene, 2003; Parks, 1980). In this study, having three possible states at t_1 for each status at t_0 resulted in a total of twelve estimated models[8].

To examine the association between MSC, DS and transitions in employment status, the analysis focused on estimated average predicted probabilities (APPs) of outcomes of interest at t_1. Predicted probabilities were obtained from the fitted multinomial model for each individual using the model-implied probability function (Agresti, 2010). APPs were then computed by averaging these individual predicted probabilities over the sample. To compare transition risks by exposure status, APPs were estimated under counterfactual scenarios where MSC (respectively DS) was set to 0 for all individuals and then to 1 for all individuals, while other covariates were kept at their observed values. This provides group-comparable transition probabilities for individuals "with" versus "without" MSC (or DS) at t_0.

Confidence intervals for the APPs were derived using 1,000 nonparametric bootstrap resamples of the analytic sample. For each resample, predicted probabilities were

[8] There were two possible states at t_0 (Employed or NENR), and for each of these states there were three possible states at t_1, that is, three possible outcomes at t_1 (Employed, NENR or Retired). In a multinomial logistic model, each outcome has to be compared to a reference outcome, thus, six (3x2) models were fitted for each state at t_0.

recomputed from the fitted multinomial model under the same exposure scenarios, and percentile-based 95% confidence intervals were obtained from the empirical distribution of the bootstrapped APPs. The analysis was performed using the *multinom()* function from the *nnet* R package (Venables & Ripley, 2002).

In this multinomial setting, the focus was placed on APPs rather than Average Marginal Effects (AMEs), which were reported in the binary logistic models. While AMEs summarize changes in the probability of a single binary outcome, in multinomial models effects must be evaluated across multiple competing states. APPs directly represent the transition probabilities of interest and therefore align more closely with the objective of comparing transition risks between individuals with and without MSC or DS at t_0.

Equation 3. Model specification from multinomial logistic regressions estimated for transition across employment status, fitted separately for each gender.

$$\log\left(\frac{P(\text{Modality of interest}_{t_1} \mid Status_{t_0})_i}{P(\text{Reference modality}_{t_1} \mid Status_{t_0})_i}\right) = \beta_0 + \beta_1 \text{MSC}_{i,t_0} + \beta_2 \text{DS}_{i,t_0} + \beta_3 (\text{MSC}_{i,t_0} \times \text{DS}_{i,t_0}) + \gamma_1 \text{Age}_{i,t_1} + \sum_{l=1}^{3} \gamma_{2,l} \text{Cohort}_{li} + \sum_{k=1}^{4} \gamma_{3,l} \text{Education}_{ki} + \gamma_4 \text{Partnership}_{i,t_1} + \theta_1 \text{Cancer}_{i,t_1} + \theta_2 \text{Other chronic conditions}_{i,t_1}$$

IV. Results.

IV. 1. The association of MSC and DS with activity restrictions, in CONSTANCES (baseline waves, t_0).

IV. 1. a. Sociodemographic and health characteristics of women and men in the baseline samples.

Table II. 1 gives the (non-weighted) distribution of variables of interest among men and women aged 50-69 years old in the inclusion sample used to investigate the associations of MSC and DS with AL (Sample Ia). Table II. 2 gives the distributions in the other selected sample, restricted to respondents who were not retired at inclusion, that investigates the associations of MSC and DS with the NENR status (Sample IIa).

In sample Ia, the average age was 59.2 for women and 59.6 for men. There was a relatively low representation of the cohort born between 1943-1948, who was eligible to retire at age 60 (5.44% among women, 7.04% among men) and, as explained earlier, an over-representation of individuals who had at least completed a high school diploma (67.07% of women and 59.48% of men) or post-graduate degrees (26.39% versus 22.21% for women, $p<0.01$). Most respondents were partnered with this being more common among men (72.41% versus 64.33% for women). Regarding activity status, around half of respondents were employed at inclusion (52.23% of women, 51.77% of men), with the proportion of those NENR being higher among women (9.73% versus 7.23% for men, $p<0.05$). The outcome AL, was significantly more reported by women (43.96%) than men (37.89%) ($p<0.01$).

Turning to reported health conditions in this sample, DS were found among 16.95% of women and 14.99% of men ($p<0.01$). Regarding MSC, the higher reporting among women reflected their higher experiences with both diagnosis of osteo-articular diseases (18.21% of women, 15.71% of men, $p<0.01$) and consistent body pain, whether experienced for more than 30 days a year (63.90% of women, 55.56% of men, $p<0.01$), or permanently (40% of women, 33.58% of men, $p<0.01$).

In contrast, cardiovascular diseases, diabetes, and respiratory diseases, grouped as "Other chronic conditions", were all more reported by men: 37.85% of men reported experiencing at least one of these conditions, versus 29.68% of women ($p<0.01$).
Focusing on the other selected sample of non-retired respondents at inclusion (Sample IIa, N= 32003), the average ages were 56 for women and 55.9 for men. Representation from the 1943-1948 and 1949-1954 cohorts was particularly low (0.73% and 0.75%, respectively), as many in these cohorts had reached minimum retirement age by the time of the inclusion surveys (2012-2020) but were not officially retired. Men in this sub-sample also showed higher rates of post-graduate degrees (29.37% versus 24.83% for women) and vocational certificates (26.76% versus 18.97% for women). Consistent with the first sample, most respondents were partnered, with a higher partnership rate among men (68.72% versus 62.59% for women). Health condition patterns in this sample were similar to the previous one: women reported higher rates of DS, MSC, and cancer, while

men reported higher rates of other chronic conditions. As for the outcome of interest relating to activity status, the proportion of women falling into the NENR category was significantly higher among women (16%) compared to men (11.65%).

Table II. 1. Distribution of Activity limitations, Musculoskeletal conditions and Depressive symptoms and sociodemographic variables and other health conditions, at inclusion (t_0) over sample of analysis on AL (Sample Ia, N= 33590).

	Women N=17972	Men N=15618	Z- scores and t-statistics, with p-values (Women versus Men)
Global Activities Limitation	8010 (44.57%)	5963 (38.18%)	z = 9.17 ; p<0.01
Musculoskeletal conditions	12326 (68.58%)	9529 (61.01%)	z = 8.75; p<0.01
Osteo-articular diseases	3273 (18.21%)	2453 (15.71%)	z = 5.58 ; p<0.01
Body pain for ≥ 30 days a year	11485 (63.90%)	8678 (55.56%)	z = 10.02 ; p<0.01
Permanent body pain	7189 (40.00%)	5245 (33.58%)	z = 9.75 ; p<0.01
Depressive symptoms	3046 (16.95%)	2341 (14.99%)	z = 4.49 ; p<0.01
Musculoskeletal conditions and Depressive symptoms	2440 (13.58%)	1659 (10.62%)	z = 7.76 ; p < 0.01
Age (Average)	59.2	59.6	t= -5.59; p < 0.01
Cohort			
1943-1948	978 (5.44%)	1100 (7.04%)	z = -5.90 ; p<0.01
1949-1954	5016 (27.91%)	4567 (29.24%)	z = -2.30 ; p<0.01
1955-1960	5602 (31.17%)	4869 (31.18%)	z = -0.01 ; p=0.99
1961-1971	6376 (35.48%)	5082 (32.54%)	z = 4.65 ; p<0.01
Highest educational attainment			
Post-graduate degree	3991 (22.21%)	4122 (26.39%)	z = -7.84 ; p<0.01
Undergraduate degree	4938 (27.48%)	3007 (19.25%)	z = 15.56 ; p<0.01
High School diploma	3123 (17.38%)	2162 (13.84%)	z = 8.18 ; p<0.01
Vocational Certificate	3559 (19.80%)	4535 (29.04%)	z = -17.32 ; p<0.01
No diploma	2361 (13.14%)	1792 (11.47%)	z = 4.34 ; p<0.01
Partnership status			
In partnership	11562 (64.33%)	11309 (72.41%)	z = -9.13 ; p<0.01
Health conditions			
History with Cancer	1833 (10.20%)	1094 (7.00%)	z = 9.92 ; p<0.01
Other chronic conditions	5334 (29.68%)	5912 (37.85%)	z = -13.04 ; p<0.01
Cardiovascular diseases	2105 (11.71%)	2758 (17.66%)	z = -14.35 ; p<0.01
Diabetes	580 (3.23%)	1071 (6.86%)	z = -14.99 ; p<0.01
Respiratory diseases	3217 (17.90%)	2997 (19.19%)	z = -2.76 ; p=0.01
Employment status			
Employed	9386 (52.23%)	8085 (51.77%)	z = 0.59 ; p=0.56
Retired	6837 (38.04%)	6404 (41.00%)	z = -46 ; p<0.01
Neither Employed Nor Retired	1749 (9.73%)	1129 (7.23%)	z = 7.84 ; p<0.01

Source: Selected sample of respondent aged between 50 and 69 (Sample Ia, N= 33 590) from the inclusion waves of the CONSTANCES cohort.
***Notes*:** Gender differences in means were tested using two-sample z-tests; a t-test was used for the difference in age distribution.

Table II. 2. Distribution of "Neither Employed Nor Retired", Musculoskeletal conditions and Depressive symptoms and sociodemographic variables and other health conditions at inclusion (t_0) over sample of analysis on employment status, based on the non-retired individuals at inclusion (sample IIa, N= 32300).

	Women N=17480	Men N=14523	Z- statistic and t-statistics, with p-values (Women versus Men)
Neither Employed Nor Retired	2796 (16.00%)	1692 (11.65%)	z = 10.37 ; p<0.01
Musculoskeletal conditions	11869 (67.90%)	8802 (60.61%)	z = 8.23; p<0.01
Osteo-articular diseases	2786 (15.94%)	2149 (14.80%)	z = 2.60 ; p<0.01
Body pain for ≥ 30 days a year	11215 (64.16%)	8056 (55.47%)	z = 10.14 ; p<0.01
Permanent body pain	6821 (39.02%)	4742 (32.65%)	z = 7.94 ; p<0.01
Depressive symptoms	3349 (19.16%)	2576 (17.74%)	z = 2.96 ; p<0.01
Musculoskeletal conditions and Depressive symptoms	2662 (15.23%)	1802 (12.41%)	z = 6.75 ; p < 0.01
Age (Average)	56	55.9	t= 1.17; p =0.24
Cohort			
1943-1948	128 (0.73%)	109 (0.75%)	z = -0.19 ; p=0.85
1949-1954	1539 (8.80%)	1194 (8.22%)	z = 1.78; p=0.07
1955-1960	6765 (38.70%)	5733 (39.48%)	z = -1.12 ; p=0.27
1961-1970	9048 (51.76%)	7487 (51.55%)	z = 0.26 ; p=0.79
Highest educational attainment			
Post-graduate degree	4341 (24.83%)	4266 (29.37%)	z = -8.57 ; p<0.01
Undergraduate degree	4804 (27.48%)	2906 (20.01%)	z = -7.86 ; p<0.01
High School diploma	3050 (17.45%)	1994 (13.73%)	z = -8.38 ; p<0.01
Vocational Certificate	3316 (18.97%)	3886 (26.76%)	z = 13.65 ; p<0.01
No diploma	1969 (11.26%)	1471 (10.13%)	z = 3.09 ; p<0.01
Partnership status			
In partnership	10941 (62.59%)	9980 (68.72%)	z = -6.88 ; p<0.01
Health conditions			
History with Cancer	1536 (8.79%)	625 (4.30%)	z = 11.66 ; p<0.01
Other chronic conditions	4417 (25.27%)	4429 (30.50%)	z = -8.92 ; p<0.01
Cardiovascular diseases	1549 (8.86%)	1761 (12.13%)	z = -9.07 ; p<0.01
Diabetes	412 (2.36%)	737 (5.07%)	z = -12.79 ; p<0.01
Respiratory diseases	2878 (16.46%)	2541 (17.50%)	z = -2.86 ; p<0.01
Activity restrictions			
Limitation in global activities	7833 (44.81%)	5588 (38.48%)	z = 9.08 ; p<0.01

Source: Selected sample of respondent aged between 50 and 69 and not retired at baseline (Sample IIa, N= 32 003) from the inclusion waves of the CONSTANCES cohort (2012-2021).
***Notes*:** Gender differences in means were tested using two-sample z-tests; a t-test was used for the difference in age distribution.

IV. 1. a. Associations of MSC and DS with likelihood of AL and being NENR, at inclusion (t_0).

Figure II. 2 displays the percentage distributions of AL from Sample Ia and employment status from sample IIa, among women and men aged 50-69, with and without the conditions of interest (MSC and DS). Next, Table II. 3 displays the estimated average marginal effects (AMEs) from fitted simple logistic regressions stratified by gender at inclusion, based on both study samples (Sample Ia, and Sample IIa). Odds ratios are displayed in Table II.S.1 and Table II.S.2 of supplementary materials. These estimations further test the associations at inclusion between MSC, DS and AL and being NENR, once controlling for other diseases and sociodemographic variables.

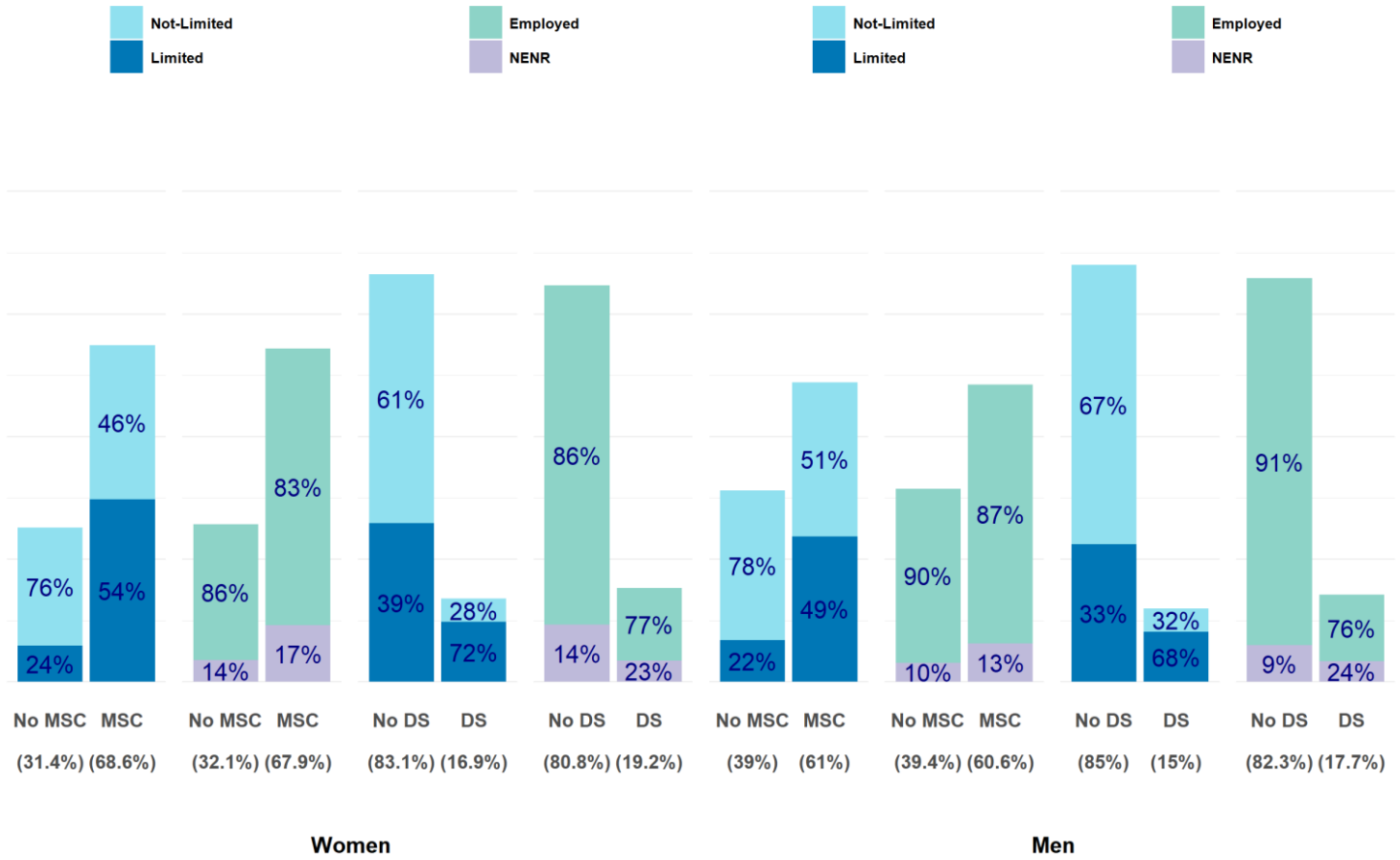
Distributions of AL and employment status conditional on MSC and DS.

Sarting with distributions presented in Figure II. 2, displayed percentages indicated signs of an overall positive correlation between MSC, DS and reporting AL or falling into the NENR category[9]. Among the 68.6% of women reporting MSC at inclusion, 54% were already reporting AL, while this proportion amounted to 24% among women who did not report MSC. Among men, 49% of those who reported MSC at inclusion also reported AL, and 22% of men with no MSC reported AL. For women with DS at inclusion (16.9%), 72% were also reporting AL, while 39% of women without DS reported AL. Within men, reporting AL was found among 68% of those with DS (13.9%) and 33% among those without DS.

Regarding employment status in the sample excluding the retired individuals at inclusion, 17% of women and 13% of men with MSC were NENR at inclusion, compared to 14% and 10% of those without MSC, respectively. Conversely, being employed was slightly more observed among women and men without MSC (86% for women and 90% for men without MSC, versus 83% and 87% for women and men with MSC, respectively). Finally, 23% of women and 24% of men who have reported DS were NENR, versus 14% and 9% for women and men without DS, respectively.

[9] All described differences in percentages discussed in this section were confirmed to be statistically significant at the 5% level, based on results from chi-square tests with $p<0.05$.

Figure II. 2. Distribution of AL and employment status over sample of analysis on AL (sample Ia, N= 33590 and sample IIa, N= 32003) at baseline (t_0) , among women and men with and without MSC and DS.



Source: Selected samples of respondent aged between 50 and 69 (Sample Ia, N= 33, 590, and Sample IIa, N= 32 003) from the inclusion waves of the CONSTANCES cohort (2012- 2021).
***Example of interpretation*:** 68.6% of women in Sample Ia reported musculoskeletal conditions (MSC), and among them, 54% declared being "Limited" in their daily activities; 67.9% of women in sample IIa reported MSC and 17% of them were neither employed nor retired (NENR); 15% of men in the Sample Ia had depressive symptoms (DS), and among them 68% declared being limited in their daily activities; 17.7% of men in sample IIa declared DS and among them 24% were NENR.

Table II. 3. Estimated average marginal effects of MSC, DS and control variables, from baseline (t_0) simple logistic regression models stratified by gender (based on samples Ia and IIa).

	Dependent variable:			
	Activity Limitation (AL)		Employment Restrictions among non-retired individuals (Neither Employed Nor Retired)	
	Women (1)	Men (2)	Women (3)	Men (4)
Variables of interest				
MSC	**0.27***** (0.25, 0.28)	**0.24***** (0.22, 0.24)	**0.01*** (0, 0.03)	0.01 (0, 0.02)
DS	**0.28***** (0.26, 0.30)	**0.3***** (0.28, 0.32)	**0.07***** (0.05, 0.08)	**0.1***** (0.09, 0.12)
Covariates				
Age	0 (-0.01, 0)	0 (0, 0)	**0.01***** (0.01, 0.01)	**0.01***** (0.01, 0.01)
Cohort *(ref: 1961-1971)*				
1955-1960	0.01 (-0.02, 0.03)	**0.03***** (0.01, 0.06)	**0.02**** (0.01, 0.04)	**0.02***** (0.01, 0.04)
1949-1954	0.02 (-0.01, 0.06)	0.03 (-0.01, 0.07)	**0.04**** (0.01, 0.07)	0 (-0.03, 0.02)
1943-1948	0.05 (0, 0.1)	0.03 (-0.02, 0.08)	0.03 (-0.03, 0.1)	-0.04 (-0.08, 0)
Highest educational attainment *(ref: Post-graduate degree)*				
Undergraduate degree	**0.03**** (0.01, 0.05)	**0.04***** (0.02, 0.06)	**0.03***** (0.02, 0.05)	0.01 (0, 0.03)
High School diploma	**0.04**** (0.02, 0.06)	**0.06***** (0.03, 0.08)	**0.07***** (0.06, 0.09)	**0.04***** (0.02, 0.05)
Vocational Certificate	**0.07***** (0.05, 0.09)	**0.1***** (0.08, 0.12)	**0.1***** (0.08, 0.11)	**0.06***** (0.05, 0.07)
No diploma	**0.12***** (0.09, 0.14)	**0.08***** (0.05, 0.1)	**0.16***** (0.14, 0.18)	**0.1***** (0.08, 0.12)
Partnership	0 (-0.02, 0.01)	-0.01 (-0.03, 0)	**0.04***** (0.03, 0.05)	**-0.07***** (-0.1, -0.06)
Other chronic diseases	**0.09***** (0.08, 0.11)	**0.1***** (0.08, 0.11)	**0.03***** (0.02, 0.04)	**0.05***** (0.04, 0.06)
History with cancer	**0.08***** (0.05, 0.1)	**0.06***** (0.03, 0.09)	**0.02*** (0, 0.04)	**0.03*** (0, 0.05)
Observations	17,972	15,618	17,480	14,523
Log Likelihood	−10,942.69	−9,194.28	−7,179.25	−4,727.17
Akaike Inf. Crit.	21,915.38	18,418.56	14,388.50	9,484.34

Source: Selected samples of respondent aged between 50 and 69 from the inclusion waves of the CONSTANCES cohort Analysis of AL (1) (2) are based on the selected sample of 33590 respondents from waves 2012, 2013, 2014, 2017, 2018, 2019,2020,2021 (Sample Ia); analysis of employment restrictions (3) (4) are based on the selected sample of 32003 from waves 2012-2021 (Sample IIa).
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

Association between MSC, DS and AL.

Estimated AMEs of variables of interest on AL, from fitted simple logistic regressions (Table II. 3) based on the selected sample from inclusion (Sample Ia), further confirmed a significant association between MSC or DS, and AL, among all, even after adjustment on the sociodemographic characteristics and other health conditions.

MSC and DS were positively associated, on average, with a higher risk of reporting AL at inclusion for both women and men. Precisely, reporting MSC was associated with a 27 and 24 percentage point higher predicted probabilities of AL among women and men, respectively (all $p<0.001$). The gender difference in the AME of MSC reached statistical significance at the 5% level, suggesting that the association between MSC and AL was slightly more pronounced among women[10]. As for DS, estimated AME of DS on AL exceeded 25 percentage points among all (AME=0.28 for women, and AME=0.3 for men, all $p<0.001$), with no signs of significant gender differences in associations between DS and AL.

In regards to other diseases, reporting history of cancer or other chronic diseases, which include diabetes, cardiovascular, or respiratory disease were also positively associated with the risks of declaring AL for both genders (For cancer: AME=0.08 for women, OR= 0.06 for men; For other chronic diseases: AME= 0.09 for women, OR= 0.1 for men; all $p<0.01$). As for sociodemographic factors, age and cohort were generally not significantly associated with the risk of reporting AL at t_0 (except for men born between 1955 and 1960 for whom there was a significant positive association with reporting AL compared to younger men born between 1961 and 1971). A social health gradient based on educational attainment was detected for both men and women: Having a post-graduate degree (reference modality) was estimated to be associated with a lower likelihood of reporting AL compared to other educational attainments. Besides, the AME of either having no diploma or having vocational certificates were higher than the AME of completing high school diplomas and undergraduate degrees, implying that the lower the educational level the higher the positive association with declaring AL. Finally, in regards to partnership

[10] This was confirmed by results from interacted models, where the coefficient of Gender interacted with MSC was statistically significant at the 5% level, p=0.015.

status, there was no significant association with declaring AL regardless of gender at inclusion.

Association between MSC, DS and being NENR.

In the analysis of the association of MSC and DS with the risk of being NENR, based on the sample of non-retired respondents at inclusion (Sample IIa) estimated AMEs suggested different patterns. Results likely confirmed an association of DS with the status of "NENR" for both women and men: Reporting DS at t_0 was associated with a 7 and 10 percentage point higher probabilities of falling in the NENR category among women and men, respectively. The AME of DS on the likelihood of being NENR at inclusion was significantly higher among men compared to women (as confirmed by results from interaction model[11]). In contrast, The AME of MSC on the likelihood of being NENR at inclusion was only significant at the 5% level for women (AME= 0.1, p=0.021, versus p=0.051 for the strata of men).

As for history of cancer and other chronic diseases, they were positively linked with the likelihood of being "NENR" for both women and men at t_0. Turning to socio-demographic factors, age was positively associated with being NENR for both women and men non-retired at t_0 (AME=0.01); and there was a gender heterogeneity in the association of partnership with employment status, as expected in the men "breadwinner" organization: being in partnership was positively associated with being NENR among women (AME=0.04, p<0.01), whereas it was negatively associated with this status among men (AME= -0.07, p <0.01).

[11] This was confirmed by results from interacted models, where the coefficient of Gender interacted with DS was statistically significant at the 5% level, p=0.0235.

IV. 2. MSC, DS and transitions in AL and across employment status, between inclusion (t_0) and first follow-up (t_1).

This section presents results from the analyses based on CONSTANCES' inclusion waves (t_0, 2012- 2021) and first subsequent follow-up waves (t_1, 2013-2022). These analyses investigated the impact of MSC and DS on transitions in AL and across employment status. For AL, the analyses examined the risks of onset of AL at t_1 among those who have not declared AL at t_0, and risks of persistence of AL at t_1 for respondents who declared a limitation at t_0. Regarding employment, the transitions of interest were the transition into NENR or retirement status at t_1 for those employed at t_0, and the chances of regaining employment at or getting into retirement t_1, for the NENR category at t_0.

IV. 2. a. MSC, DS and transitions in AL status from t_0 to t_1.

Table II. 4 shows that among the 20 197 respondents followed at t_1, 45.35% of women and 48.14% of men did not report limitations in neither time points, with this outcome slightly more common among men (z= -2.71, p<0.01). Conversely, 25.26% and 22.75% of women and men respectively reported persistent limitations across both time points, a pattern more common among women (z=2.03, p=0.04). Conditional distributions displayed in panels (B) show that among those who were not limited at t_0 (N= 11420), more than 80% remained not limited at t_1 and less than 20% experienced an onset of limitation at $\boldsymbol{t_1}$ (15.57% among women, and 19.77% among men)[12]. Looking at these proportions, women who were initially not limited (which was less frequent than in men, as shown in Table II. 1) were more likely to remain in this status at follow-up. As for those who were limited at $\boldsymbol{t_0}$ (N=8777), 54.49% of women remained in this state at $\boldsymbol{t_1}$ and 56.89% of men.

[12] The distributions reported in Table 4 indicate that AL is not strictly irreversible, as some respondents transition out of limitation between t_0 and t_1. This observation does not invalidate the approach adopted in Chapter 1 where AL was treated as an absorbing state within the attribution framework (Nusselder & Looman, 2004b) which is a methodological assumption required to decompose the contribution of diseases to the prevalence of AL in a cross-sectional context. The findings in Chapter 1 were interpreted as associations rather than causal effects. By examining transitions over one follow-up wave, Chapter 2 builds on this analysis by investigating the associations between the health conditions of interest and changes in AL status over time.

Table II. 4. Joint (A) and conditional (B) distributions of modalities of transitions in AL status from inclusion (t_0) to first follow-up (t_1), across women and men (based on sample II, N= 20 197).

(A) Joint distributions.

	Women (N= 10 999)		**Men (N=9 198)**	
t_0 \ t_1	Not Limited	Limited	Not Limited	Limited
Not limited	4988 (45.35%)	913 (8.3%)	4428 (48.14%)	1091 (11.86%)
Limited	2320 (21.09%)	2778 (25.26%)	1586 (17.24%)	2093 (22.75%)

(B) Conditional distributions.

	Women (N= 10 999)		**Men (N= 9 198)**	
t_0 \ t_1	Not Limited	Limited	Not Limited	Limited
Not limited (N_W= 5901, N_M= 5519)	84.53%	15.57%	80.23%	19.77%
Limited (N_W= 5098, N_M= 3679)	45.5%	54.49%	43.11%	56.89%

Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1) N= 20 197 (Sample Ib).
***Example of interpretation*:** 45.35% of women in the selected sample (N= 10 999) have not declared a limitation at neither baseline (t_0) nor at t_1. Among women who declared not being limited at t_0 (N_W= 5901), 15.57% declared an onset of a limitation at t_1.

Table II. 5 shows that reporting MSC at t_0 significantly increased risks of the onset of AL at t_1 when 'Not-limited' at t_0 (AME= 0.05 both women and men, p<0.001) and increased the predicted probability of persistence of AL at t_1 when limited at t_0 by more than 10 percentage points (AME= 0.16 for women and AME= 0.11 for men; both p<0.001). Regarding DS, they significantly increased risks of AL onset at t_1 (AME= 0.05 for women and AME= 0.12 for men, both p<0.001). DS were also predicted to increase the

probability of persistence of AL at t_1 by 12 and 13 percentage points for women and men initially limited at t_0, respectively. Gender differences in AME of MSC and DS on risks of AL onset and persistence were not statistically significant at the 5% level, as confirmed by overlapping confidence intervals (along with results from interacted models).

Regarding covariates, estimates showed that reporting either other chronic diseases (diabetes, cardiovascular, or respiratory disease) or history of cancer at t_0 significantly increased the risk of AL onset and persistence at t_1. For onset, the AME did not exceed those for MSC or DS, except among men where history of cancer had a higher estimated AME than MSC ($AME_{Cancer} = 0.11$ versus $AME_{MSC} = 0.05$), yet 95% confidence intervals were overlapping. AME of MSC on the persistence of AL were higher than the AME of other chronic diseases and cancer among women limited at t_0, but not among men at this status ($AME_{other\ chronic\ diseases} = 0.15$ versus $AME_{MSC} = 0.11$), yet confidence intervals were overlapping.

As for sociodemographic factors, older cohorts had higher risks of AL onset at t_1: among women who were not limited at t_0, those born before 1961 were more likely to become limited by t_1; among men, the pattern was evident for cohorts born before 1949 (aged 64–69 at follow-up, AME=0.1, p=0.02). For persistence of AL, both men and women born between 1943 and 1948 where more likely to remain limited at t_1 once limited at t_0 (AME=0.13 for women and AME=0.18 for men, all p<0.01). Educational attainment showed a clear gradient: relative to the highest educational group, holding a vocational certificate was associated with a higher risk of AL onset and persistence at t_1, for both men and women (AME=0.04 for women, and AME=0.03 for men, all p<0.05).

Table II. 5. Estimated average marginal effects of MSC, DS and control variables, from simple logistic regression models investigating AL status at t_1, stratified by gender (based on samples Ib = 20 197).

Status at t_1:	**Onset of AL** (Not-Limited t_0 to Limited at t_1)		**Persistence of AL** (Limited at t_0 to Limited at t_1)	
	Women (1')	Men (2')	Women (3')	Men (4')
Variables of interest				
MSC	**0.05***** (0.03, 0.07)	**0.05***** (0.03, 0.07)	**0.16***** (0.13, 0.2)	**0.11***** (0.07, 0.15)
DS	**0.05**** (0.01, 0.09)	**0.12***** (0.08, 0.17)	**0.12***** (0.09, 0.16)	**0.13***** (0.1, 0.17)
Covariates				
Age	-0.01** (-0.01, 0)	0 (-0.01, 0)	0 (-0.01, 0)	0 (-0.01, 0)
Cohort *(ref: 1961-1971)*				
1955-1960	**0.03*** (0, 0.06)	0.01 (-0.02, 0.05)	0.04 (0, 0.09)	0.04 (-0.01, 0.1)
1949-1954	**0.09**** (0.04, 0.14)	0.04 (-0.02, 0.1)	0.06 (-0.02, 0.13)	0.07 (-0.01, 0.16)
1943-1948	**0.1*** (0.02, 0.18)	**0.1*** (0.01, 0.18)	**0.13**** (0.04, 0.23)	**0.18**** (0.08, 0.29)
Undergraduate degree	0 (-0.02, 0.03)	0.02 (0, 0.05)	0.02 (-0.02, 0.06)	0.05 (0, 0.1)
High School diploma	0.02 (-0.01, 0.05)	0.02 (-0.01, 0.06)	0 (-0.05, 0.04)	**0.08**** (0.02, 0.13)
Vocational Certificate	**0.04*** (0.01, 0.07)	**0.03*** (0, 0.06)	**0.06**** (0.02, 0.1)	**0.09***** (0.05, 0.13)
No diploma	0.02 (-0.02, 0.05)	**0.04*** (0, 0.08)	0.05 (0, 0.1)	**0.11***** (0.05, 0.16)
Partnership	-0.01 (-0.03, 0.01)	0 (-0.03, 0.02)	-0.02 (-0.05, 0.01)	-0.03 (-0.06, 0.01)
Other chronic diseases	**0.05**** (0.02, 0.07)	**0.07***** (0.04, 0.09)	**0.11***** (0.08, 0.14)	**0.15***** (0.11, 0.18)
Cancer	**0.04*** (0.01, 0.07)	**0.11***** (0.07, 0.15)	**0.08***** (0.04, 0.11)	**0.08**** (0.04, 0.13)
Observations	5901	5519	5098	3679
Log Likelihood	−2,492.15	−2,660.51	−3,374.17	−2,383.28
Akaike Inf. Crit	5,014.30	5,351.02	6,778.34	4,796.56

Source: Selected samples of respondents aged between 50 and 69 from the first follow-up waves of the CONSTANCES cohort (2013- 2022, Sample Ib): Analysis of 'Onset of AL' (1') (2') are based on the selected sample of 11420 respondents that **did not** declare limitations at baseline waves (t_0); Analysis of 'Persistence AL' (3') (4') are based on the selected sample of 8777 respondents that **declared** limitations at baseline waves (t_0).
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

IV. 2. b. MSC, DS and transitions across employment status from t_0 to t_1.

Table II. 6 displays the distributions of transitions across employment status from t_0 to t_1 for each gender. Figure II. 3 and Figure II. 4 display results of the estimated average predicted probabilities (APPs)[13] of transitions from fitted multinomial logistic models, controlling for covariates, for the status of MSC and DS at baseline (t_0), respectively.
Among non-retired participants with complete data in variables of interest (Sample IIb N = 18,869), most individuals remained employed at both time points, with this proportion slightly higher among men (72.92%) than women (71.02%; z = −2.44, p = 0.014). In contrast, a relatively low proportion of respondents experienced transitions from NENR status at t_0 to employment status at t_1 (1.68% among women and 2.16% among men). Remaining in the NENR category at both t_0 and t_1 was more frequent among women (10.65%) than men (7.16%; p = 0.013). Regarding transitions, 5.05% of employed women and 4.35% of employed men at t_0 became NENR at t_1, while 10.66% of employed women and 14.09% of employed men at t_0 had retired by t_1. Among those who were NENR at t_0, about 10.71% of women and 12.04% of men regained employment at t_1 whereas roughly one-fifth had retired.

The APPs estimated from the multinomial models highlighted a significant influence of MSC and DS on the risk of becoming NENR at t_1 among those employed at t_0, of similar magnitudes for both genders. Women with an MSC had a higher predicted probability of becoming NENR at t_1 than those without (5.5% vs. 3.9%; p < 0.001). For men, the corresponding probabilities were 4.7% and 3.6% (p < 0.001) respectively. Men with MSC were also significantly less likely to remain at work than their counterparts. The differences were even larger when comparing individuals with and without DS at inclusion. Among employed women, those with DS had a 9.1% APP of becoming NENR at t_1, compared with 4.1% for those without DS (p < 0.001). Among men, the APPs were 8.1% and 3.5%, respectively (p < 0.001). Significant differences were also observed in the

[13] As the specification of the multinomial models involved fitting 12 different models (6 sets of analysis conditional on being employed at t_0, and 6 sets of analysis conditional on being NENR at t_0), results were summarized by estimations of average predicated probabilities of each state of interest.

probabilities of remaining employed at t_1. Those reporting DS at t_0 had lower APPs of remaining employed (85.1% versus 80.7% among women and 82.3% versus 78.3% among men; both $p < 0.001$).

Among respondents who were NENR at t_0, gender-specific patterns emerged. Women with MSC were significantly more likely to remain NENR at t_1 than those without (APPs= 68.6% versus 64.8%; $p < 0.001$), and to have retired by t_1 compared to their counterparts. Women with DS were more likely to have retired and less likely to resume working by t_1 compared to their counterparts. As for the case of men, those who were NENR and declared MSC at t_0, were less likely to resume working by t_1 compared to their counterparts (APPs= 11.7% versus AME= 13.4%). Regarding DS, significant differences were observed among men only when comparing APP of remaining NENR at t_1: NENR men at t_0 who reported DS the same year were estimated with an APP of remaining in this status of 70.6% compared to 65.5% compared to men with no DS at t_0 ($p<0.01$). While various significant differences were detected, the relatively small sample of respondents who were experienced transitions out of NENR called for caution in the interpretation of these results.

Supplementary analyses (Figure II. S.1 and Figure II. S.2) examining other chronic conditions and history of cancer yielded similar patterns: respondents with such conditions also had higher APPs of becoming NENR at t_1 compared with those without. However, the size of these differences was either comparable to, or slightly larger than, those observed for MSC—but not for DS. This suggests that the associations between MSC and DS and transitions into NENR status are substantial and not less consequential than those linked to other chronic diseases.

Table II. 6. Joint (A) and conditional (B) distributions of modalities of transitions in employment status from baseline (t_0) to first follow-up (t_1), across women and men (based on sample IV, N= 18869).

(A) Joint distributions.

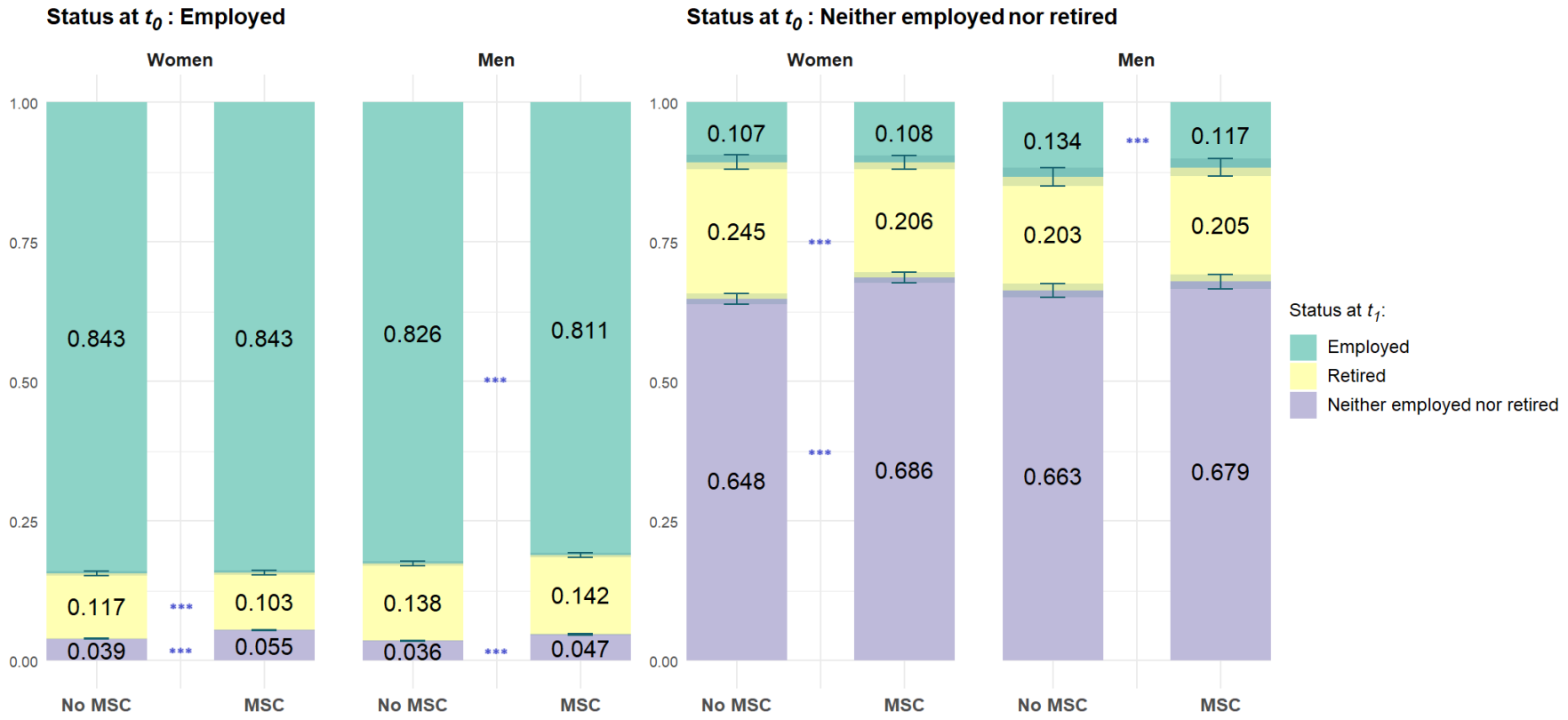
	Women (N= 10 564)			Men (N= 8305)		
t_0 \ t_1	Employed	NENR	Retired	Employed	NENR	Retired
Employed	7503 (71.02%)	450 (4.26%)	949 (8.98%)	6056 (72.92%)	323 (3.89%)	1046 (12.59%)
NENR	178 (1.68%)	1125 (10.65%)	359 (3.4%)	106 (1.28%)	595 (7.16%)	179 (2.16%)

(B) Conditional distributions.

	Women (N= 10 564)			Men (N= 8305)		
t_0 \ t_1	Employed	NENR	Retired	Employed	NENR	Retired
Employed (N_W= 8902, N_M= 7425)	84.28%	5.05%	10.66%	81.56%	4.35%	14.09%
NENR (N_W= 1662, N_M= 880)	10.71%	67.69%	21.60%	12.04%	67.61%	20.34%

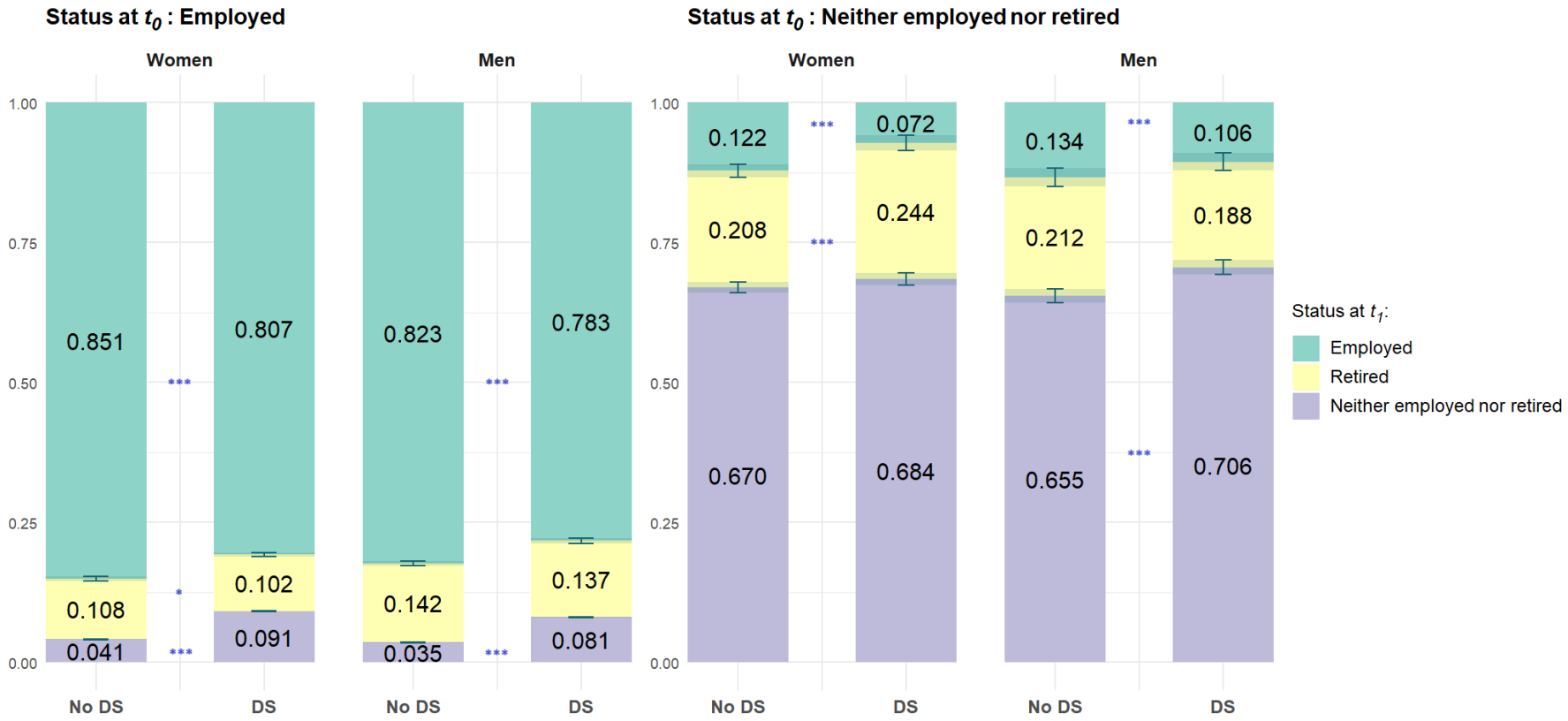
Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), N= 18 869.
***Example of interpretation*:** 71.02% of women in the selected sample (N= 10 564) were employed at both (t_0) and t_1. Among women who were employed t_0 (N= 8902), 5.05% became NENR at t_1.

Figure II. 3. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models on transitions in employment status from t_0 till t_1, for each gender – Conditional on MSC at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1) (Sample IIb, N= 18 869).
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of MSC from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients of MSC from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed women at inclusion (t_0) who reported MSC, the APP of their transition into the status of "NENR" was estimated to be 5.5%, versus 3.9% for those who did not report MSC at t_0. The difference in estimated APPs was significant at the 1% level.

Figure II. 4. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models on transitions in employment status from t_0 till t_1, for each gender – Conditional on DS at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), (Sample IIb, N= 18 869).
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of DS from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients of DS from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed men at inclusion (t_0) who reported DS, the APP of their transition into the status of "NENR" was estimated to be 8.1%, versus 3.5% for those who did not report DS at t_0. The difference in estimated APPs was significant at the 1% level

V. Robustness checks.

We conducted several robustness checks to ensure the reliability of our findings.

V. 1 Variables' modifications.

A first robustness check involved modifying the indicator used to identify MSC. In our primary analysis, MSC were defined as cases where individuals were either diagnosed with an osteo-articular disease or reported frequent pain lasting at least 30 days per year, or a pain that persisted throughout the year. In an alternative model, MSC were defined more narrowly as individuals diagnosed with an osteo-articular disease or those reporting permanent pain throughout the year (for more than 30 days). The results remained consistent (Supplementary materials, section C), with similar estimates for the impact of MSC on both AL and likelihood of falling in the NENR category.

Additionally, given the underrepresentation of certain birth cohorts in some models, we re-estimated the models without controlling for this variable. Our findings for the variables of interest remained robust; however, we retained the birth cohort variable as a control due to its relevance for the study design.

Finally, given the high correlation between DS and MSC, we estimated separate models for each condition. The results were not significantly different from those obtained in the models including both variables, along with an interaction terms for both, confirming the robustness of our findings.

V. 2 Pooled interaction models.

As mentioned in the empirical strategy, stratified models by gender were our preferred specification for the main analysis, as they allow for clear interpretation of gender-specific estimates. To further assess the robustness of the gender patterns identified, we additionally estimated pooled logistic regression models that included gender as an explanatory variable alongside interaction terms with MSC and DS. Two specifications were considered: a targeted interaction model, in which only MSC and DS were interacted

with gender, and a fully interacted model, in which all covariates were interacted with gender. In both specifications, the results remained consistent with those obtained from the stratified models. For the analyses focused on AL, estimated average marginal effects of variables of interest were nearly identical to the ones found in the main models. Besides, the interaction terms confirmed that the associations of MSC and DS with risks of onset and persistence of AL did not differ significantly between men and women. In a similar manner, results from interacted multinomial models for the analysis of transitions in employment status, showed no signs of a gender difference in the associations between MSC and DS, with the risk of transitioning into the NENR status. This supports our main conclusion that gender disparities in restrictions are primarily driven by differences in the prevalence of these conditions rather than by differences in their disabling impact. As results were almost identical to the ones shown in this work, they are not further displayed in the supplementary materials, but are available upon request.

V. 3 Examining the cases of "Lost at follow-up".

For the analysis focused on AL, 33590 respondents were selected at inclusion (t_0), from whom 13,393 individuals had no data in the variables of interest in the first-follow-up (t_1), which was a relatively high drop off rate (around 40%). Similarly, for the analysis focused on employment status, 32003 respondents were selected at t_0, of whom 13134 were dropped (around 41%). We performed multiple checks to ensure that this drop-off rate does not significantly impact the robustness of our results. These checks included examining the baseline characteristics of those who were not lost at follow-up, performing imputations of their missing information at follow-up, and doing models' re-estimations. The procedure of imputation covered both our disease variables and outcomes of interest at the first follow-up. Logistic regressions were used to impute information on whether there was an onset of other chronic conditions or a change in partnership status at follow-up. For our outcomes of interest, we considered extreme scenarios, that is, the possibilities of whether all respondents without follow-up data were either all "Limited" or "Not-Limited" in regards to their AL status at t_1, or either all "Employed", "Retired", or "NENR", in regards to their employment status. Results of the analysis are detailed in supplementary materials (Sections D and E).

In summary, the results confirmed that the associations observed in the main analysis were largely consistent when including individuals lost to follow-up under various assumptions. Distributions at inclusion showed that MSC and other chronic diseases were more prevalent among those with follow-up data (that were included in our main analysis), whereas reporting DS and being NENR were more common in the sample of respondents excluded from our models. Across all model specifications, MSC and DS remained significantly associated with higher risks of AL onset and persistence for both men and women. These findings were robust even when follow-up data were imputed under extreme assumptions.

In the analysis of employment transitions, MSC and DS both consistently increased the risk of becoming NENR at t_1 for both employed men and women. These associations held across alternative assumptions regarding the employment status of individuals lost at follow-up. In addition, MSC and DS were evidenced to reduce the probability of remaining employed at follow-up among those employed at t_0 in most cases. For individuals who were NENR at inclusion, MSC and DS showed more heterogeneous effects, particularly among women. For instance, DS significantly increased the likelihood of remaining NENR under some assumptions but not others, though this variation likely reflects small sample sizes rather than selection bias. Among men, DS effects on remaining NENR across time, were significant in models excluding the lost, but weakened under certain assumptions about re-employment. Overall, while some heterogeneity emerged in subgroups with small sample sizes, the direction and significance of key findings were generally robust, reinforcing the reliability of the main analysis results.

V. 4 Self-reported reasons for activity restrictions.

Beyond the statistical analyses at inclusion, respondents who reported being limited in their activities compared with others of the same age were asked to identify the main reasons for their limitations from a predefined list of fourteen conditions. These included osteoarthritis, severe pain, depression, other chronic diseases, and some disorders such as sleep disorders. Following the statistical analyses, the distributions of self-reported

reasons were examined to assess whether they aligned with the prominent roles of MSC and DS in explaining AL.

The distributions (detailed in the supplementary materials, Figure II. S.7) showed that "osteoarthritis" and "severe pain" were the most frequently reported reasons for AL among both men and women. "Depression" accounted for around 13% of responses among women and 8% among men, while fatigue (reported by 30% of women) and physical accidents (reported by 15% of men) were more commonly selected. Additionally, in a separate questionnaire on MSC, respondents were asked whether they had permanently stopped working before retirement due to a "Back" or "Joint" problem. Among those who were NENR at inclusion and answered this question, 17.3% of men and 13.0% of women responded with "yes." Although purely descriptive, these findings reinforced the strong link between MSC and the experience of both AL and early withdrawal from employment prior to retirement, as perceived and reported by respondents themselves.

VI. Discussion and conclusion.

This work investigated the impact of MSC and DS on activity restrictions in mid-adulthood (ages 50-69), leveraging the large French CONSTANCES cohort which allowed for focusing on separate gender groups, and accounting for a substantial set of comorbidities and socioeconomic variables. Our results showed that MSC and DS had strong associations with declaring an AL at inclusion waves, and both conditions increased risks of onset of AL in the first subsequent wave, for both men and women. Both conditions also increased risks of falling into the NENR category in the first follow-up for women and men who were employed at CONSTANCES' inclusion waves. Overall, women were more likely to report AL, to be in the NENR category, to declare DS, and experience MSC at inclusion. Important insights could be inferred from these results which we detail in this section.

VI. 1 MSC: disabling conditions that likely restrict activity and work participation, and are more common among women.

MSC are more frequently reported by women, either as diagnosed osteo-articular diseases or reported persistent pain. Our results bring new insights in exploring the transitions after one year towards activity restrictions. MSC increase the risk of developing AL and of losing employment for both genders, and also decrease the chance of recovering from AL. In other words, in a dynamic view, men and women experience similar patterns of disadvantage in terms of activity restrictions when they have MSC, meanwhile women are more exposed to them.

AL is also more common among women, and our findings suggest it is partly caused by MSC. Several factors likely contribute to the increased rates of MSC among women, which include biological factors including hormonal changes, and social factors including disparities in occupational experiences (Campos-Serna et al., 2013; Guignon, 2008; Oksuzyan et al., 2009; Yung et al., 2020). Apart from these factors, differences in pain perception and reporting may play a role. Some studies suggest that women are more likely to experience, report, and seek help for pain, which may result in higher reports of musculoskeletal pain and more frequent diagnoses of osteo-articular diseases (Overstreet et al., 2023). However, if this reporting bias exists in our data, it does not result in women being less at risk of AL when they report them; and even more, we found a lower chance to recover from AL when reporting MSC, therefore the reporting bias is likely to be limited.

VI. 2 DS: More commonly identified among women, and predict the onset of activity restrictions.

Depressive symptoms were more frequently reported by women in our data, even after adjusting thresholds to account for gender differences in the reporting of symptoms. This aligns with existing literature which consistently shows a higher prevalence of depression among women (Girgus & Yang, 2015; Hyde & Mezulis, 2020; Van de Velde et al., 2010). Similarly to MSC, various social factors may contribute to these differences including

differences in occupational experiences, and combining work and family responsibilities (Beaufils et al., 2023; Cambois et al., 2017; Girgus & Yang, 2015). Our results further confirmed that DS were significantly associated with reported AL and being out of employment for both men and women at inclusion, which confirms other results (Buss et al., 2022). Regarding transitions across time, the analyses show that DS increased the risk of onset and persistence AL for both genders. These results further come in line with the relevance of the role of the higher prevalence of DS among women in contributing to women's disadvantage in AL. DS also predict employment restriction by the next year: employed men and women with DS are more likely to become NENR and less likely to remain employed then their counterparts; NENR men and women with DS are less likely to work the next year being rather still NENR for men or retired for women.

The significant detected association of DS with onset of restrictions at first follow-ups support the direction of a disabling impact going from DS to activity restrictions. However, it is still worthy to mention that reverse causality is plausible, which can also come in line with results of our cross-sectional analysis showing strong associations between DS and AL: AL may contribute to the onset of depressive symptoms, as experiencing limitations among middle-aged adults can be stressful, and would negatively impact mental well-being (Liu et al., 2023; WHO, 2023). Also noting that DS is more prevalent among the lost at follow-up, caution is needed when interpretating the findings and claiming for further investigations.

VI. 3 Insights on the "Neither employed nor retired" status.

The status of NENR, which include unemployment and inactivity, was found among a non-negligible proportion of the 50-69 year-old volunteers in our study. Our baseline results showed that being NENR was more common among women, and that reporting DS was strongly associated with being in this category for both genders. Among women, MSC was positively associated with the status of NENR. When looking at one-year transitions, both MSC and DS were associated with increased risks of becoming NENR in

the first follow-up among those who were employed at inclusion for both genders. Men who were NENR and reported DS at inclusion were significantly more likely to stay in this status over time compared to men with no DS, while among women, NENR women at inclusion who reported DS were more likely to become retired in the next follow-up compared to women with no DS who were more likely to gain back employment. As for MSC, women who were NENR and declared a MSC were significantly more likely to stay NENR over time compared to women with no MSC, while men who were NENR at inclusion and declared MSC were only significantly less likely to regain back employment compared to men with no MSC. However, the selected sample of NENR might challenge the generalization of these findings, as the patterns differed in results from robustness checks.

Insights on the role of MSC in becoming NENR echoes findings from the literature on the link of MSC with occupational factors which drives employment exits (Govaerts et al., 2021). In severe cases, workforce exits can be through disability pensions, which are known to be strongly associated with MSC (Badarin et al., 2023). Individuals who have not reached the minimum retirement age and are eligible to these pensions would either identify themselves as “Inactive”, which falls in the NENR category, or “retired” if they are not expected to go back to work, even if they have not reached official retirement. Future studies with detailed employment data, including pension information, along with health data, would provide a more nuanced understanding of the relationship between MSC with employment exits. In any case, the likelihood to remain at work is decreased by the MSC.

Regarding DS, our results showed that they were associated with employment exits for both genders over time. Overall, DS can result in reduced performance and productivity of workers which contribute to higher risks of employment exists (Adler et al., 2006; Andreeva et al., 2015). For women, workplace stressors and the dual responsibilities of work and family, which may further exacerbate depressive symptoms (Beaufils et al., 2023b), can influence their decisions to leave the workforce. Results of strong associations between DS and being in the NENR category at inclusion also echo reverse causality between DS and employment exists: for men, periods of inactivity may increase

the likelihood of experiencing depressive symptoms (Andreeva et al., 2015; Artazcoz et al., 2004); and for women, facing hiring discrimination related to health, gender, or age, may encounter prolonged job-seeking challenges, which could further impact their mental health (Grant, 2011; Hennein et al., 2023; G. Kim et al., 2020). Future studies with larger volumes of data on transitions across health and employment status over time, would better depict the strength of each causal direction between DS and employment restrictions.

While this study highlights the significant role of MSC and DS in the likelihood of being in the NENR category, it is important to acknowledge that being out of employment, whether unemployed or inactive, may also result from factors unrelated to health. These can include personal or family choices, especially among women, as well as external economic or labor market shocks. The hypotheses and findings of this study do not contradict such possibilities. Rather, by showing consistent associations between MSC and DS and the likelihood of being in the NENR category at both inclusion and follow-up waves, the results suggest that these conditions play a relevant role in driving individuals out of employment. This is particularly evident in the transition analyses, where both MSC and DS increased the probability of exiting employment among those who were initially working. Nonetheless, future research could integrate a broader set of factors, such as job quality, caregiving responsibilities, and local labor market conditions, to better situate the impact of these health conditions within the wider determinants of employment trajectories. Future works are also encouraged to investigate whether the transition out of employment improves the quality of life of men and women who experienced working with a disabling condition. The use of well-being indicators in follow-ups could be relevant.

VI. 4 Study limitations.

Our work provided many insights that came in line with our hypotheses and literature findings. There are however limitations that are worthy of noting. To begin with, a novel aspect of our study involved using longitudinal data to examine the associations between MSC and DS, with AL and employment restrictions. Although multinomial logistic

regressions allowed us to measure transitions, we were limited in the ability to use dynamic panel data models. This limitation stemmed primarily from the fact that MSC could only be identified at a single time point, specifically at the inclusion waves. In follow-up questionnaires, respondents were asked if they had been diagnosed with osteo-articular diseases and if they had experienced body pain in the past 12 months, but no duration of the pain was specified. This lack of specificity restricted our ability to identify MSC in the same way across inclusion and follow-up waves, as these conditions are typically defined by symptoms lasting for at least 30 days per year. The option of focusing only on diagnosed osteo-articular diseases was dismissed since this approach would likely exclude a large group of individuals suffering from other MSC that are underdiagnosed. Thus, relying solely on diagnoses would have compromised the scope of our estimates. DS were also only considered at inclusion, as the CES-D questionnaire was only available for two follow-up questionnaires (2015, 2018), and thus using it as a longitudinal variable would have significantly reduced our sample size, by restricting us to only use data from inclusion waves of 2014 and 2017. Overall, we believe that dynamic panel data models could potentially provide a clearer picture of the relationships we investigate and offer ways to address endogeneity issues.

Another limitation we encountered was the relatively low proportion of respondents getting in and out of employment, which constrained our ability to draw robust conclusions from significant results. Moreover, we planned to analyze transitions over three time points, yet this was not feasible for employment restrictions due to small sample sizes in certain categories, with some transitions representing fewer than a dozen individuals. However, for AL, we had a larger sample and were able to conduct analysis across three time points. The insights gained were consistent with those presented in this chapter.

An additional limitation concerns the exclusion of certain variables known to influence activity limitations and employment, such as parenthood status and lifestyle behaviors. These were not included as control variables because doing so would have substantially reduced the sample size due to missing data on these measures. Our models focused on the most relevant controls for our objectives.

The use of self-reported health conditions is another limitation to acknowledge. CONSTANCES relies on validated procedures designed to approximate diagnosed conditions as closely as possible, which helps limit measurement error, but reporting bias remains possible. That is, some conditions may go undiagnosed, and some depressive symptoms for instance, may not be recognized or reported. However, given that our findings are consistent with the existing literature, this bias might likely be modest.

Attrition at follow-ups is also a limitation worthy of noting. We explored loss to follow-up by applying assumptions and imputations, and the patterns observed were consistent with our main results. These findings reinforce the robustness of our conclusions, although confirmation from additional data sources would be valuable.

Finally, while CONSTANCES data intended to be representative of the French population, the process of examination in health centers has selected the participants. The sample primarily includes salaried workers and their families, excluding agricultural and self-employed individuals (Goldberg et al., 2017a). This exclusion may limit the generalizability of our findings to other social groups. However, CONSTANCES data include a large variety of situations which contribute to highlight disparities and to bring new insight and knowledge.

VI. 5 Concluding remarks.

In this work, we used data from inclusion and follow-up waves of the French CONSTANCES cohort to examine the impact of MSC and DS on activity restrictions in men and women, aged 50-69 at inclusion. Both MSC and DS were associated with activity limitations and increased the risk of being out of employment over follow-up, for both genders. Our results revealed rather similar patterns for men and women regarding the predictive power of MSC and DS regarding the onset of activity restrictions and the risk of remaining restricted. However, they primarily suggest that gender differences in risks of activity restrictions are associated with the higher prevalence of MSC and DS in women. These findings reinforce the importance of addressing MSC and DS early in mid-adulthood to reduce their long-term impact on participation in daily and work activities. Lowering the risks of these conditions would benefit both men and women and would also potentially reduce gender differences in activity restriction.

Prevention and early management of MSC are particularly relevant in the workplace. Improving ergonomic conditions, monitoring occupational risks, and ensuring timely workplace adaptations can help limit both the occurrence and the consequences of musculoskeletal problems. Given women's higher exposure to such risks, policy attention should also extend to factors beyond employment, such as unequal domestic workloads and biological vulnerabilities linked to hormonal changes, which contribute to women's greater burden of MSC. In general, detection of such disorders and specific recommendations (physical activity, rehabilitation, treatment…) for individuals in their 50's could be helpful.

Similarly, our results suggest that preventive actions targeting depressive symptoms are relevant. Reducing psychosocial stressors, improving job security, and facilitating access to mental health support in occupational and primary care settings can help prevent DS and mitigate their effects on work and daily functioning. Attention to gendered social factors, such as the dual responsibilities of work and family and the concentration of women in more precarious jobs, remains key to understanding and addressing these inequalities. Early detection of DS is also needed to prevent a deterioration of the symptoms and further consequences on the quality of life and social participation.
Overall, this study's findings highlight that both musculoskeletal conditions and depressive symptoms could play a critical role in shaping activity limitations and employment trajectories. Strengthening prevention and early intervention around these conditions can contribute both to healthier ageing and to more sustainable employment among adults approaching retirement age, as well as reducing the gender gap in healthy ageing.

VII. References.

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Chapter 2. Supplementary materials.

A. Estimated odds ratios (ORs) of MSC and DS, and control variables from fitted models.

Table II.S.1. Estimated odds ratios associated with MSC, DS and control variables, from baseline (t_0) simple logistic regression models stratified by gender (based on samples Ia and IIa).

	Dependent variable:			
	Activity Limitation (AL)		Employment Restrictions among non-retired individuals (Neither Employed Nor Retired)	
	Women (1)	Men (2)	Women (3)	Men (4)
Variables of interest				
MSC	**3.76***** (3.47, 4.07)	**3.25***** (3.00, 3.54)	1.06 (0.96, 1.18)	**1.17*** (1.02, 1.33)
DS	**4.65***** (3.90, 5.55)	**4.12***** (3.48, 4.87)	**1.40***** (1.13, 1.74)	**2.72***** (2.21, 3.34)
MSC x DS	**0.70**** (0.57, 0.85)	0.94 (0.77, 1.16)	1.00 (0.74, 1.35)	0.87 (0.68, 1.12)
Covariates				
Age	0.99 (0.97, 1.00)	0.99 (0.98, 1.01)	**1.08***** (1.05, 1.10)	**1.09***** (1.06, 1.11)
Cohort *(ref: 1961-1971)*				
1955-1960	1.04 (0.93, 1.17)	**1.19**** (1.05, 1.35)	**1.20**** (1.05, 1.37)	**1.27**** (1.07, 1.50)
1949-1954	1.12 (0.93, 1.34)	1.16 (0.95, 1.41)	**1.38**** (1.10, 1.68)	0.95 (0.70, 1.28)
1943-1948	1.25 (0.98, 1.59)	1.18 (0.91, 1.52)	1.30 (0.81, 2.08)	0.58 (0.29, 1.11)
Highest educational attainment *(ref: Post-graduate degree)*				
Undergraduate degree	**1.14**** (1.05, 1.25)	**1.25***** (1.12, 1.39)	**1.39***** (1.22, 1.59)	**1.19*** (1.00, 1.44)
High School diploma	**1.15**** (1.04, 1.28)	**1.33***** (1.19, 1.50)	**1.91***** (1.66, 2.20)	**1.58**** (1.32, 1.89)
Vocational Certificate	**1.41***** (1.28, 1.56)	**1.62***** (1.48, 1.79)	**2.26***** (1.98, 2.59)	**1.91***** (1.64, 2.22)
No diploma	**1.72***** (1.54, 1.92)	**1.48***** (1.31, 1.68)	**3.29***** (2.85, 3.80)	**2.65***** (2.22, 3.16)
Partnership	0.98 (0.92, 1.00)	0.95 (0.87, 1.02)	**1.36***** (1.24, 1.49)	**0.48***** (0.44, 0.54)
Other chronic diseases	**1.53***** (1.42, 1.64)	**1.59***** (1.48, 1.72)	**1.26***** (1.15, 1.38)	**1.60***** (1.43, 1.79)
History with cancer	**1.42***** (1.28, 1.58)	**1.33***** (1.16, 1.53)	**1.16**** (1.00, 1.33)	**1.32**** (1.05, 1.65)

Source: Selected samples of respondent aged between 50 and 69 from the inclusion waves of the CONSTANCES cohort Analysis of AL (1) (2) are based on the selected sample of 33590 respondents from waves 2012-2014, and 2017-2021; analysis of employment restrictions (3) (4) are based on the selected sample of 32003 from waves 2012-2021).
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

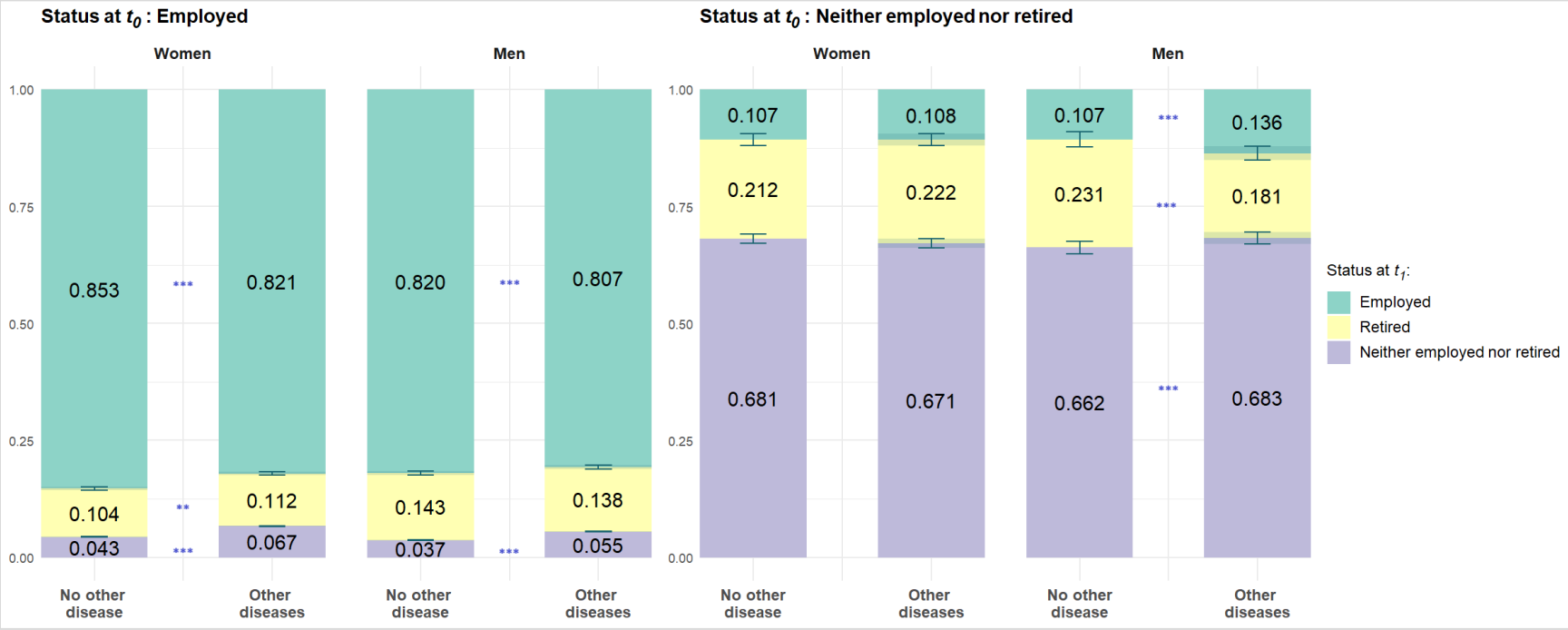
Table II.S.2. Estimated odds ratios associated with MSC, DS and control variables, from simple logistic regression models investigating AL status at t_1 , stratified by gender (based on samples Ib = 20 197).

Status at t_1:	**Onset of AL** (Not-Limited t_0 to Limited at t_1)		**Persistence of AL** (Limited at t_0 to Limited at t_1)	
	Women (1')	Men (2')	Women (3')	Men (4')
Variables of interest				
MSC	**1.60***** (1.36, 1.88)	**1.34**** (1.16,1.55)	**1.81***** (1.52, 2.17)	**1.51***** (1.25, 1.83)
DS	**1.80*** (1.15, 2.74)	**1.74*** (1.21, 2.47)	1.26 (0.90, 1.77)	**1.51*** (1.07, 2.12)
MSC × DS	0.69 (0.42,1.16)	1.27 (0.81, 2.01)	1.43 (0.99, 2.08)	1.27 (0.86, 1.87)
Covariates				
Age	**0.96*** (0.93, 0.98)	0.99 (0.96, 1.02)	0.98 (0.96, 1.00)	0.98 (0.95, 1.01)
Cohort *(ref: 1961-1971)*				
1955-1960	**1.31*** (1.01, 1.71)	1.10 (0.85, 1.41)	1.20 (0.98, 1.47)	1.21 (0.94, 1.98)
1949-1954	**1.99**** (1.33, 2.98)	1.30 (0.89, 1.91)	1.28 (0.93, 1.75)	1.36 (0.94, 1.98)
1943-1948	**2.10**** (1.22, 3.61)	**1.79**** (1.11, 2.89)	**1.78*** (1.17, 2.71)	**2.29**** (1.41, 3.74)
Highest Educational Degree *(ref: Post-graduate degree)*				
Undergraduate degree	1.02 (0.84,1.25)	1.18 (0.97,1.43)	1.10 (0.93, 1.30)	0.82 (0.66, 1.01)
High School diploma	1.14 (0.91, 1.43)	1.18 (0.95,1.46)	0.99 (0.82, 1.19)	**0.72*** (0.58, 0.90)
Vocational Certificate	**1.32*** (1.06,1.70)	**1.2*** (1.03,1.49)	**1.29*** (1.08, 1.54)	**0.68**** (0.57, 0.82)
No diploma	1.15 (0.87, 1.49)	**1.31*** (1.02, 1.67)	**1.23*** (1.00, 1.5)	**0.63*** (0.49, 0.81)
Partnership	0.94 (0.81, 1.09)	1.00 (0.85, 1.17)	0.91 (0.81, 1.02)	0.88 (0.76, 1.03)
Other chronic diseases	**1.40***** (1.21, 1.63)	**1.52***** (1.32, 1.75)	**1.61***** (1.43, 1.81)	**1.86***** (1.62, 2.15)
Cancer	**1.32*** (1.06 , 1.63)	**1.86***** (1.51, 2.28)	**1.39***** (1.18, 1.64)	**1.46***** (1.16, 1.83)

Source: Selected samples of respondents aged between 50 and 69 from the first follow-up waves of the CONSTANCES cohort (2013- 2022): Analysis of 'Onset of AL' (1') (2') are based on the selected sample of 11420 respondents that **did not** declare limitations at baseline waves (t_0); Analysis of 'Persistence AL' (3') (4') are based on the selected sample of 8777 respondents that **declared** limitations at baseline waves (t_0).
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

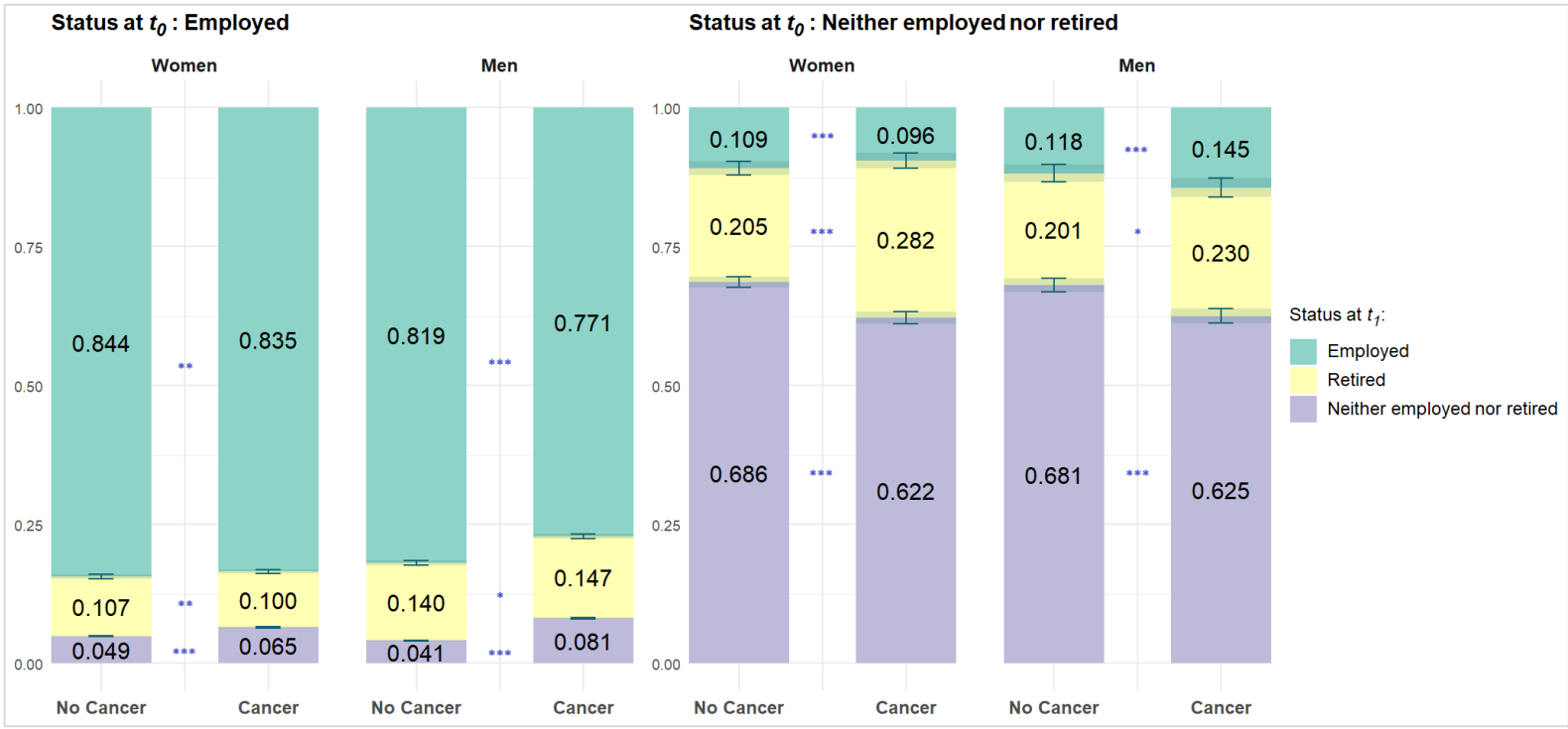
B. Impact of other chronic diseases and Cancer on transitions in employment status.

Figure II. S.1. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models on transitions in employment status from t_0 till t_1, for each gender – Conditional on reporting other chronic diseases (either diabetes, cardiovascular, or respiratory diseases) at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), N= 18 869.
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of 'Other chronic diseases' from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed men at inclusion (t_0) who reported other chronic diseases (diabetes, cardiovascular, or respiratory disease), the APP of their transition into the status of "NENR" was estimated to be 5.5%, versus 3.7% for those who did not report any of the other diseases at t_0. The difference in estimated APPs was significant at the 1% level.

Figure II. S.2. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models on transitions in employment status from t_0 till t_1, for each gender – Conditional on reporting a history with <u>Cancer</u> at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), N= 18 869.
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of 'Cancer' from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients of Cancer from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed women at inclusion (t_0) who reported a history with cancer, the APP of their transition into the status of "NENR" was estimated to be 6.5%, versus 4.9% for those who did not report a history with Cancer at t_0. The difference in estimated APPs was significant at the 1% level.

C. Results of robustness checks of replacing "MSC" with "Severe MSC".

Table II.S.3. Estimated average marginal effects (AME) of severe MSC (osteo-articular diseases or permanent body pain) and DS on AL and employment restrictions, from inclusion (t_0) simple logistic regression models stratified by gender (based on samples I and III).

	Dependent variable:			
	Activity Limitation (AL)		***Employment Restrictions (Neither Employed Nor Retired)***	
	Women	**Men**	**Women**	**Men**
	(1)	**(2)**	**(3)**	**(4)**
Variables of interest				
Severe MSC	**0.25***** (0.23, 0.26)	**0.23***** (0.21, 0.24)	**0.03***** (0.02, 0.04)	**0.01**** (0, 0.03)
DS	**0.28***** (0.26, 0.29)	**0.30***** (0.27, 0.32)	**0.06***** (0.05, 0.08)	**0.1***** (0.08, 0.12)
Observations	17,972	15,618	17,480	14,523
Log Likelihood	−10,942.69	−9,194.28	−7,170.66	−4,725.79
Akaike Inf. Crit.	21,915.38	18,418.56	14,371.31	9,481.59

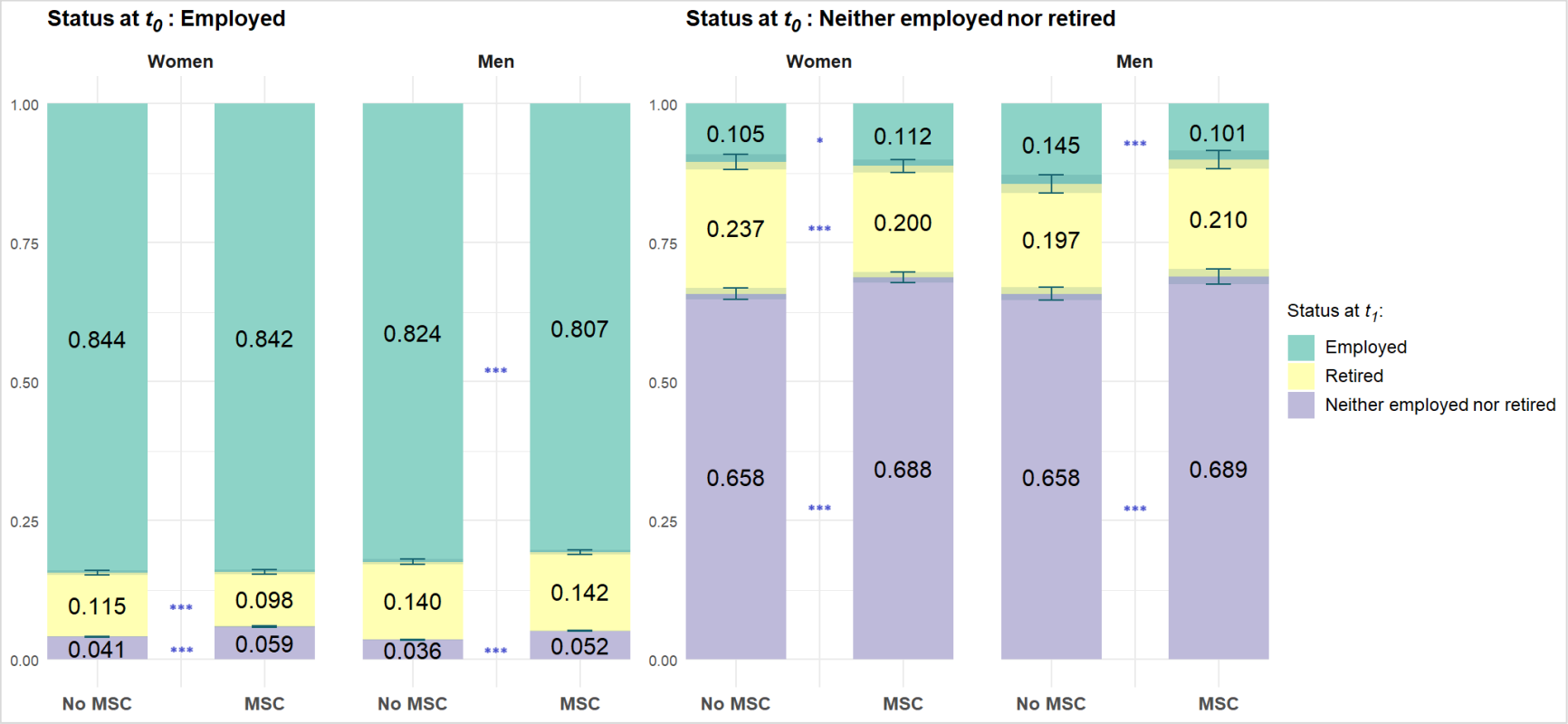
Source: Selected samples of respondent aged between 50 and 69 from the inclusion waves of the CONSTANCES cohort (2012- 2021): Analysis of AL (1) (2) are based on the selected sample of 33590 respondents, and analysis of employment restrictions (3) (4) are based on the selected sample of 32003.
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

Table II.S.4. Estimated odds ratios associated with MSC (osteo-articular diseases or permanent body pain) and DS, from simple logistic regression models investigating AL status at t_1 , stratified by gender (based on samples II = 20 197).

Status at t_1:	**Onset of AL** (Not-Limited t_0 to Limited at t_1)		**Persistence of AL** (Limited at t_0 to Limited at t_1)	
	Women (1')	Men (2')	Women (3')	Men (4')
Variables of interest				
Severe MSC	**1.52***** (1.31, 1.77)	**1.42**** (1.23,1.65)	**1.73***** (1.51, 1.99)	**1.65***** (1.41, 1.93)
DS	**1.52*** (1.09, 2.10)	**2.00*** (1.50, 2.65)	**1.53*** (1.22, 1.92)	**1.51*** (1.17, 1.95)
Severe MSC × DS	0.83 (0.52, 1.32)	1.00 (0.63, 1.57)	1.17 (0.88, 1.56)	1.33 (0.95, 1.85)
Observations	5901	5519	5098	3679
Log Likelihood	−2,494.39	−2,659.42	−3,365.50	−2,366.71
Akaike Inf. Crit	5,018.78	5,348.85	6,761.00	4,763.41

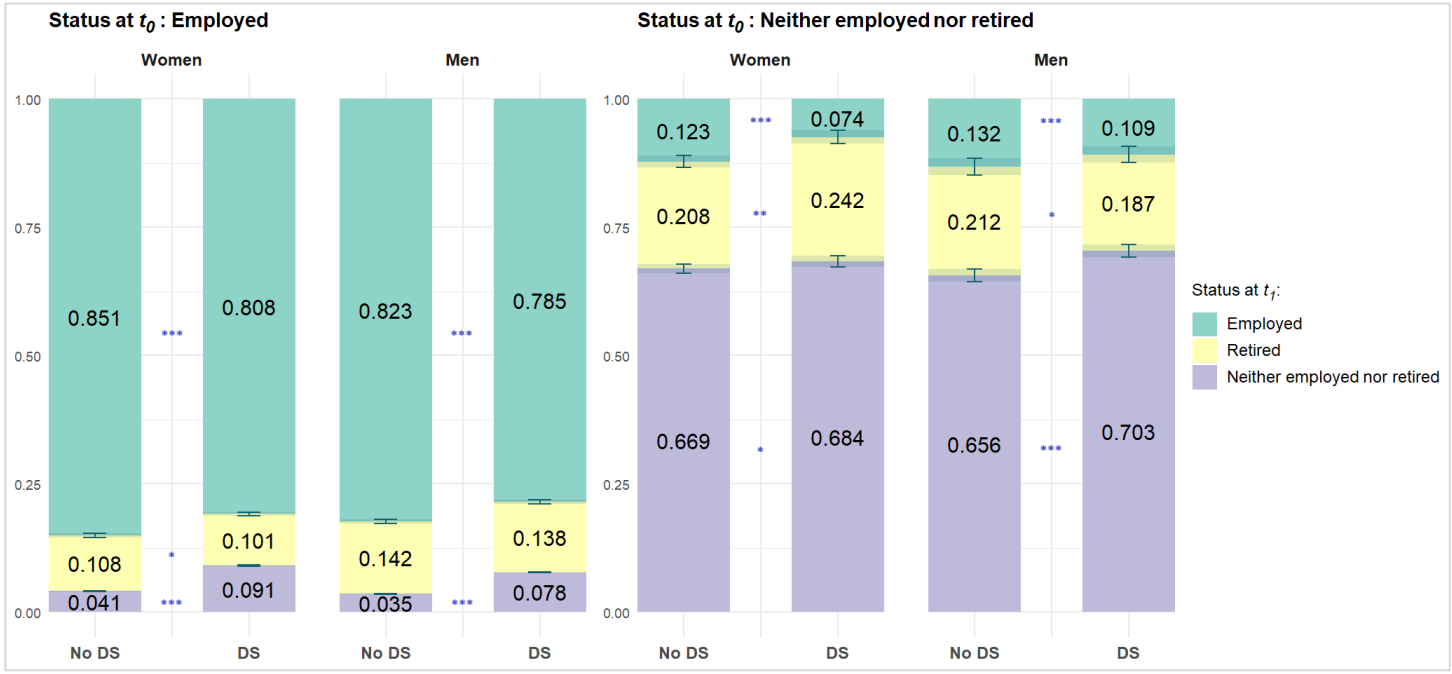
Source: Selected samples of respondents aged between 50 and 69 from the first follow-up waves of the CONSTANCES cohort (2013- 2022): Analysis of 'Onset of AL' (1') (2') are based on the selected sample of 11420 respondents that **did not** declare limitations at inclusion waves (t_0); Analysis of 'Persistence of AL' (3') (4') are based on the selected sample of 8777 respondents that **declared** limitations at inclusion waves (t_0).
Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

Figure II. S.3. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models on transitions in employment status from t_0 till t_1, for each gender – Conditional on severe MSC (osteo-articular diseases or permanent body pain) at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), N= 18 869.
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of 'Cancer' from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients of severe MSC from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed women at inclusion (t_0) who reported severe MSC, the APP of their transition into the status of "NENR" was estimated to be 5.9%, versus 4.1% for those who did not report severe MSC at t_0. The difference in estimated APPs was significant at the 1% level.

Figure II. S.4. Estimated average predicted probabilities (APPs) of employment status at t_1, from fitted multinomial models (with severe MSC among explanatory variables) on transitions in employment status from t_0 till t_1, for each gender – Conditional on DS at t_0.



Source: Selected samples of respondent aged between 50 and 69 with available data in variables of interest at first follow-up (t_1), N= 18 869.
Notes: Average predicted probabilities (APP) of each modality at t_1 were based on estimated coefficients of 'Cancer' from multinomial models, and were calculated following three steps: (1) exponentiating the estimated coefficients of DS from the model for each outcome modality, (2) summing the exponentiated values across all modalities to ensure the probabilities sum to one, and (3) normalizing each exponentiated value by this sum; *p<0.05; **p<0.01; ***p<0.001.
***Example of interpretation*:** Among employed women at inclusion (t_0) who reported DS, the APP of their transition into the status of "NENR" was estimated to be 9.1%, versus 4.1% for those who did not report DS at t_0. The difference in estimated APPs was significant at the 1% level.

D. Results from robustness checks accounting for "Lost at follow-up" (Distributions and estimations).

Table II.S.5. Distribution of health variables at inclusion (t_0), over sample of analysis on Activity Limitations (sample I) for those with and without follow-up data at t_1, by gender.

	Women <u>with</u> follow-up data N=10999	Women <u>without</u> follow-up data N=6973	Z scores and p-values (With – Without)	Men <u>with</u> follow-up data N= 9198	Men <u>without</u> follow-up data N=6420	Z scores and p-values (With – Without)
Activity restrictions						
Limited in global activities	46.35%	41.76%	6.03	40.00%	35.58%	5.6
Employment status						
NENR	9.14%	10.67%	-3.38	6.12%	8.82%	-6.4
Employed	49.59%	56.39%	-8.9	48.51%	56.43%	-9.75
Retired	41.28%	32.94%	11.22	45.37%	34.75%	13.27
Health conditions						
Musculoskeletal conditions	71.27%	64.35%	9.74	64.02%	56.70%	9.24
Depressive symptoms	15.98%	18.47%	-4.33	14.50%	15.69%	-2.04
Inc. DS+MSC	12.97%	14.53%	-2.96	10.40%	10.93%	-1.06
History with Cancer	10.80%	9.25%	3.35	8.15%	5.36%	6.74
Other chronic conditions	31.48%	26.85%	6.62	40.49%	34.08%	8.12
Inc. Diabetes	3.50%	2.80%	2.6	7.53%	5.89%	4.01
Cardiovascular diseases	12.38%	10.66%	3.51	18.54%	16.40%	3.44
Respiratory diseases	18.97%	16.21%	4.72	20.66%	17.09%	5.57

Source: Selected sample of respondent aged between 50 and 69 (N= 33 590) from the inclusion waves of the CONSTANCES cohort focused on AL (sample I).
***Notes*:** Differences in means between groups followed up and groups not followed-up were tested using two-sample z-tests.

Table II.S.6. Distribution of health variables at inclusion (t_0), over sample of analysis of individuals not retired at inclusion (sample III), for those with and without follow-up data at t_1, by gender.

	Women with follow-up data N=10564	Women without follow-up data N=6916	Z scores and p-values (With – Without)	Men with follow-up data N= 8305	Men without follow-up data N=6218	Z scores and p-values (With – Without)
Employment status						
NENR	15.73%	16.40%	-1.17	10.60%	13.06%	-4.58
Employed	84.27%	83.60%	1.17	89.40%	86.94%	4.58
Health conditions						
Musculoskeletal conditions	70.65%	63.71%	9.61	63.76%	56.40%	8.98
Depressive symptoms	18.35%	20.40%	-3.38	17.30%	18.32%	-1.58
Inc. DS+MSC	14.79%	15.91%	-2.01	12.43%	12.38%	0.08
History with Cancer	9.34%	7.94%	3.21	4.77%	3.68%	3.19
Other chronic conditions	26.33%	23.66%	3.97	31.94%	28.56%	4.38
Inc. Diabetes	2.43%	2.24%	0.82	5.35%	4.71%	1.72
Cardiovascular diseases	9.13%	8.46%	1.52	12.33%	11.85%	0.87
Respiratory diseases	17.22%	15.31%	3.32	18.77%	15.79%	4.68

Source: Selected sample of respondent aged between 50 and 69 and not retired at inclusion (N= 32 003) from the inclusion waves of the CONSTANCES cohort (2012-2021).
***Notes*:** Differences in means between groups followed up and groups not followed-up were tested using two-sample z-tests.

Table II.S.7. Distribution of MSC and DS conditional on AL and employment status at inclusion (t_0) among those with and without follow-up data at t_1 within <u>women</u>.

	Status at t_0	With MSC	With DS		***Status at t_0***	With MSC	With DS		***Status at t_0***	With MSC	With DS
Women <u>with</u> follow-up data	Not-Limited (N= 5901)	3529 (59.80%)	496 (8.41%)	**Women <u>without</u> follow-up data**	Not-Limited (N= 4061)	2116 (52.10%)	354 (8.7%)	**Z- scores; p-values (With-Without), for women**	Not-Limited	Z=7.61; p<0.01	Z=-0.54; p=0.58
	Limited (N= 5098)	4310 (84.5%)	1262 (24.75%)		Limited (N=2912)	2371 (81.4%)	934 (32.07%)		Limited	Z=3.61; p<0.01	Z=-7.06; p<0.01
	Employed (N=8902)	6203 (69.68%)	1515 (17.02%)		Employed (N=5782)	3650 (63.12%)	1072 (18.54%)		Employed	Z=8.25; p<0.01	Z=-2.36; p<0.05
	NENR (N=1662)	1260 (75.81%)	423 (25.45%)		NENR (N=1134)	756 (66.67%)	339 (29.89%)		NENR	Z=5.29; p<0.01	Z=-2.59; p<0.01

Source: Selected samples of women aged between 50 and 69 (both sample I and sample III of study) from the inclusion waves of the CONSTANCES cohort (2012-2021).
***Notes*:** Differences in means between groups followed up and groups not followed-up were tested using two-sample z-tests.
Example of interpretation: Within women who **had follow-up data**, 84.5% of those who were limited at inclusion (N=5098) reported MSC at inclusion, while this proportion amounted to 81.4% within women who **had <u>no</u> follow-up** data. This suggests that MSC were more common among limited women who were included in the analysis that used follow-up information, compared to those excluded due to the missing follow-up information; the difference in means was significant at the 1% level, with a z-score equals to 3.61.

Table II.S.8. Distribution of MSC and DS conditional on AL and employment status at inclusion (t_0) among those with and without follow-up data within men.

	Status at t_0	With MSC	With DS		***Status at t_0***	With MSC	With DS		***Status at t_0***	With MSC	With DS
Men with follow-up data	Not-Limited (N= 5519)	2989 (54.16%)	422 (7.65%)	**Men without follow-up data**	Not-Limited (N= 4136)	1906 (46.08%)	333 (8.05%)	**Z- scores; p-values (With-Without), for men**	Not-Limited	Z=7.85; p<0.01	Z=-0.73; p=0.46
	Limited (N=3679)	2900 (78.82%)	912 (24.79%)		Limited (N= 2284)	1734 (75.91%)	674 (29.51%)		Limited	Z=2.62; p<0.05	Z=-4.01; p<0.01
	Employed (N=7425)	4886 (63.11%)	1109 (14.93%)		Employed (N=5406)	2988 (55.27%)	861 (15.93%)		Employed	Z=8.94; p<0.01	Z=-1.53; p=0.13
	NENR (N=880)	609 (69.20%)	328 (37.27%)		NENR (N=812)	519 (63.92%)	278 (34.24%)		NENR	Z=2.30; p<0.05	Z=1.30; p=0.19

Source: Selected samples of men aged between 50 and 69 (both sample I and sample III of study) from the inclusion waves of the CONSTANCES cohort (2012-2021).
***Notes*:** Differences in means between groups followed up and groups not followed-up were tested using two-sample z-tests.
Example of interpretation: Within men who **had follow-up data**, 78.82% of those who were limited at inclusion (N=3679) reported MSC at inclusion, while this proportion amounted to 75.9% within men who **had no follow-up** data. This suggests that MSC were more common among limited men who were included in the analysis that used follow-up information, compared to those excluded due to the missing follow-up information; the difference in means was significant at the 5% level, with a z-score equals to 2.62.

Table II.S.9. Estimated ORs from fitted simple logistic models on transitions in AL (t_0 *till* t_1) stratified by gender, for each model specification (excluding those lost at follow-up and including them with imputations of AL=1 or AL=0 at t_1).

Study population:	**Excluding lost-at follow-up** (No imputations)		**Including lost at follow-up** (Imputation with AL =1 at t_1)		**Including lost at follow-up** (Imputation with AL =0 at t_1)	
Status at t_1:	**Onset of AL** (Not-Limited t_0 to Limited at t_1)					
	Women	Men	Women	Men	Women	Men
MSC at t_0	**1.60***** (1.36, 1.88)	**1.34**** (1.16,1.55)	**1.54***** (1.38, 1.72)	**1.35**** (1.22,1.51)	**1.65***** (1.42, 1.92)	**1.35***** (1.18,1.54)
DS at t_0	**1.80*** (1.15, 2.74)	**1.74*** (1.21, 2.47)	**2.34***** (1.7, 3.23)	**2.16*** (1.64, 2.84)	**1.75***** (1.16, 2.57)	**1.58*** (1.13, 2.17)
MSC × DS at t_0	0.69 (0.42,1.16)	1.27 (0.81, 2.01)	0.76 (0.52, 1.12)	1.29 (0.89, 1.88)	0.66 (0.41, 1.07)	1.19 (0.79, 1.82)
Constant	*1.26 (0.23, 6.79)*	*0.25 (0.05, 1.22)*	***0.04*******(0.01, 0.16)*	***0.02****** *(0, 0.09)*	***10.04**** *(1.34, 75.05)*	*1.28 (0.2, 8.23)*
Observations	5901	5519	9962	9655	9962	9655
Status at t_1:	**Persistence of AL** (Limited at t_0 to Limited at t_1)					
	Women	Men	Women	Men	Women	Men
MSC at t_0	**1.81***** (1.52, 2.17)	**1.51***** (1.25, 1.83)	**1.97***** (1.69, 2.3)	**1.58***** (1.34, 1.86)	**1.88***** (1.59, 2.22)	**1.26**** (1.06, 1.5)
DS at t_0	1.26 (0.90, 1.77)	**1.51*** (1.07, 2.12)	**1.63***** (1.23, 2.18)	**1.96***** (1.46, 2.66)	1.02 (0.74, 1.39)	1.17 (0.86, 1.58)
MSC × DS at t_0	1.43 (0.99, 2.08)	1.27 (0.86, 1.87)	1.24 (0.9, 1.7)	1.18 (0.83, 1.66)	1.33 (0.95, 1.87)	1.26 (0.9, 1.77)
Constant	*1.33 (0.35, 5.05)*	*1.27 (0.16, 6.18)*	*0.33 (0.07, 1.5)*	*0.5 (0.09, 2.97)*	***24.9****** *(5.64, 110.3)*	***16.31*********(2.84, 93.8)***
Observations	5098	3679	8010	5963	8010	5963

Source: Selected samples of respondents aged between 50 and 69 from the first follow-up waves of the CONSTANCES cohort (2013- 2022): Analysis of 'Onset of AL' (1') (2') are based on the selected samples of respondents who **did not** declare limitations at inclusion waves (t_0); Analysis of 'Persistence of AL' (3') (4') are based on the selected samples of respondents who **declared** limitations at inclusion waves (t_0).

Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

Table II.S.10. Estimated average marginal effects (AMEs) of MSC and DS models on transitions in AL (t_0 *till* t_1), from fitted simple logistic stratified by gender, for each model specification (excluding those lost at follow-up and including them with imputations of AL=1 or AL=0 at t_1).

Study population:	**Excluding lost-at follow-up** (No imputations)		**Including lost at follow-up** (Imputation with AL =1 at t_1)		**Including lost at follow-up** (Imputation with AL =0 at t_1)	
Status at t_1:	**Onset of AL** (Not-Limited t_0 to Limited at t_1)					
	Women	Men	Women	Men	Women	Men
MSC at t_0	**0.05***** (0.03, 0.07)	**0.05***** (0.03, 0.07)	**0.06***** (0.05, 0.08)	**0.05***** (0.04, 0.07)	**0.04***** (0.03, 0.05)	**0.03***** (0.02, 0.04)
DS at t_0	**0.05**** (0.01, 0.09)	**0.12***** (0.08, 0.17)	**0.11***** (0.08, 0.14)	**0.15***** (0.12, 0.18)	**0.03*** (0.01, 0.05)	**0.07***** (0.04, 0.09)
Observations	5901	5519	9962	9655	9962	9655
Status at t_1:	**Persistence of AL** (Limited at t_0 to Limited at t_1)					
	Women	Men	Women	Men	Women	Men
MSC at t_0	**0.16***** (0.13, 0.2)	**0.11***** (0.07, 0.15)	**0.14***** (0.11, 0.16)	**0.09***** (0.06, 0.11)	**0.12***** (0.1, 0.15)	**0.05***** (0.03, 0.08)
DS at t_0	**0.12***** (0.09, 0.16)	**0.13***** (0.1, 0.17)	**0.11***** (0.09, 0.13)	**0.13***** (0.11, 0.15)	**0.05***** (0.03, 0.07)	**0.06***** (0.03, 0.08)
Observations	5098	3679	8010	5963	8010	5963

Source: Selected samples of respondents aged between 50 and 69 from the first follow-up waves of the CONSTANCES cohort (2013- 2022): Analysis of 'Onset of AL' (1') (2') are based on the selected samples of respondents who **did not** declare limitations at inclusion waves (t_0); Analysis of 'Persistence of AL' (3') (4') are based on the selected samples of respondents who **declared** limitations at inclusion waves (t_0).

Notes: Estimated odds ratios (ORs) are based on fitted simple logistic regression models, stratified by gender; 95% confidence intervals are derived from standard errors; * p<0.05, ** p<0.01, *** p<0.001.

Figure II. S.5. Summary of all estimated APPs of employment status at t_1 conditional on employment status and DS at t_0 from the different specifications (with and without imputations at t_1).

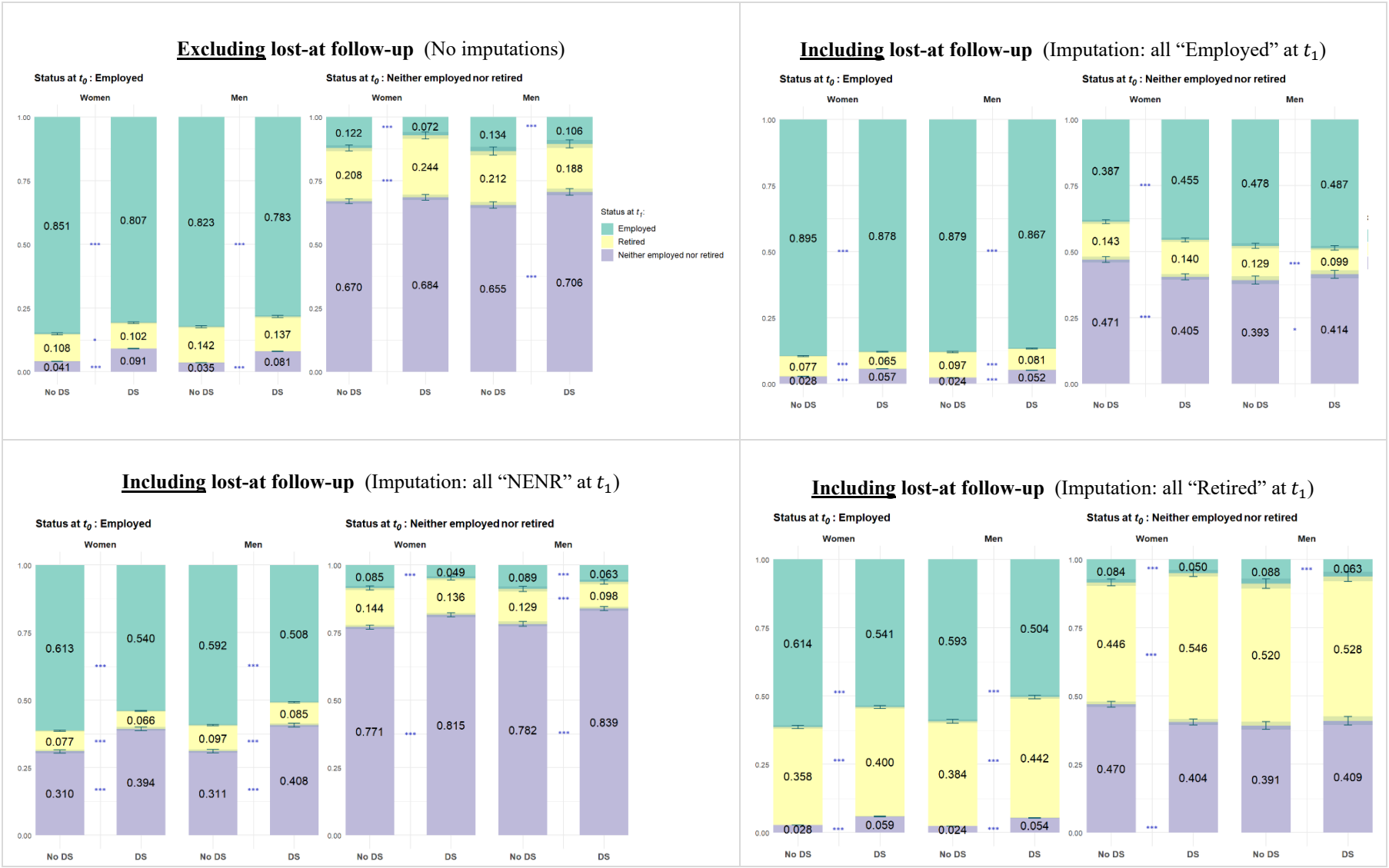
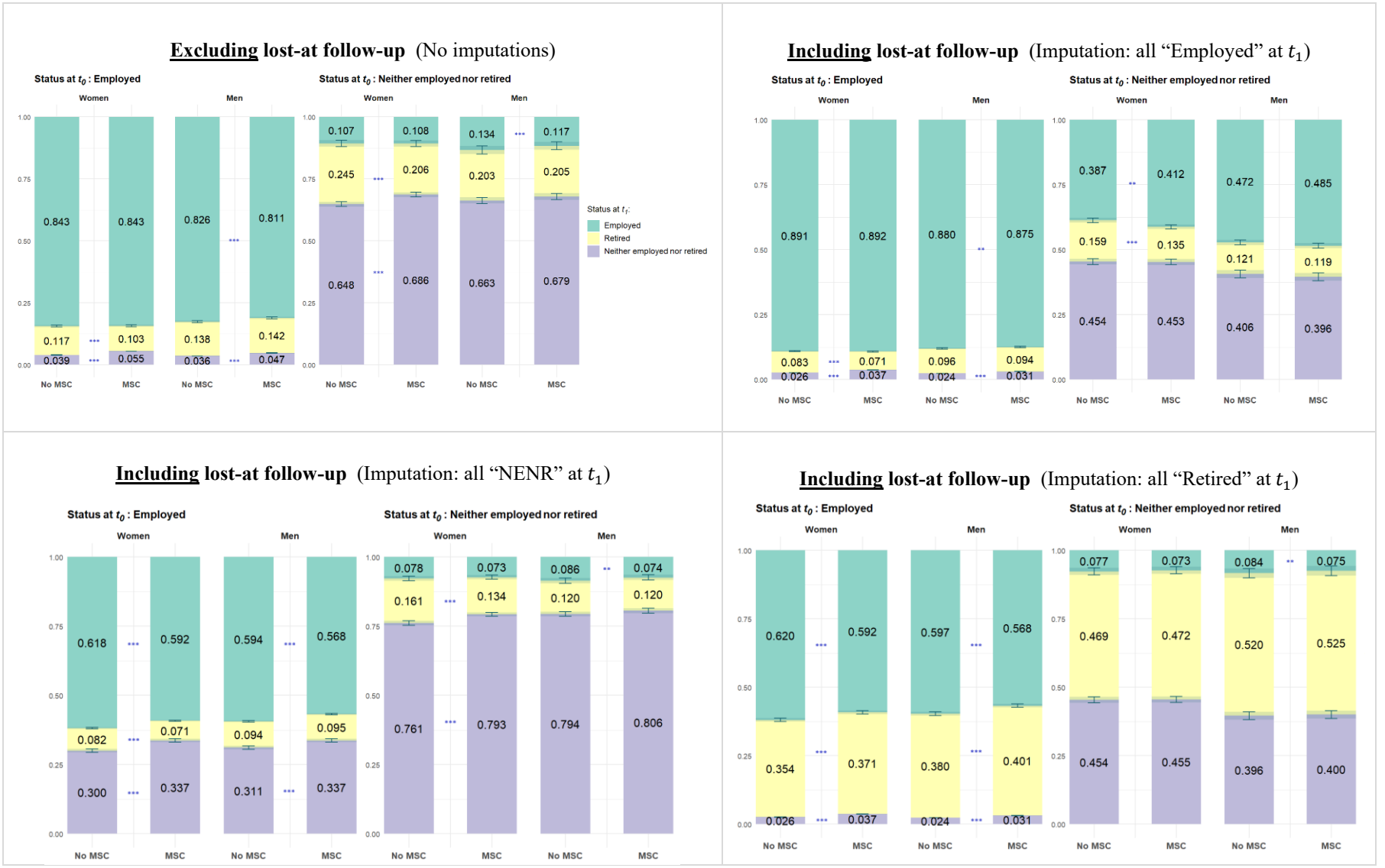


Figure II. S.6. Summary of all estimated APPs of employment status at t_1 conditional on employment status and MSC at t_0 from the different specifications (with and without imputations at t_1).



E. Discussion of results from analyses accounting for "Lost at follow-up".

E.1. Distributions across 'Lost' and 'Not-Lost' at follow-up.

In summary, regarding the distribution of health variables at inclusion among individuals with and without follow-up data (Table II.S.5 and Table II.S.6), our results showed that AL, MSC, and other chronic diseases were more frequently reported among participants with follow-up data, for both genders (For example, MSC were reported by 71.27% of women with follow-up data compared to 64.35% of those without; $p<0.01$). However, the reporting of DS and being classified as NENR at inclusion, was slightly more common among those excluded (without follow-up data) than those with follow-up data (for example, NENR was found among 8.82% of men excluded from the main analysis versus 6.12% of men included).

Further examining the distributions of MSC and DS within each inclusion category of AL and employment status (Table II.S.7 and Table II.S.8), the results suggest the following: among both men and women, the proportion of reporting MSC was lower in the sample without follow-up data, among those who were "Not limited" or "Employed" at inclusion. Additionally, "Limited" and "NENR" respondents with follow-up data were significantly more likely to report MSC than their counterparts, without follow-up data. In contrast, for DS, among Limited, Employed and NENR women at inclusion, those without follow-up data were more likely to report DS at inclusion than those with follow-up data (all $p<0.05$).

E.2. Associations between MSC, DS and transitions in AL, following imputations.

In the analysis of transitions in AL status (Table II.S.9 and Table II.S.10), all estimated models, regardless of whether individuals lost to follow-up were excluded or their AL status at t_1 was imputed with extreme values, showed that MSC and DS significantly increased the risk of AL onset and persistence, for both men and women.

E.3. Associations between MSC, DS and transitions in employment status, following imputations.

The case of MSC.

Across all model specifications, MSC were consistently associated with a significantly increased risk of becoming NENR at t_1 among both men and women who were employed at t_0. Additionally, MSC were shown to reduce the likelihood of remaining in employment in models where inclusion employed individuals lost at follow-up were assumed to be either all "NENR" or all "retired" at t_1. Since MSC were less prevalent among the employed at inclusion who were lost at follow-up, compared to those who were not lost, including them, under the assumption that they all became NENR or retired, could have biased the results against finding a strong association between MSC and employment exit over time. That is, if this difference introduced bias, we might have expected MSC to appear less associated with becoming NENR in these scenarios. However, this was not the case. The continued significance of MSC in increasing the risk of NENR t_1 among those employed at t_0 suggests that the associations observed in the analysis excluding those lost to follow-up were robust, even when accounting for potential bias due to attrition.

For individuals who were NENR at t_0, the original model indicated that MSC significantly increased the probability of remaining in the NENR category at t_1 only among women. This association disappeared in the alternative models that accounted for individuals lost to follow-up, under the assumption that they were either all employed or retired in the first follow-up. This heterogeneity in results is unlikely to stem from selection bias, as MSC were more prevalent among women who were NENR at inclusion and retained in the sample. This suggests that the observed variation in results maybe likely due to limited statistical power, given the relatively small size of the NENR subgroup at inclusion.

The case of DS.

Across all model specifications, DS were associated with an increased risk of becoming NENR at t_1 among individuals employed at t_0, for both men and women. DS also reduced the likelihood of remaining employed at t_1. This consistency across models reinforces the

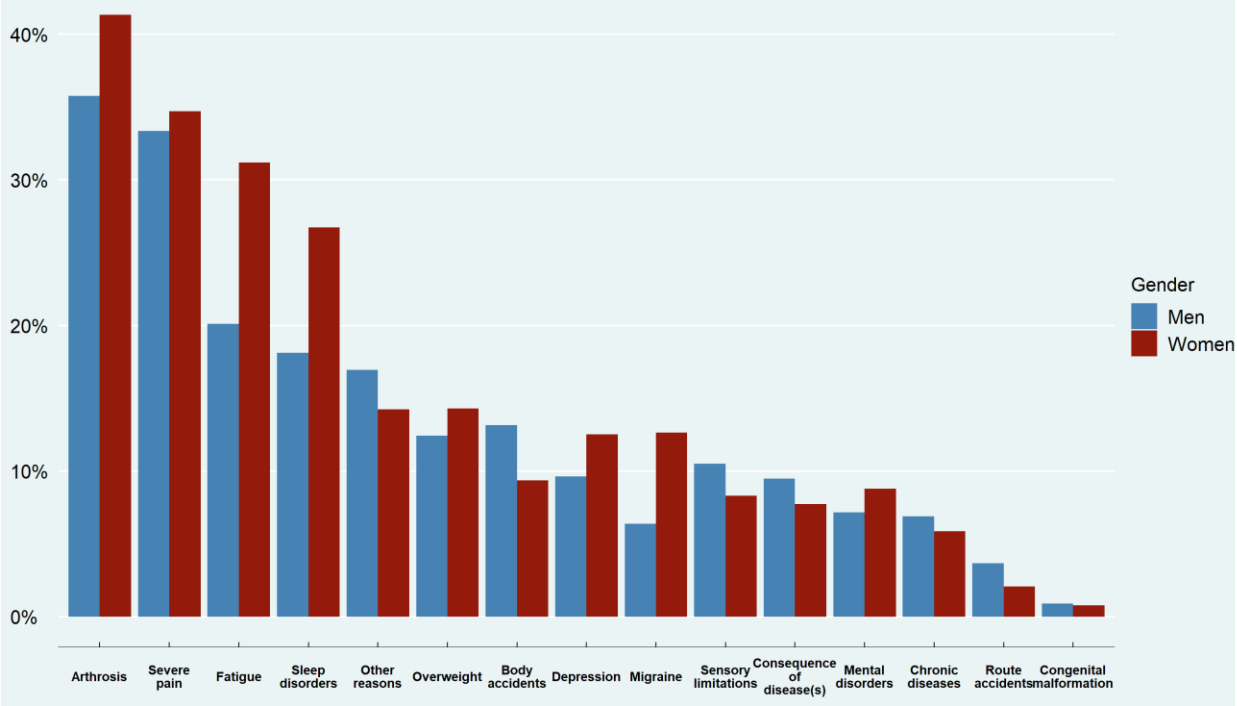
robustness of the findings from the original analysis, which excluded those lost to follow-up.

However, some heterogeneity emerged in the association between DS and employment status at t_1 among individuals who were NENR at t_0. For women, DS were significantly associated with a higher probability of remaining in the NENR category, both in the original sample (excluding those lost to follow-up) and when including them under the assumption that they all remained NENR at t_1. In contrast, when assuming that all NENR women lost to follow-up had returned to employment by t_1, the models suggested that DS increased the likelihood of transitioning back to employment. As discussed, the proportion of DS was slightly higher among NENR women who were lost to follow-up than those who remained in the sample, yet the heterogeneity with respect to the counterfactual scenario as with the observed heterogeneity in MSC results, may stem from the relatively small size of the NENR subgroup at inclusion.

For men, results from the original analysis (excluding those without follow-up data) indicated that those who were NENR at inclusion and reported DS were significantly more likely to remain NENR at t_1 and less likely to return to employment. This pattern remained consistent when including those lost to follow-up under the assumptions that they were either all NENR or all retired at t_1. However, this association lost statistical significance when assuming that all such men were employed at t_1. As in the case of women, this heterogeneity is likely driven by the small number of NENR individuals at inclusion, particularly among men.

F. Distribution of answers to: “If limited in general activities, for what reasons?”.

Figure II. S.7. Distribution of answers to “If limited in general activities compared to people same age, for what reason(s) ? by gender.



Source: Selected sample of respondent aged between 50 and 69 (N= 33 590) from the inclusion waves of the CONSTANCES cohort.
***Notes*:** respondents who reported being limited in their activities compared with others of the same age were asked to identify the main reasons for their limitations from a predefined list of fourteen conditions.
Example if interpretation: Among men who declared being limited, around 36% associated their limitation to arthrosis, while this proportion amounted to around 42% among women.

Chapter 3. Postponing retirement and the risk of being “Neither employed nor retired” in France: Heterogeneity with respect to health histories.

Co-authored with Léa Cimelli

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Extended abstract.

Population ageing has led many OECD countries to reform their pension systems by raising statutory retirement ages to ensure financial sustainability. While these reforms have contributed to higher employment rates among middle-aged and older adults, several studies have shown that they also lead to alternative labor-market exits before retirement eligibility, including unemployment, disability pensions, or inactivity. These statuses, grouped under the category "Neither Employed Nor Retired" (NENR), accounted for about 11% of adults aged 53 to 69 in France in 2015. As this situation challenges the objective of extending working lives, identifying the factors associated with such outcomes has become essential.

Previous research has examined how responses to pension reforms differ across gender and social groups, but health has received comparatively less attention, despite its central role in shaping retirement decisions. Poor health can limit work capacity and increase the risk of exiting employment through NENR status. Chronic diseases such as musculoskeletal disorders (MSD), cardiovascular diseases (CVD), and depression are particularly relevant in this regard. These conditions are common in mid-adulthood, restrictive (in line with results from previous chapters), and unequally distributed across gender and social groups. Examining whether individuals with these health conditions are more likely to be NENR following an increase in statutory retirement ages is therefore particularly relevant.

This chapter investigates whether health histories influenced responses to the 2010 French pension reform. This specific reform raised the statutory retirement age, that is the earliest age to claim pension benefits, from 60 to 62, and the full-rate pension age from 65 to 67. These increases were phased in gradually by birth cohort: for those born after July 1st, 1951, the retirement age increased by four months per cohort, until fully implemented for those born in 1956 and later. The reform was announced and applied rapidly, affecting those just months away from retirement, which left little room for individual adjustment. This setup allows to compare adjacent birth cohorts with different statutory retirement ages to estimate the impact of the reform. The analysis uses a difference-in-differences (DiD) strategy that takes advantage of the cohort-based implementation of the reform to identify its effects. To ensure comparability between cohorts, the analysis is restricted to cohorts born between 1948 and 1953, and estimates the effects of the increase of statutory ages from 60 to 61 (the statutory retirement age for those born in 1953).

We use linked data from two sources: medical data from the French CONSTANCES cohort, and administrative records from the French National Pension Fund ("*Caisse Nationale d'Assurance Vieillesse*" – CNAV). CONSTANCES is a large population-based cohort representative of adults aged 18 to 69 in France. Enrollment in this cohort took place between 2012 and 2022, when participants underwent health examinations and provided information on their birth year, demographic background, socioeconomic status, along with information on their current and past health status. CONSTANCES' data were matched to CNAV records, which contain yearly information on employment history, validated quarters for the pension eligibility count, retirement status, and periods of unemployment, disability, sickness, or inactivity, as well as private-sector earnings, for a timeline that covers years prior and post CONSTANCE's enrolment waves. In our analytical sample, we selected respondents who belonged to cohorts 1948 till 1953, with no missing values in our variables of interest, which left us with a sample of 22,324 respondents, for whom we used administrative records between the ages of 55 and 65, totaling 245,464 yearly observations, over the periods of 2005 till 2018.

The outcome of interest which relates to work status, is derived from CNAV data. Each year, individuals are classified into one of three categories: "Employed" (if more than two trimesters were spent in employment or similar activity), "Retired" (when they claim and start receiving retirement pensions), or "NENR" (if more than two trimesters were spent in unemployment, disability, or periods with no contribution to any retirement scheme). Regarding health conditions, health history is obtained from CONSTANCES data, where information on health history was collected through self-reported diagnoses at health centers. Respondents were given a list of chronic diseases and asked whether they have been diagnosed with any of them, and if so, they were asked to specify the age of diagnosis. We focused on histories with depression, any CVD (such as stroke, myocardial infarction, or angina), or any osteoarticular disease (OSD) (including arthritis and related conditions, which are types of MSD) between ages 40 and 55. This choice was made to limit endogeneity as we investigate work status after age 55.

Regarding our empirical strategy, drawing on the approach of previous works (Dubois & Koubi, 2017; Rabaté & Rochut, 2020), we implement a DiD linear model. The control group includes those born between January 1st 1948 and June 30th 1951 (for whom statutory retirement age was 60), and the treated group involves those born between July 1st 1951 and December 31st 1953 (among whom statutory age gradually increased from 60 to 61). In the implemented DiD model, we include "history with health condition" as a main explanatory variable and interact it with the DiD estimator to assess whether the impact of the 2010 pension reform varies depending on individuals' prior health conditions. Given that our outcome variable comprises three mutually exclusive work statuses, "Employed", "Retired", and NENR, we estimate three separate linear probability models, each using a binary indicator for one of the outcomes. This approach allows to

examine how the reform affected each labor market status individually. We start with fitting models without accounting for history of health conditions to compare our results with findings from the literature. Next, three sets of models are estimated, one for each health condition: depression, OSD, and CVD, which result in a total of six models. We additionally control for gender, highest educational attainment, contribution history to the social security system, and nationality. These initial models estimate the effect of the reform at the age-60 threshold but do not allow for the identification of horizon effects, that is, changes in behavior occurring at other ages in response to the reform. Given the complexity of models required to test for heterogeneity in horizon effects and sample size constraints, horizon effects are briefly explored in a supplementary analysis.

Results from the implemented DiD models, without accounting for health conditions, are consistent with findings from Rabaté and Rochut (2020): the 2010 pension reform significantly increased the probability of being employed at age 60, but also increased the probability of falling into the NENR category. This pattern is observed when comparing treated individuals (born after July 1st, 1951 up to 1953) to individuals in the control group (born between 1948 and June 1951). The DiD estimates show a dual effect of the reform at age 60: both an increase in employment and a rise in NENR status.Turning to heterogeneity by prior health conditions, estimates from DiD models confirm that the impact of the reform differed between individuals with and without a history of depression, OSD, and CVD prior to age 55. Specifically, the increase in the probability of being NENR at age 60 was significantly larger for individuals with a prior diagnosis of depression, OSD, and CVD, compared to those without such a history. Across robustness checks, including alternative variable definitions, and the inclusion of sick leave in NENR, significant heterogeneity in the reform's impact remained observed for all conditions. When further restricting the selection of cohorts, results remained robust only for the case of depression.

These findings underscore the importance of considering health histories, particularly histories of depression, osteoarticular, and cardiovascular diseases, when assessing and designing pension reforms. Among the three conditions examined, findings of heterogeneity effects in the response to the reform with respect to history of depression, remained consistent in all robustness checks. This indicates that mental health plays a distinctive role in shaping responses to increases in statutory retirement ages. The French pension system includes specific pathways for individuals whose health limits work capacity, such as early retirement schemes for those officially recognized as disabled or unfit for work. However, comparable provisions for mental health conditions remain limited. Individuals affected by depression may therefore face difficulties maintaining employment while lacking eligibility for early retirement on health grounds, resulting in a higher likelihood of being in the NENR category.

I. Introduction.

Globally, the ongoing ageing of populations has become a central concern for economic policy. Across OECD countries, the ratio of individuals aged over 65 to the working-age population has increased from 19% in 1980 to 31% in 2023, and is expected to reach 52% by 2060 (OECD, 2025). France is no exception: the share of individuals aged 65 and over is expected to reach 28% of the population by 2050 (Bonnet et al., 2021b). This phenomena has been an important subject of interest for public policies as these demographic changes present major economic challenges, which include the widely discussed rising need for health expenditures in long-term care (Belmonte et al., 2023; Jones & Dolsten, 2024; Kallestrup-Lamb et al., 2024; R. Lee & Miller, 2002; Okamoto et al., 2023). In addition, public pension systems face a growing number of beneficiaries coinciding with a smaller number of contributors, as a result of population ageing. In the aim of ensuring financial sustainability of their pensions systems, many OECD countries have responded to population ageing by implementing pension reforms that extended working lives, by raising statutory and/or ordinary retirement age (OECD, 2023b). This includes the United States and several European countries like France, Italy, Germany, Finland, and the Netherlands. While implemented reforms have contributed to increasing employment among middle-aged and older adults (Pilipiec et al., 2021), evidence also points to some reforms simultaneously leading to increased rates of labor market exit prior to official retirement ages, through alternative pathways (Berkman & Truesdale, 2023; Nivalainen & Ilmakunnas, 2025; Rabaté & Rochut, 2020; Serrano-Alarcón et al., 2023). These pathways include unemployment, disability pensions, or other inactivity statuses, grouped under a category labelled "Neither Employed Nor Retired" (NENR). In France, 11% of adults aged between 53 and 69 fell in this category in 2015 (D'Isanto et al., 2018). As this status challenges the intended goals of policymakers, which are focused on expanding durations of working lives, understanding who is most affected by the postponement of retirement ages, and through which pathways, has become crucial.

Several studies have documented heterogeneous responses to pension reforms across gender and social groups, including differences by educational attainment and

occupational class (Emmerson et al., 2022; Nivalainen & Ilmakunnas, 2025; Staubli & Zweimüller, 2013; Zemmour, 2024). However, health status has received comparatively less attention as a potential source of heterogeneity in reform responses, despite its central role in shaping retirement decisions. When considered, health was often proxied by sick leave records (Rabaté & Rochut, 2020b; Staubli & Zweimüller, 2013), which capture temporary absences rather than specific conditions that may constrain individuals' capacity to work. As health tends to decline with age, extending working lives also extends periods during which it may affect labor-market participation. In ageing populations, chronic diseases are highly prevalent and represent a major factor influencing the ability to remain in employment. Examining how health status affects responses to raising retirement ages, particularly chronic diseases, is therefore increasingly relevant.

This study investigates whether the effects of the 2010 French reform, which gradually raised the statutory retirement age from 60 to 62, on transitions into NENR status varied according to individuals' chronic disease histories. In this introductory section, we begin by reviewing existing evidence on how health can influence retirement decisions, highlighting the main mechanisms through which chronic conditions contribute to labor-market exits and early retirement, besides summarizing key findings for major disease groups. We then present the institutional context of our study by describing the French pension system and detailing the 2010 reform, along with other concurrent policy changes that may have affected retirement behaviors. Next, we briefly describe the objectives and methods used in this work, and discuss its contribution to the literature.

I. 1. How does health affect retirement decisions?

I. 1. a. Mechanisms linking health with retirement decisions.

In contexts not necessarily involving pension reforms, health has been identified as a major determinant of individual labor-market decisions. Chronic health conditions, as well as poor self-perceived, physical, and mental health, have been shown to increase risks of unemployment, early retirement decisions (before reaching full eligibility), and

transitions into disability pensions (Berg et al., 2010; de Wind et al., 2013; Rijn et al., 2014; Robroek et al., 2013; Vanajan et al., 2020). Several mechanisms explain these associations. Poor health particularly associated with chronic diseases can lead to activity restrictions that impair work capacity. According to the "disablement process model" (Nagi, 1964; Verbrugge & Jette, 1994), chronic diseases initiate a chain of consequences: diseases cause bodily impairments, which in turn lead to functional limitations, than can be either physical, sensory, or cognitive, which manifest as difficulties in, for instance, holding objects, climbing stairs, walking long distances, or recalling memories. These limitations can then further restrict individuals' participation in various activities, from essential daily tasks such as eating, bathing, or housekeeping, to broader social and professional engagements, including employment.

Beyond the physiological mechanisms, poor health can also affect retirement decisions through psychological and social channels. Individuals experiencing deteriorating health may anticipate future work limitations, fear further health decline, or face explicit or implicit pressure from employers to leave (de Wind et al., 2013; Reeuwijk et al., 2013; Sundstrup et al., 2020). As pension reforms extend working lives, the period during which health can influence labor-market trajectories increases, potentially creating or widening disparities between "healthy" and "unhealthy" workers with regard to employment status. Furthermore, when statutory eligibility ages are raised, individuals who have already exited employment face an extended period without income from either work or pension. Garrouste & Perdrix (2022), drawing on Grossman's (1972) health capital model, identify this change in the budget constraint as a key channel through which reforms delaying retirement affect individuals. This income gap is likely to weigh more heavily on those whose health limits their capacity to return to employment, as they have fewer means to bridge the period between job exit and pension eligibility.

I. 1. b. Specific health conditions associated with labor-market exits before retirement.

Building on evidence that chronic diseases increase transitions into unemployment or disability pensions prior to retirement eligibility, several specific conditions have been

associated with being NENR. Diabetes, for example, has been associated with higher risks of work cessation and disability pension among workers in their mid-adulthood (Rumball-Smith et al., 2014; von Bonsdorff et al., 2018). Respiratory diseases, particularly chronic obstructive pulmonary disease (COPD), have also been linked to reduced work ability and premature employment exit due to fatigue and breathing difficulties (Gruet, 2018; Wheaton et al., 2015). Likewise, studies on cancer survivorship report persistent employment interruptions and lower return-to-work rates that can last for years after diagnosis (de Boer et al., 2020; Taskila & Lindbohm, 2007).

Other chronic conditions that are more common in mid- and late adulthood, namely musculoskeletal disorders (MSD), cardiovascular diseases (CVD), and poor mental health, have received particular attention. These conditions have been consistently associated with a higher likelihood of leaving employment before retirement eligibility (Hengel et al., 2019; Kouwenhoven-Pasmooij et al., 2016; Leijten et al., 2015; Olesen et al., 2012; Rice et al., 2011; Sayeed et al., 2021). MSD, including osteoarthritis, rheumatoid arthritis, and chronic back pain, are among the leading causes of disability worldwide and a major driver of early retirement through disability pensions (Badarin et al., 2023; Briggs et al., 2016; Holland & Clayton, 2020; Polvinen et al., 2014; Ropponen et al., 2011; Vahtera et al., 2010). In Finland, poor health particularly due to MSD, has been strongly associated with disability pension uptake (Karpansalo et al., 2005). In Denmark, these disorders have been linked to lower planned retirement age, especially among women (Datta Gupta & Larsen, 2010), while in other contexts they have been shown to reduce work capacity and influence retirement intentions (Vanajan et al., 2020). CVD, including stroke, myocardial infarction, coronary artery, and ischemic heart diseases, have been linked with long term physical disabilities in many countries (Fouillet et al., 2024; Lisy et al., 2018; Taylor et al., 2002; Townsend et al., 2015; R. T. de C. Yokota, Van der Heyden, et al., 2016). Evidence has consistently associated these diseases with lower workforce participation and elevated risks of unemployment (Kouwenhoven-Pasmooij et al., 2016; Luengo-Fernandez et al., 2023; Rico et al., 2023). Conditions affecting mental health, including depression, have similarly been identified as strong predictors of early labor market exit. They are associated with lower chances of re-employment following job loss,

increased risks of transitions into disability pensions, and early retirement decisions (van Rijn et al., 2014; Olesen et al., 2012). In Australia, poor mental health has been linked to early retirement among men and premature workforce withdrawal among women (Olesen et al., 2012).

In the French context, MSD, CVD, and poor mental health are common in mid-adulthood and have been strongly associated with activity restrictions (consistent with results from chapters 1 and 2). Results from the 2019 "Global Burden of Disease" ranked mental and musculoskeletal disorders among the main contributors to years lived with disabilities in France (Francis-Oliviero et al., 2024). For CVD, specifically stroke, myocardial infarction, coronary artery, and ischemic heart diseases, both prevalence and hospitalizations have risen in recent years, with the Ministry of Health reporting levels "never experienced before" in 2022 (Santé publique France, 2025). Given their prevalence and restrictive impact, examining whether these specific conditions shape responses to policies extending working lives is therefore important for policymakers, for guiding their policy designs and anticipations of the effects of such reforms.

MSD, CVD, and poor mental health have also been shown to contribute to gender and social health inequalities in France (as confirmed by results in chapter 1). From mid-adulthood, women report higher prevalence of MSD and depression (Crimmins et al., 2011; Nusselder, Cambois, et al., 2019; Nusselder, Wapperom, et al., 2019), reflecting both biological differences and inequalities in social experiences such as occupational trajectories (Beaufils et al., 2024; Cambois et al., 2017). MSD and CVD are more prevalent among socially disadvantaged groups, including those with low educational attainment and individuals in unskilled or low-skilled occupations. For MSD, this reflects greater exposure to physical risk factors such as awkward postures, repetitive movements, and manual handling (Govaerts et al., 2021; Greggi et al., 2024; Yung et al., 2020). Elevated CVD risks in these groups are associated with adverse health behaviors, limited healthcare access, and harmful occupational exposures common in manual jobs, such as dust, fumes, and fibres (Fang et al., 2010; Grahn et al., 2022; Mackenbach et al., 2000; Vandersmissen et al., 2020). Investigating whether MSD, depression and CVD hinder the

extension of working lives is therefore essential for understanding possible sources of heterogeneity in responses to pension reforms across gender and social groups, when they exist.

I. 2. The French institutional context and the 2010 reform.

The French case provides an analytically rich setting for the objectives of our work. Its pension system is both complex and deeply institutionalized, combining multiple schemes that collectively ensure broad coverage while incorporating specific provisions for individuals whose health limits work capacity (Bozio, 2022). Compared with many European countries, it remains one of the most comprehensive and redistributive systems, supported by a high level of public expenditure on pensions, around 14% of GDP in recent years, which is among the highest in the OECD countries (OECD, 2023). Moreover, the 2010 pension reform offers a particularly relevant case to study as it was implemented unexpectedly, and marked the first increase in the statutory retirement age since 1983 (Caroli et al., 2023), prompting immediate behavioral and political responses.

I. 2. a. Overview of the French pension system in the early 2000s.

The French pension system operates on a pay-as-you-go (PAYG) basis (Bozio, 2022). It is a public system composed of multiple schemes that differ in their rules and structure, ranging from defined-benefit to points-based models. Pension entitlements are primarily determined by the duration of contribution periods and earnings accumulated over an individual's working life. In the early 2000s, French retirees enjoyed living standards comparable to those of the working population (Conseil d'orientation des retraites, 2022). Pension expenditures represent a significant national budget, and accounted for 12.4% of GDP in 2006, a 16.3% increase since 1990 (OECD, 2009). This growth is partly attributable to population ageing and the entry of larger cohorts into retirement age. Demographic ageing has also led to a deterioration in the ratio of working-age individuals to retirees, raising recurrent concerns about the long-term financial sustainability of the system. According to the OECD's 2009 Pensions at a Glance report (OECD, 2009), the

old-age dependency ratio in France was projected to reach 0.29 by 2010. This ratio has been steadily increasing since 1990 and is expected to continue rising in the coming decades.

I. 2. b. Increasing retirement ages and the 2010 pension reform.

Two key age thresholds structure the French pension system. The first is the statutory eligibility age (SEA), which defines the earliest age at which individuals may begin claiming their retirement benefits. Before the 2010 reform, the SEA was fixed at 60, although earlier retirement was possible for individuals in poor health (according to specific rules, further detailed in **I. 2. d**), with long contribution histories, or employment in strenuous occupations. The second is the end of penalty age (EPA), the age at which a full pension can be claimed regardless of contribution duration, set at 65 prior to the 2010 reform. These thresholds have been demonstrated to be strong predictors of retirement behavior: In 2010, 29% of individuals aged 59 were already retired, a share that rose to 60% at age 60 (SEA) and to 90% at age 65 (EPA) (Zemmour, 2024).

The 2010 reform increased both the SEA and EPA. These increases were implemented gradually, with increments of a few months depending on individual's birth years. The SEA rose from 60 (for those born before July 1st , 1951) to 62 (for those born after January 1st , 1955), and the EPA increased from 65 to 67 over the same cohorts, as detailed in Box III. A. While pension reforms had been a recurring feature of French political history since 1993, the 2010 reform was notable for its unexpected implementation (Caroli et al., 2023) and for being the first reform since 1983 to alter the SEA. The proposal to raise the retirement age appeared in a public debate during spring 2010, and was formalized within a few months. In May 2010, a government's policy paper identified the increase in the retirement age as the only way to ensure financial sustainability of the pension system without affecting standard of livings of employed workers and retirees (Ministère de la transformation et de la fonction publique, 2010). Afterwards, the Minister of Labor presented the main orientations in June, the bill was then submitted to the Council of Ministers in July, detailing the specific schedule of age increases across birth cohorts. The content and timing of the reform came as a surprise, particularly because it affected some

individuals who were already close to the previous retirement age (those born in 1951). Earlier reforms had been more gradual, while this one introduced changes that took effect rapidly across successive cohorts. On January 1st 2012, the reform was accelerated: For individuals born after January 1st 1952, SEA and EPA were raised from four to five months until the two age limits of SEA and EPA were reached (62 and 67).

Box III. A. Evolution of statutory eligibility age (SEA) under the 2010 French pension reform.

Birth date	SEA before the 2010 reform	SEA before January 1st 2012	SEA after January 1st 2012 (Reform acceleration)
Prior to July 1st 1951	60	60	60
Between July 1st and December 31st 1951	60	60 and 4 months	60 and 4 months
1952	60	60 and 8 months	60 and 9 months
1953	60	61	61 and 2 months
1954	60	61 and 4 months	61 and 7 months
1955	60	61 and 8 months	62
After 1955	60	62	62

I. 2. c. Other pension reforms.

The 2010 pension reform took place in a context where previous reforms were still being implemented and additional policy adjustments were underway. Pension reforms in France typically involve simultaneous modifications to several parameters of the system. The generations affected by the 2010 reform were exposed not only to changes in the SEA and the EPA, but changes in other factors.

Extension of contribution periods.

A key precedent to the 2010 reform was the 2003 reform, which introduced a progressive extension of the contribution period required to qualify for a full-rate pension (Bozio, 2006; Charni, 2016). For individuals born between 1949 and 1952, the required number of quarters increased incrementally by one per cohort. This measure, combined with the later increase in the SEA introduced in 2010, created a double mechanism encouraging

longer working lives. As both adjustments were cohort based, they were expected to have converging effects on retirement timing. Simulation analyses by Dubois and Koubi (2017) indicated that the interaction between the two reforms reinforced the extension of working lives, though the overlap was relatively modest for individuals born in the 1950s.

Relaxation of Early Retirement Conditions for Long Careers.

The 2003 reform also introduced an early retirement scheme for individuals with long careers ("*Carrières longues*"). Eligibility was granted to those who started working before the age of 18 and had completed a sufficient number of contribution periods. Over time, the eligibility rules for this scheme were modified. Periods of relaxation allowed more workers to qualify, partly offsetting the effects of the increase in the SEA, while later periods, especially after 2012, tightened the conditions and reduced access. Yet, these adjustments were not cohort-based. When eligibility was restricted after 2012, the effects of the early retirement scheme and the SEA reform moved in the same direction, both encouraging longer working lives. When eligibility was relaxed, the scheme acted as a compensatory measure for individuals affected by the SEA increase. However, Dubois and Koubi (2017) showed that its mitigating impact remained limited, largely because many individuals did not have complete contribution records.

Elimination of the Job Search Exemption ("Dispense de Recherche d'Emploi").

Another significant measure was the elimination of the Job Search Exemption ("Dispense de Recherche d'Emploi"). Unemployment benefits ("allocation d'aide au retour à l'emploi") are time-limited income-replacement allowances administered by the unemployment insurance system (UNÉDIC), calculated based on previous earnings and normally conditional on active job search (Code Du Travail, Art. L5422-1 to L5422-3). Unlike retirement pensions, they are not permanent entitlements and cease when the individual reaches eligibility for a full-rate pension. However, a policy introduced in 1984 exempted unemployed individuals over the age of 55 from the obligation to actively seek work while continuing to receive these benefits, provided they met specific eligibility criteria. This exemption was abolished on January 1st 2012, notably affecting the 1951 and 1952 birth cohorts who were aged between 59 and 61 at that time. The removal of this

exemption, combined with the rise in the SEA, is expected to have had converging effects by encouraging higher employment rates among older workers. However, it may also have induced a substitution between unemployment and other non-employment statuses, such as being inactive or seeking disability pensions, thus altering the composition of the NENR group toward more precarious situations.

I. 2. d. The Pension system and the recognition of illness.

The French retirement system provides specific pathways for individuals whose health has been officially recognized as limiting their capacity to work. Two primary pathways exist: retirement at the SEA without penalty and early retirement based on health-related grounds.

Retirement at SEA with full rate (no penalty).

Retirement at the SEA without penalty applies to insured individuals recognized as "disabled" ("*Invalide*") by the health insurance system and receiving a disability pension or the allowance for disabled adults. Disability pensions are institutionally distinct from retirement pensions: they are administered by the health insurance system (CPAM) and compensate for the loss of earnings capacity resulting from non-occupational illness or accident. They are granted to individuals whose work capacity has been reduced by at least two-thirds, and their amount depends on the severity of the disability: 30% of average earnings from the ten best years for individuals still capable of some gainful activity (category 1), 50% for those assessed as unable to pursue any occupation (category 2), or 50% plus a supplement for third-party assistance for those who additionally require help with daily activities (category 3) (Code de La Sécurité Sociale, Décret N° 85-1353, 1985).

Upon reaching the SEA, these benefits are automatically converted into retirement pensions at the full rate, regardless of contribution duration. Retirement at the SEA without penalty also applies to individuals identified by the old-age insurance system as "unfit to work" at the SEA. This conversion mechanism implies that the 2010 reform, by

raising the SEA, also extended the period during which affected individuals remained on disability benefits before transitioning to retirement.

Certain medical conditions are particularly prevalent among recipients of disability pensions. For instance, psychiatric disorders, led by depression, accounted for 28.1% of new cases in 2006, while musculoskeletal diseases represented 23.8% (Cuerq et al., 2008). Cardiovascular diseases accounted for 11.7% of new cases of disability. More recent data confirmed these patterns (Mette et al., 2023), and the predominance of psychiatric and musculoskeletal disorders was also observed among individuals labelled as "unfit" for work (Courtois et al., 2023). According to the *Conseil d'orientation des retraites* (COR), 56,509 (representing 9.5% of new retirees) were declared unfit for work in 2011, while 33,919 (5.7% of new retirees) transitioned from disability pensions to retirement pensions (Conseil d'orientation des retraites, 2019), representing a relatively modest share of new retirees.

Early retirement conditional on health status.

Regarding early retirement based on health status, it exists but affects a smaller share of the population. The Early Retirement for Disabled Workers scheme ("*Retraite anticipée pour handicap"*), introduced in 2003 and generalized to all pension schemes in 2010, allows insured individuals to retire as early as age 55, provided they meet contribution requirements, and either have an officially recognized permanent disability rating of at least 80% (assessed by the French social security system) or formal recognition as a disabled worker ("*travailleur handicapé*"). In 2011, only 1,313 new retirees benefited from this measure (Conseil d'orientation des retraites, 2019).

Another option, the Early Retirement for Permanent Disability ("*retraite anticipée pour incapacité permanente*"), applies to individuals in the private-sector general scheme who have suffered from occupational diseases or work-related accidents resulting in an officially recognized permanent disability rating of at least 10%, as determined by the French social security system. Introduced in 2010, it allows retirement at age 60 with a full-rate pension regardless of contribution length. This measure was still in its early

stages in 2011, with 983 new beneficiaries reported by COR (Conseil d'orientation des retraites, 2019).

Overall, the overlapping reforms illustrate the complex and evolving nature of the French pension landscape in the early 2010s. While the 2010 reform stands out for its direct increase in retirement ages, the simultaneous evolution of contribution requirements and early retirement pathways following the reform, likely contributed to shaping the diverse labor-market responses observed among older workers.

Existing evidence on the effects of the 2010 pension reform.

Several studies have examined the consequences of the 2010 French pension reform on employment and retirement behaviors. Overall, findings converge in showing that the reform effectively postponed retirement, and increased employment around the SEA. However, these gains were accompanied by substitution toward alternative exit routes of NENR status such as unemployment, inactivity, or disability pensions. Analyses by Dubois & Koubi (2017) and by Rabaté and Rochut (2020), using difference-in-differences (DiD) designs on adjacent cohorts, confirmed that while the reform extended working lives, a substantial share of individuals unable to remain in employment shifted into non-employment categories, that is NENR. A working paper by Charni (2016) explored the effects of the reform among individuals who were unemployed prior to the reform. Using a DiD approach, the study found that the reform increased the probability of reemployment after age 55, supported by policy incentives encouraging senior hiring. At the same time, it raised transitions from unemployment to inactivity, suggesting that, for some, the tightening of early retirement options led to substitution toward sickness or disability benefits rather than sustained employment.

Further studies provided complementary evidence on heterogeneous responses to the 2010 French reform. Using administrative data, Ben Halima et al. (2023) found that the rise in the SEA increased sickness absences after age 60, especially among women and individuals with prior work-related diseases (*"maladies professionnelles"*). Caroli et al. (2023) observed increases in healthcare consumption following the reform, particularly

for consultations of general practitioners among younger men in the treated cohorts, and physiotherapy visits among women. Zemmour (2024) documented a rise in the proportion of NENR individuals at ages 60–61, with pronounced inequalities across gender and occupational class: employment gains were concentrated among higher-skilled workers, while manual workers and women more frequently experienced extended periods outside employment before reaching eligibility.

While these studies provide consistent evidence that the reform prolonged working lives on average, they also reveal variation in responses across gender and social groups. Yet, health has so far been captured through sick-leave records or healthcare use. To date, no work has examined whether individuals' health histories with specific chronic diseases, including depression, has shaped responses to the 2010 French reform.

I. 3. This work.

Building on the literature linking chronic diseases with employment and retirement behaviors, specifically depression, MSD, and CVD, this study investigates whether a history with either of these conditions has influenced individuals' likelihood of being in the NENR category as a result of the French 2010 reform. This is particularly relevant in the French context, as there are multiple schemes designed to acknowledge and account for health status, allowing earlier retirement for those whose capacity to work is limited. It is therefore essential to assess whether, despite the institutional provisions, heterogeneity in responses to the 2010 French reform with respect to health histories were present.

Using administrative data from the French national pension fund ("*Caisse National d'assurance maladie"* - CNAV) and medical data from the French CONSTANCES cohort, the analysis explores whether the impact of the reform on retirement behaviors was heterogeneous across individuals who had histories with either depression, osteoarticular diseases (OSD) which belong to the group of MSD, or CVD. Relying on the difference-in-differences (DiD) framework applied in previous research (Dubois & Koubi, 2017; Rabaté

& Rochut, 2020b), the study focuses on cohorts born between 1948 and 1953, ensuring proximity between treated and control groups, and examines the different impacts of the change in SEA from 60 to 61 on employment, NENR and retirement rates at age 60. Horizon effects are examined in a complementary analysis reported in the Supplementary Materials. Given the complexity of models required to test for heterogeneity and sample size constraints, these results are provided as complementary insights.

II. Data.

II.1 Source.

This study uses data from two linked sources: Information on socio-demographic and health characteristics is drawn from the French CONSTANCES cohort, while employment information comes from administrative records provided by the "*Caisse Nationale d'Assurance Vieillesse"* (CNAV).

II.1. a The French CONSTANCES cohort.

The French CONSTANCES cohort is a large population-based French study (CONSTANCES team et al., 2015) that recruited adults aged 18 to 69 during inclusion waves from 2012 to 2020, reaching approximately 200,000 participants. Recruitment relies on the national health insurance system, which covers more than 85% of the French population (excluding agricultural workers). Individuals were randomly selected and invited by mail, with stratification by age, sex, occupational status, and region. At inclusion, participants completed questionnaires on lifestyle, health, physical limitations, and social and personal characteristics, and attended a standardized medical examination at one of the participating health examination centers. During this visit, participants were asked to bring their "*Carnet de santé"* ("Health records") and underwent physiological and biological assessments, with additional cognitive tests for those aged 45 years or older. Information on socioeconomic characteristics, past and current occupations, and family medical history was also collected.

Although CONSTANCES was designed to sample from the general population of CNAM beneficiaries, participation required attending a health examination at a participating

center among 21 health centers that were part of the CONSTANCES project. This requirement led to a low participation rate, around 8% (Launay, 2024), resulting in a volunteer cohort that is not fully representative of the French population. As documented in several works that have used data from the CONSTANCES cohort (Goldberg et al., 2017b; Neufcourt et al., 2020), as well as the cohort's protocol, volunteers tend to be more educated and in better health than non-participants. These selection patterns reflect well-known gradients in participation in health surveys. Despite this, the cohort includes a broad diversity of social positions, occupations, and health conditions, enabling the study of associations between chronic diseases and activity restrictions. Because of the selection mechanism that is not fully captured by the cohort's sampling weights, and because the objective of the analysis is to estimate associations rather than population prevalence, weights are not applied in this work.

II.1. b Administrative records from CNAV.

Administrative records from CNAV provide longitudinal information on individuals' employment histories and pension contributions. These data originate from the National Career Management System ("*Système National de Gestion des Carrières*" -SNGC), which traces, for each insured person, all periods of activity giving rise to old-age insurance contributions from age 16 until retirement, including assimilated periods (like unemployment, sickness, disability, maternity, or parental leave). CNAV manages the pension system for private-sector employees, known as the "régime general", which is the main branch of France's public pension system. In addition, the SNGC tracks quarters validated in other statutory pension schemes when individuals have contributed outside the "régime général", which is the case of, for example, military servants and self-employed individuals. Consequently, some individuals in the CNAV extract may not have contributed directly to the CNAV scheme but appear because of validated periods in other pension systems.

II.1. c Selected sample.

Our analysis was restricted to CONSTANCES respondents born between 1948 and 1953 with no missing information in the main variables of interest, and with available CNAV records between ages 55 and 65 (even if information was not available for all years). This

resulted in panel data comprising 245,464 observations over the period of 2003 till 2018, from 22,324 individuals (Detailed flow chart in (A) in supplementary materials).

II.2 Variables of interest.

II.2. a. Outcome: Activity status.

Activity status is identified from CNAV administrative records. These data provide, for each individual and each calendar year, the number of validated quarters used to calculate pension entitlements. The validated quarters correspond to periods of employment in the private sector, unemployment, sickness, disability, or other periods recognized by social security schemes. CNAV data also record the year in which an individual claims and begins receiving a retirement pension, known in the French system as the "*Année de liquidation*". Based on this information, three mutually exclusive annual activity statuses were defined: "Employed", "Neither Employed Nor Retired (NENR)", and "Retired". A year is coded as "Retired" when the individual claims and starts receiving a retirement pension. If the year does not correspond to the start of retirement pension receipt, the activity status is determined according to the distribution of validated quarters across different statuses.

In line with the objectives of this study, a year is classified as "NENR" when at least two quarters are spent in unemployment, disability, or without any contribution to a pension scheme, that is, periods of inactivity. This definition is consistent with D'Isanto et al., (2018), who identified unemployment benefits and disability pensions as the main income sources among the NENR population. Conversely, a year is coded as "Employed" when more than two quarters are validated as employment, which includes work in the private sector, military service, sick leave, or contributions to other retirement schemes. Some individuals claim their pension in a year when they still have other validated contributions. Similarly, there are cases in which two quarters are classified as NENR and two as employment. To maintain consistency with the study's objectives, NENR is prioritized when at least two quarters fall under NENR categories. Alternative classification rules were tested as robustness checks and are described in the section of

Robustness checks. While the underlying data allow for a finer distinction between unemployment, disability, and inactivity within the NENR category, separate analyses by subcategory were not feasible given the limited sample sizes, particularly for disability.

II.2. b. History with health conditions.

During their visit to health centers, CONSTANCES participants were asked whether they had ever received a medical diagnosis for a list of predefined conditions. For each reported condition, they were also asked to indicate the age at diagnosis. The list included diabetes, cancer, cardiovascular, respiratory, and osteoarticular diseases, and other conditions affecting the thyroid, gastrointestinal, and the cognitive system. Mental health status was proxied through reports of treated depression, suicidal attempts, or diagnoses of anxiety and depressive disorders.

For this study, we specifically focus on declared diagnosis of CVD (including myocardial infarction, angina, stroke, lower limb arteritis, and other conditions); osteoarticular diseases (including arthritis, and other conditions), and a history with treated depression, between the ages of 40 and 55 inclusive. The focus on these three conditions reflects their well-established associations with labor-market withdrawal and disability. Including additional diseases in the analysis was not feasible due to missing information, which would have required further exclusion of respondents and substantially reduced the analytical sample.

II.2. c. Social variables.

Highest educational attainment.

As a control variable in our empirical models, we used information on highest educational attainement categorized into: “No diploma”, “High-school diploma”, “Vocational certificate”, “Undergraduate degree”, and “Graduate or Post-graduate degree”. This followed common practice in French surveys and was consistent with the international standard classification of education (ISCED, 2011) (UNESCO, 2012).

Nationality.

In CONSTANCES' questionnaire, respondents were asked to indicate their nationality, and three answer options were possible: "French since birth", "French by acquisition", and "Foreigner". We additionally used this variable as a control in our empirical work.

Contribution history.

The CNAV data include, for each respondent, the year of their first recorded contribution to the social security system. Using this information, we constructed a binary indicator identifying individuals who had contributed before the age of 18, in order to capture potential eligibility for the early retirement scheme for long careers ("*Carrières longues*").

Longest occupied socio-occupational class.

Upon joining the CONSTANCES cohort, participants reported their complete employment history since labor market entry, including any periods of unemployment or inactivity. Using this information, we reconstructed individual occupational trajectories from age 20 to 55, following the approach by Beaufils (2024), with the same data. Occupations were coded according to the French socio-occupational classification system (Professions et Catégories Socioprofessionnelles: PCS) (INSEE, 2020), which characterizes positions by job content, employment status, employer type, and qualification level.

Following Beaufils[14] (2022), we grouped occupations into five categories: self-employed, highly-skilled, skilled, low-skilled, and unskilled workers (see Box III. B), and additionally captured periods of unemployment or inactivity. For each year between ages 20 and 55, individuals were assigned to one of these five occupational categories or classified as unemployed or inactive. From this trajectory, we derived an indicator reflecting the socio-occupational category in which each individual spent the longest cumulative period between ages 20 and 55. As this variable contains approximately 10% missing values

[14] The classification of occupational class used here differs from that used in Chapter 1 as it mainly distinguishes between unskilled and low-skilled manual/clerical workers as done in other works (Amossé & Chardon, 2006; Beaufils, 2022; Desrosières & Thévenot, 2002).

among our selected sample (see Table III. 1 in the results section), we use it only to describe the sample composition and in robustness analyses, while relying on highest educational attainment as the primary social covariate in the main analysis.

Box III. B. Details on the classification of socio-occupational class.

Category	Occupations
Self-employed	Craftworkers, retailers, business owners
Highly-skilled workers	Managers, professionals and intellectual occupations
Skilled workers (intermediate)	Teaching associate professionals, health and social work intermediate occupations, administrative occupations of public and private companies, technicians, and associate professionals
Low-skilled clerical and manual workers	Government executives, administrative staff, accounting and insurance clerks, workers in handling, storage and transport…
Unskilled clerical and manual workers	Unskilled industrial, craft workers, cashiers, store employees, waitresses, child care workers, domestic workers, operators…
Not employed	Long-term sickness, family care or homemaker, not seeking employment

III. Methods.

The main objective of this work is to assess heterogeneity in responses to the 2010 French pension reform with respect to individuals' health histories, focusing on their likelihood of being employed, NENR, or retired at age 60. The analysis proceeds in several steps. After defining the treated and control cohorts, we begin by describing the evolution of employment, NENR, and retirement between ages 55 and 65. Because the reform gradually raised the SEA from 60 to 61 for cohorts born between July 1st 1951 and December 30th 1953, treated and control cohorts encounter the eligibility threshold at different ages**.** The relevant variation induced by the reform therefore lies in how labor-market outcomes evolve with age across neighboring cohorts**,** rather than across calendar years, which motivates examining the evolution of the outcomes of interest by age. In the main empirical step, we estimate the reform's impact at age 60 using the same DiD approach used in other works (Rabaté & Rochut, 2020). In a complementary analysis, we inspect dynamic or "horizon" effects after age 60 and evaluate whether these differ across

health histories. Due to the complexity and limitations of the used models, we keep this analysis as a supplementary work as we do not make solid conclusions from the results, but treat it as supplementary insights.

III.1. Identifying treated and control groups.

In line with the reform's implementation thresholds, the analytical sample includes individuals born between 1948 and 1953. The control group includes cohorts born before July 1st, 1951, who were unaffected by the increase in the statutory eligibility age (SEA), while the treated group includes those born after July 1951 for whom the SEA was raised from 60 to 61. Details on the composition of the control and treated groups are displayed in Box III. C. A binary indicator for "treatment status" is defined accordingly, taking the value 1 for individuals born after July 1st 1951 and 0 otherwise.

Restricting the analysis to adjacent cohorts, rather than involving all cohorts affected by the reform (born after 1953), ensures proximity between groups and limits potential confounding due to generational or labor market differences (additional cohort restrictions are done in robustness checks). It is acknowledged that some individuals within the treated cohorts may have benefited from specific exemptions and were therefore not directly affected by the SEA increase. However, these cases could not be identified with our data. The interpretation of effects is therefore made in the broader context of concurrent policy adjustments (described in **I. 2. c**), recognizing that our estimates capture the overall behavioral response to the 2010 reform environment rather than its isolated effect, which was identified in other works (Dubois & Koubi, 2017; Rabaté & Rochut, 2020).

Box III. C. Composition of selected control and treated groups, with their age at the time of the reform and their statutory eligibility ages.

Group	Cohorts	SEA before the 2010 reform	Age in July 2010 (timing of the reform)	SEA before January 1st 2012	SEA after January 1st 2012 (Reform acceleration)
Control	1948	60	61-62	60	60
	1949	60	60-61	60	60
	1950	60	59-60	60	60
	Born **before** July 1st 1951	60	59	60	60
Treated	Born **after** July 1st 1951	60	58	60 and 4 months	60 and 4 months
	1952	60	57-58	60 and 8 months	60 and 9 months
	1953	60	56-57	61	61 and 2 months

III.2. Descriptive exploration of employment, NENR, and retirement rates between ages 55 and 65.

We begin by visually examining evolution in employment, NENR, and retirement rates between ages 55 and 65 for the selected cohorts. This exploratory step allows us to visualize patterns before and after the shift in the SEA. Rates at each age are compared between treated and control groups to observe whether pre-reform trajectories diverge and whether changes concentrate around ages 60 and 61, which are the statutory ages before and after the reform for our selected cohorts. In addition, we explore these trajectories by gender to assess whether any differences in patterns arise predominantly among men or women. In line with our work's objectives, we explore the rates across groups of individuals who reported histories with either depression, OSD, or CVD. Each condition is examined separately, comparing individuals who reported a history of the specific condition with those who did not, resulting in six distinct strata.

After the visual inspection of rates by age, we formally test whether differences in employment, NENR, and retirement rates between treated and control cohorts at each

age are statistically significant, after adjusting for gender, educational attainment, nationality, contribution history, and cohort fixed effects. This is done by fitting linear models that include an interaction between treatment status and age categories. This descriptive step verifies whether the patterns observed visually persist after adjustment for covariates. The same approach is applied separately within each health history stratum.

III.3. Heterogeneity in the impact of the 2010 reform at age 60.

III.3.a. Difference-in-Difference specifications.

This analysis constitutes the main empirical component of the study. The empirical strategy follows the approach of previous studies (Dubois & Koubi, 2017; Rabaté & Rochut, 2020), which rely on DiD frameworks estimated using linear probability models. Observations are restricted to ages between 55 and 62. The detailed model design and equations are presented in Box III. D.

The DiD coefficient capturing the reform's impact is the coefficient associated with the variable labelled as "*Under SEA*" (Rabaté & Rochut, 2020). This variable is distinct from the treatment status indicator used in the descriptive analyses, which identifies cohort membership. "*Under SEA*" varies both across cohorts and across ages: it equals 1 if the individual is observed at an age below his/her cohort-specific SEA, and 0 otherwise. At age 60, it equals 1 for treated individuals who have not yet reached their new SEA, and 0 for control individuals who have already reached their SEA of 60. Because the 2010 reform increased the SEA only for cohorts born after July 1st 1951, "Under SEA" varies across cohorts at age 60. Its coefficient therefore captures the effect of the reform, specifically, the change in the probability of being in a given labor-market status resulting from the additional year spent below the eligibility threshold.

Identification relies on the standard common trend assumption applied to age profiles: in the absence of the reform, treated and control cohorts would have followed similar age-related trends in employment, NENR, and retirement. Under this assumption, the change

in outcomes observed when cohorts move from being below to above their cohort-specific SEA can be attributed to the reform. Since the SEA increased from 60 to 61 only for the treated cohorts, this identifying variation is interpreted at age 60, where treated and control cohorts differ in whether they are under the eligibility threshold. The identification used relies on the assumption of no period effects.

Box III. D. Specifications of the fitted difference-in-difference models.

(a) General specification (not accounting for disease histories)

$$Y_{iac}^{(m)} = \beta_0 + \beta_1 UnderSEA_{iac} + \sum_a \lambda_a 1\{Age = a\} + \sum_c \mu_c 1\{Cohort = c\} + X_i'\gamma + \varepsilon_{iac}$$

(b) Specification testing heterogeneity with respect to disease history

$$Y_{iac}^{(m)} = \beta_0 + \beta_1 UnderSEA_{iac} + \beta_2 Disease_i + \beta_3 (UnderSEA_{iac} \times Disease_i) + \sum_a \lambda_a 1\{Age = a\} + \sum_c \mu_c 1\{Cohort = c\} + X_i'\gamma + \varepsilon_{iac}$$

- $Y_{iac}^{(m)}$ denotes the outcome m (Employment, NENR, or retirement) which varies for individual i from cohort c by age a
- *UnderSEA* is a binary variable that equals to 1 when individual i from cohort c is under SEA at age a
- λ_a are age fixed effects
- μ_c are cohort fixed effects
- X_i' is the vector of individual characteristics including gender, education, contribution history and nationality

Three separate linear models are estimated for each of the mutually exclusive outcomes: being employed, NENR, or retired. The estimated model includes age and cohort dummies as well as individual characteristics (gender, highest educational attainment, contribution history, and nationality). We first estimate baseline models excluding health-related variables to verify whether our results align with previous findings despite differences in data sources and covariates. We then extend the specification by introducing indicators for each disease history (depression, OSD, and CVD) and interact them with "*Under SEA*" to assess whether the reform's effect differs across health histories. This specification allows the reform effect to differ by disease but assumes that the age and cohort effects do not differ by disease, which is modified in robustness checks.

III.3.b. Transition probabilities in states from ages 59 to 60 among the treated group.

Following the estimation of the main models, we compute transition probabilities between activity status from ages 59 to 60. This analysis focuses on whether the reform's effects correspond to transitions between employment, NENR, and retirement, or rather to an extension of individuals' pre-existing statuses. Among those who were employed at age 59, we estimate their average predicted probabilities of being employed, NENR, or retired at age 60 using the same model specifications while removing the *UnderSEA* variable and replacing it by the dummy variable "treatment status". The same procedure is applied to individuals who are NENR at 59. In addition, transition probabilities are estimated conditional on a history of OSD, CVD, or depression, in order to test whether transition patterns differ by health history.

IV. Results.

IV. 1 Distributions.

IV. 1. a. Social and health characteristics of selected respondents.

Table III. 1 presents the distribution of socio-demographic and health variables across treatment and control groups. Additional breakdowns by gender, shown in Table III. 2, allow exploration of gendered patterns in these variables. The composition of men and women is balanced in both groups, with women representing 50.8% of the treatment group and 50.6% of the control group. The control group mainly includes individuals born in 1949 and 1950 (around 60% of the sample), while the treatment group consists mostly of those born in 1952 and 1953 (around 81%). Overall, the treatment and control groups show broadly similar socio-demographic and health profiles, yet slight differences are detected, and are consistent with differences in the generational composition of the control and treatment group.

For instance, slight differences appear across groups of different highest educational attainment (all amounting to less than two percentage points). Vocational certificates,

high-school diplomas, and undergraduate degrees are slightly more common in the treated group (all $p<0.05$), whereas both the absence of a diploma and the possession of a graduate degree are more frequent in the control group ($p<0.001$). These differences, although small, likely reflect generational changes in access to education. Younger cohorts benefited from the expansion of secondary, vocational, and undergraduate education. The slightly higher share of graduate degrees in the control group may stem from the greater selectiveness of the education system among older cohorts, which included a smaller group of individuals who might have been more likely to pursue higher education. Regarding gender differences within both control and treatment groups, women are more likely to hold no diploma, a high-school diploma, or an undergraduate degree, whereas men more often hold vocational certificates or graduate degrees (all $p<0.001$), consistent with known gender patterns in educational attainment.

In terms of geographical origin, less than 2% of selected respondents are foreigners to France, around 4% are French by acquisition, and the remaining majority are French since birth. Concerning the longest occupied socio-occupational class, the self-employed represent a small share of respondents (2.2% in the control group and 1.9% in the treated group). In contrast, low-skilled manual and clerical workers, along with skilled workers, together account for more than 58% of both control and treated groups and are slightly more represented in the latter group ($p<0.05$). Highly skilled occupations represent 18.6% of the treated group and 20.6% of the control group ($p<0.001$) and are more common among men ($p<0.001$). Unskilled, low-skilled and skilled occupations are more frequent among women (all $p<0.001$). A small proportion of respondents, exclusively women, reported having spent most of their working lives outside employment (below 2% in both control and treatment groups). Finally, regarding contribution histories, 42% of respondents in the control group and 44.4% in the treatment group began contributing to the social security system before age 18. Early contribution was more frequent among men in both control and treated groups (all $p<0.001$).

Getting to health variables, distributions show that reporting a diagnosis between ages 40 and 55 of either depression, OSD or CVD concerned fewer than 10% of respondents in both the treated and control groups. Treated depression is the most common condition,

reported by 7.6% of respondents in the control group and 8.6% in the treated group. Overall, the proportion of reporting either condition is slightly higher in the treated group (all $p<0.001$). Gender differences in diseases' reporting follow well-established gender patterns: OSD and depression are more common among women (starting 7% and 10% of both treated and control groups, for OSD and depression respectively) whereas men report higher rates of CVD (5.7% in the treated group and 6.9% in the control group, compared to less than 4% among women).

Table III. 1. Socio-demographic and health characteristics of respondents in selected control and treatment groups from CONSTANCES.

	Control group (N= 12633)	Treated group (N= 9691)	p-values
Cohort			
1948	3180 (25.2%)		
1949	3722 (29.5%)		
1950	3725 (29.5%)		
Born before July 1st 1951	2006 (15.9%)		
Born after July 1st 1951		1837 (19%)	
1952		3971 (41%)	
1953		3883 (40.1%)	
Gender			
Women	6420 (50.8%)	4904 (50.6%)	p=0.75
Men	6213 (49.2%)	4787 (49.4%)	
Highest educational attainment			
No diploma	2044 (16.2%)	1387 (14.3%)	p<0.001
Vocational certificate	2982 (23.6%)	2437 (25.1%)	p=0.022
High school diploma	1989 (15.7%)	1636 (16.9%)	p=0.02
Undergraduate degree	2345 (18.6%)	1985 (20.5%)	p<0.001
Graduate degree	3273 (25.9%)	2246 (23.2%)	p<0.001
Geographical origin			
Foreigner	147 (1.2%)	132 (1.4%)	p=0.186
French since birth	11950 (94.6%)	9178 (94.7%)	p=0.710
French by acquisition	536 (4.2%)	381 (3.9%)	p=0.245
Longest occupied socio-occupational class			
Self-employed	279 (2.2%)	186 (1.9%)	p=0.134
Unskilled manual/clerical worker	913 (7.2%)	750 (7.7%)	p=0.149
Low skilled manual/clerical worker	3428 (27.1%)	2789 (28.8%)	p=0.007
Skilled worker	3943 (31.2%)	3175 (32.8%)	p=0.014
Highly skilled worker	2607 (20.6%)	1779 (18.4%)	P<0.001
Not employed	221 (1.7%)	151 (1.6%)	p=0.269
Missing information	1242 (9.8%)	861 (8.9%)	p=0.028
Contribution to social security system			
Contribution prior to age 18	5312 (42.0%)	4305 (44.4%)	p<0.001
Health history between ages 40 and 55			
Treated Depression	958 (7.6%)	836 (8.6%)	p=0.004
Cardiovascular diseases (CVD)	555 (4.4%)	499 (5.1%)	p=0.008
Osteoarticular diseases (OSD)	773 (6.1%)	700 (7.2%)	p<0.001

Source: Sample of merged data from CONSTANCES and CNAV records, including 22,322 respondents born between 1948 and 1953, aged 55+ in CONSTANCES' inclusion waves.
Notes: The control group includes individuals born between January 1, 1948, and June 30, 1951, and the treated group includes those born between July 1st , 1951, and December 31, 1953. Differences in means between cohorts for each displayed variable were tested using two-sample z-tests; corresponding p-values are reported.

Table III. 2. Socio-demographic and health characteristics of respondents in selected control and treatment groups from CONSTANCES, by gender.

	Control group		Treated group	
	Women (N= 6420)	**Men (N= 6213)**	**Women (N= 4906)**	**Men (N= 4787)**
Cohort				
1948	1571 (24.5%)	1609 (25.9%)		
1949	1879 (29.3%)	1843 (29.7%)		
1950	1909 (29.7%)	1816 (29.2%)		
1951 (Before July 1st)	1061 (16.5%)	945 (15.2%)		
1951 (July 1st onwards)			888 (18.1%)	949 (19.8%)
1952			2018 (41.2%)	1953 (40.8%)
1953			1998 (40.7%)	1885 (39.4%)
Highest educational attainment				
No diploma	1220 (19.0%)***	824 (13.3%)	781 (15.9%)***	606 (12.7%)
Vocational certificate	1282 (20.0%)	1700 (27.4%)***	1016 (20.7%)	1421 (29.7%)***
High school diploma	1137 (17.7%)***	852 (13.7%)	931 (19.0%)***	705 (14.7%)
Undergraduate degree	1364 (21.2%)***	981 (15.8%)	1139 (23.2%)***	846 (17.7%)
Graduate degree	1417 (22.1%)	1856 (29.9%)***	1037 (21.1%)	1209 (25.3%)***
Geographical origin				
Foreigner	61 (1.0%)	86 (1.4%)	62 (1.3%)	70 (1.5%)
French since birth	6099 (95.0%)	5851 (94.2%)	4666 (95.1%)	4512 (94.3%)
French by acquisition	260 (4.0%)	276 (4.4%)	176 (3.6%)	205 (4.3%)
Longest occupied socio-occupational class				
Self-employed	80 (1.2%)	199 (3.2%)***	62 (1.3%)	124 (2.6%)***
Unskilled manual/clerical worker	561 (8.7%)***	352 (5.7%)	450 (9.2%)***	300 (6.3%)
Low skilled manual/clerical worker	1880 (29.3%)***	1548 (24.9%)	1454 (29.6%)	1335 (27.9%)
Skilled worker	2109 (32.9%)***	1834 (29.5%)	1704 (34.7%)***	1471 (30.7%)
Highly skilled worker	853 (13.3%)	1754 (28.2%)***	597 (12.2%)	1182 (24.7%)***
Not employed	221 (3.4%)***	0 (0%)	151 (3.1%)***	0 (0%)
Missing information	716 (11.2%)***	526 (8.5%)	486 (9.9%)***	375 (7.8%)
Contribution to social security system				
Contribution prior to age 18	2317 (36.1%)	2995 (48.2%)***	1868 (38.1%)	2437 (50.9%)***
Health history between ages 40 and 55				
Treated Depression	644 (10.0%)***	314 (5.1%)	544 (11.1%)***	292 (6.1%)
Cardiovascular diseases (CVD)	203 (3.2%)	352 (5.7%)***	169 (3.4%)	330 (6.9%)***
Osteoarticular diseases (OSD)	447 (7.0%)***	326 (5.2%)	416 (8.5%)***	284 (5.9%)

Source: Sample of merged data from CONSTANCES and CNAV records, including 22,322 respondents born between 1948 and 1953.
Notes: The control group includes individuals born between January 1, 1948, and June 30, 1951, and the treat group includes those born between July 1st , 1951, and December 31, 1953. Differences in means across gender within control and treatment groups for each category were tested using two-sample z-tests; Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
Example of interpretation: Within the control group, having no diploma is found among 19% of women and 15.9% of men, and the difference in proportions is significant at the 0.1% level.

IV. 1. b. Evolution of employment, NENR, and retirement rates from ages 55 to 65 in the full sample.

Regarding the distribution of activity status, Figure III. 1 presents the distribution of employment, NENR, and retirement rates from ages 55 to 65 for the whole sample, with Figure III. 2 showing these distributions separately for men and women. Figure III. 1 to Figure III. 5 further display the evolutions across treated and control groups. Tables S.1 to S.3 in Supplementary materials present the estimated rates.

General population.

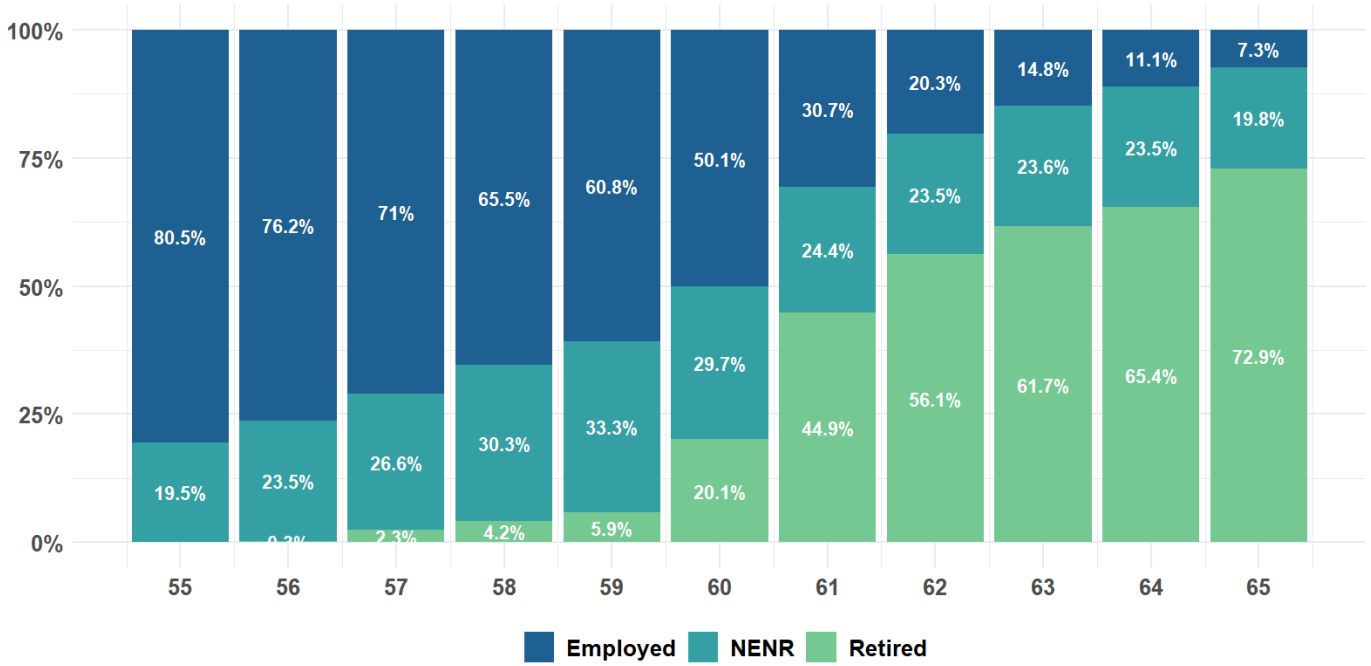
At age 55, the minimum selected age in the data, the employment rate stands at 80.5%, with higher employment among men (84.7%) than women (76.4%, $p<0.001$). At the same age, the NENR rate amounts to 19.5% in the overall sample, being higher among women (23.6%) than among men (15.3%, $p<0.001$). Among NENR individuals at this age, inactivity accounts for 75.5%, unemployment for 18.7%, and disability for 4.6% (Figure III. S.2 to Figure III. S.4 in Supplementary Materials). From ages 55 to 59, employment gradually declines to 60.8%, while the proportion of individuals NENR increases from 19.5% to 33.3%, with NENR rates consistently higher among women (all $p<0.001$). Throughout this period, the composition of NENR remains broadly stable, with inactivity exceeding 70% (and 60% among men) and unemployment representing around one quarter, being more common among men. Retirement remains marginal before age 58, particularly among women (below 2%), and rises modestly to 5.9% by age 59 among all, to 9.6% among men and 2.3% among women ($p<0.001$).

From age 60 (corresponding to SEA of the control group) onwards, a clear shift occurs. The employment rate drops to 50.1%, while the share of retirees rises to 20.1% and that of NENR to 29.7%. At this age, the NENR rate remains higher among women (34.2%), while retirement is more common among men (23.5%). By age 61, employment continues to fall to 30.7%, retirement increases to 44.9%, and NENR slightly declines to 24.4%. The composition of NENR also changes around the SEA: the share of unemployment drops from around 20% before age 60 to 16.5% at age 60 and 9.3% at age 61, consistent with the transition of some unemployed individuals into retirement upon reaching eligibility.

Disability declines from around 6% to below 2% by age 61, reflecting the automatic conversion of disability pensions into retirement pensions at the SEA. Inactivity consequently rises to account for over 88% of NENR by age 61.

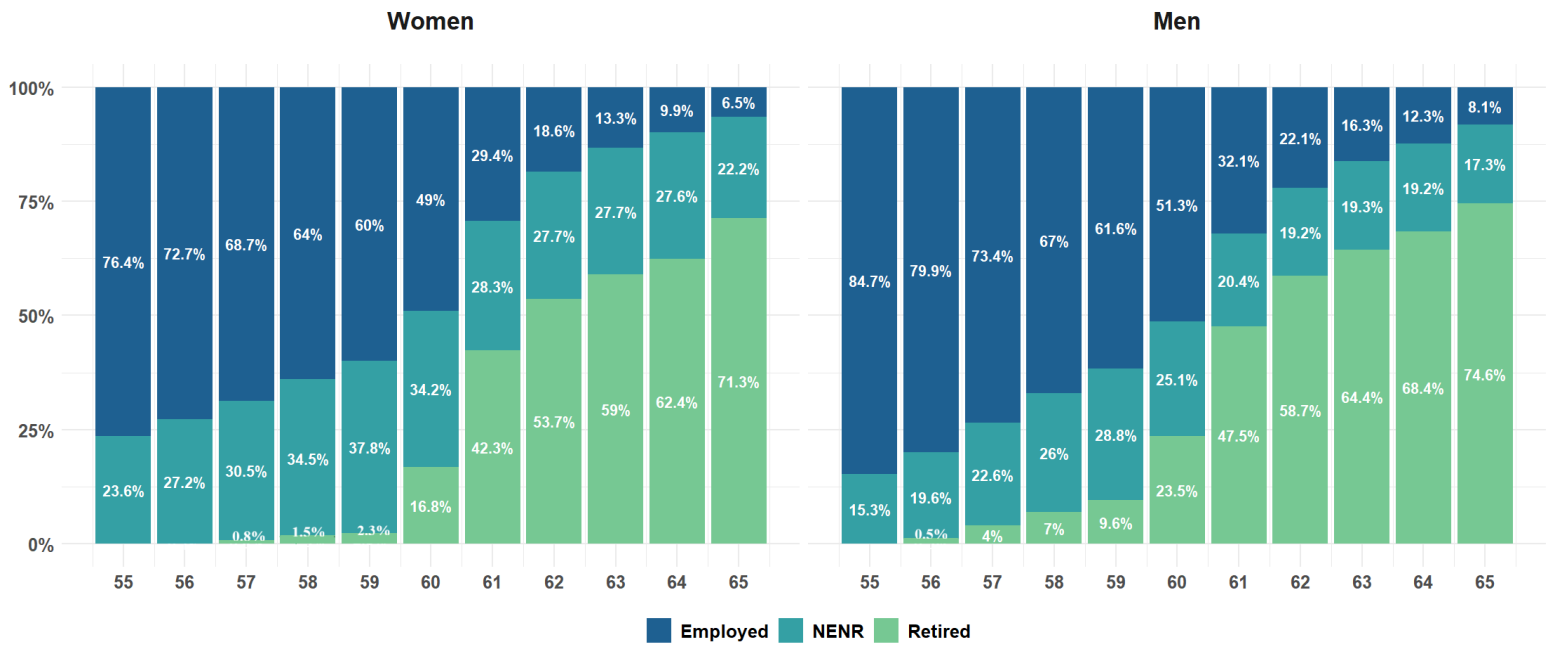
From age 62 onward, retirement becomes the dominant status, reaching 72.9% by age 65 (74.6% among men and 71.3% among women, $p<0.001$). During this period, employment continues to decline, reaching 7.3% at age 65, while NENR remains relatively stable around 23–24% before decreasing at 65, with inactivity accounting for over 90% of its composition and both unemployment and disability becoming marginal. These patterns illustrate the progressive transition from employment to retirement, with NENR often serving as an intermediate status between the two. The patterns also reflect continued employment beyond statutory ages, that is, between SEA and EPA (at age 65 for the control group).

Figure III. 1. Distributions of activity status between ages 55 and 65 among selected respondents from CONSTANCES born between 1948 and 1953, based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations over the period of 2003 till 2018).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits; and as *Employed* otherwise.
Example of interpretation: According to CNAV records, at age 55, 80.5% of selected respondents were employed, while 19.5% were classified as NENR, and 0% were retired.

Figure III. 2. Distributions of activity status between ages 55 and 65 by gender, among selected respondents from CONSTANCES born between 1948 and 1953, based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents (11324 women and 11000 men) born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations, over the period 2003 till 2018).
Notes: Activity status is derived from yearly contribution records, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise. Chi-squared tests were used to assess whether distributions differed significantly across gender: all differences were significant at the 5% level.
Example of interpretation: According to CNAV records, at age 55, 76.4% of women and 84.7% of men in the selected sample were employed, with the difference in proportions being significant at the 5% level.

Evolution across treated and control groups.

The evolutions of activity status across treated and control cohorts in the overall sample, and by gender are presented in Figure III. 3 to Figure III. 5

Differences in levels between treated and control cohorts.

Before age 60, employment levels are slightly higher in the treated group. At age 55, for example, employment reaches 83.1% among treated individuals compared with 78.4% in the control group ($p<0.001$). This difference is more pronounced among women, reflecting higher employment levels among the younger cohorts of women composing the treated group. In contrast, retirement is marginally more frequent in the control group at ages 58 and 59, particularly among men, consistent with the greater prevalence of long contribution histories among men and therefore greater eligibility for long-career early retirement schemes (Table III. 2). NENR levels are slightly higher in the control group between ages 55 and 59, especially among women, mirroring lower employment levels observed in these cohorts.

At ages 60 and 61, differences between the treated and control groups become more marked. Employment remains higher among the treated group, with the gap being greater than the observed gap across previous ages. At age 60, the NENR rate in the treated group is roughly six percentage points higher than in the control group, consistent with a temporary substitution from employment to NENR among individuals who are not yet eligible for retirement. At age 61, the NENR rate goes back to being slightly higher among the control group.

After age 61, differences in rates persist but are smaller. Employment remains slightly higher in the treated group until age 65, and retirement is higher in the treated group at ages 63 and 64, in contrast to age 65 where the rate is higher among the control group. NENR evolves in a similar way across groups but is marginally higher among the control group between ages 61 and 64 before reversing at age 65. Once gender, education, nationality, contribution history, and cohort fixed effects are taken into account, only a limited set of differences remains statistically significant at the 5% level, which is the case of: employment at age 62, NENR at ages 63 and 65, and retirement at age 65. This

indicates that many disparities in levels of employment, NENR, and retirement rates after age 62, reflect compositional differences rather than distinct behavioral patterns.

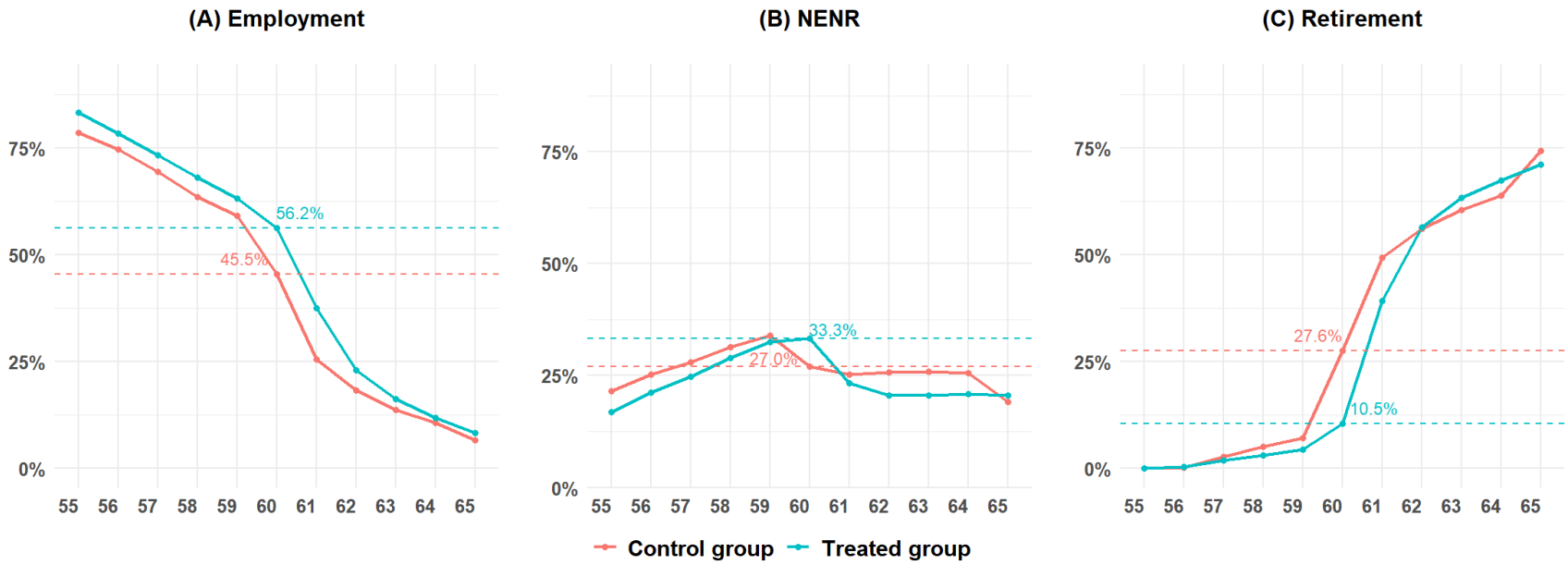
Differences in evolution patterns.

Between ages 55 and 59, employment declines steadily in both groups, with similar slopes ($p=0.78$), illustrating the common trend assumption. This decline is accompanied by rising NENR and retirement. Retirement begins to increase slightly earlier among the control group. It is clear that prior to age 60, evolution of employment, NENR, and retirement rates go in the same direction for the treated and control groups.

A sharper divergence emerges at ages 60 and 61. Among the control group, the fall in employment between ages 59 and 60 is largely offset by a rise in retirement as individuals reach eligibility. Among the treated group, who have not yet reached eligibility, employment falls more moderately and is accompanied by simultaneous increases in both NENR and retirement. The rise in NENR is more visible among women, while among men the transition is concentrated in retirement. Between ages 60 and 61, retirement increases more sharply in the treated group as they reach the statutory eligibility age, accompanied by a decline in NENR rates.

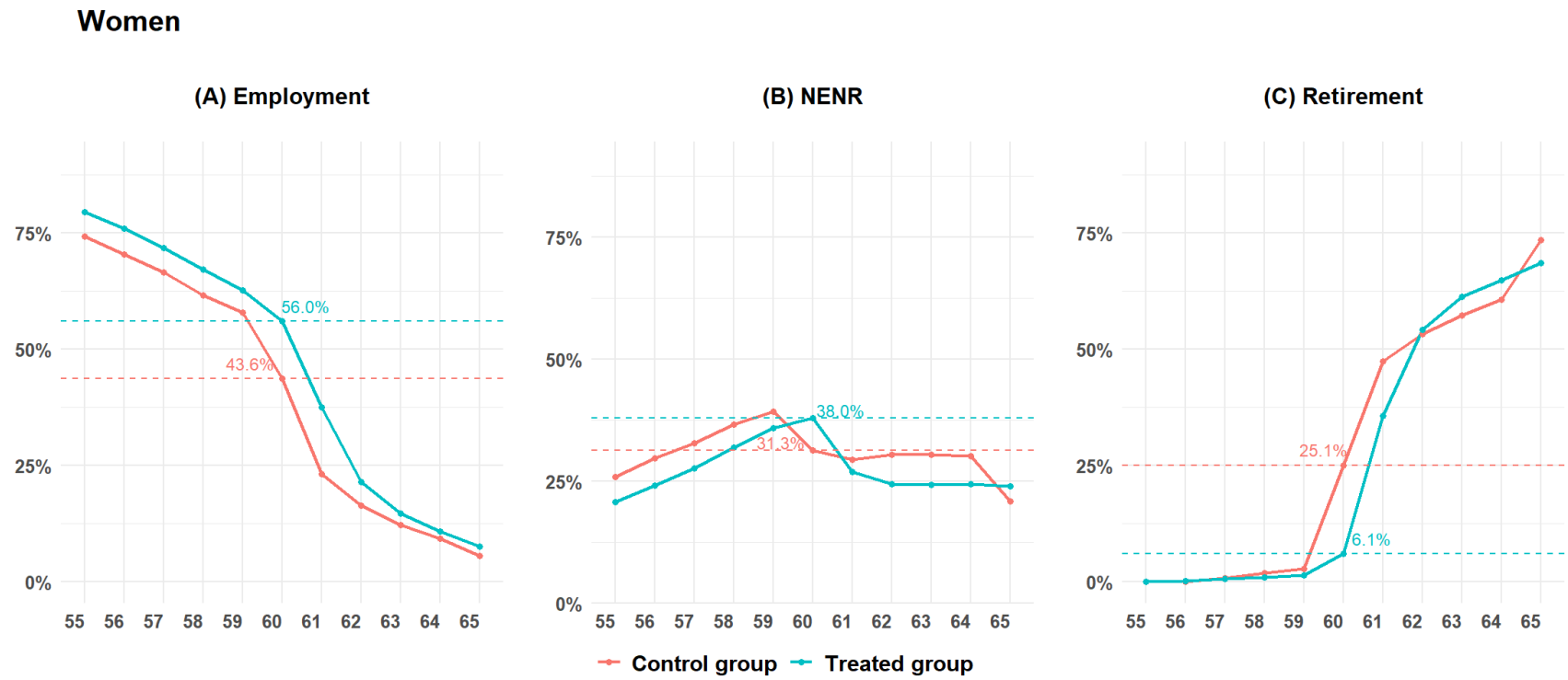
After age 61, the evolution of activity status becomes more similar across groups, with employment continuing to decline, retirement continuing to rise, and NENR stabilizing within a relatively narrow range. An exception are patterns observed between ages 64 and 65, where NENR rates decline among the control group, met by a greater increase in retirement rates compared to the treated group.

Figure III. 3. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treated groups based on CNAV records.



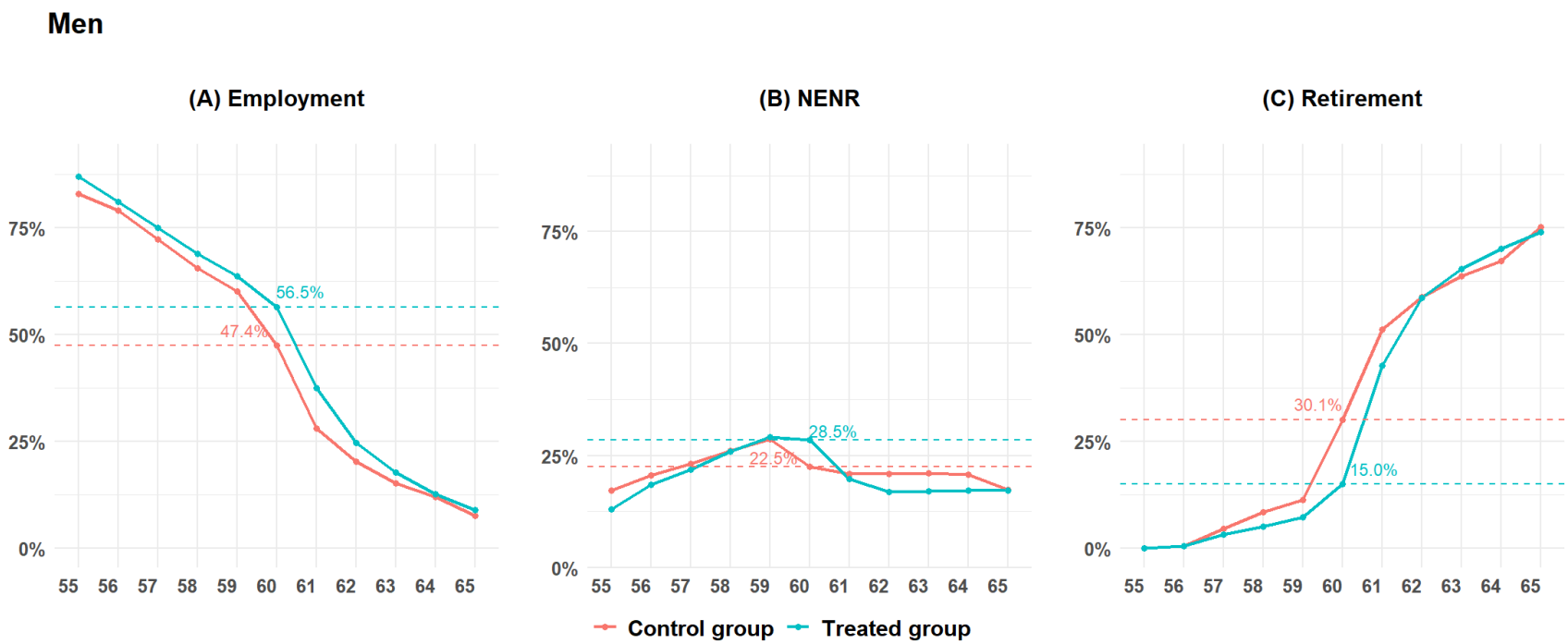
Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

Figure III. 4. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treated groups within <u>women</u> based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 11324 women born between 1948 and 1953, matched with their employment histories from CNAV (124502 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

Figure III. 5. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treated groups within men based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 11000 men born between 1948 and 1953, matched with their employment histories from CNAV (120962 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

IV. 1. c. Evolution in employment, NENR, and retirement rates from ages 55 to 65, stratified by history with health condition.

Figure III. 6 to Figure III. 8 present employment, NENR, and retirement rates across treatment and control groups, stratified by respondents' history of depression, OSD, or CVD. Each condition is examined separately, comparing individuals who reported a history of the specific condition with those who did not, resulting in six distinct strata. Detailed estimated rates of activity status are provided in Table III. S.4 till Table III. S.6 of the supplementary materials. Decomposition of the NENR category across the different strata are further shown in Figure III. S.5, Figure III. S.6, and Figure III. S.7 in supplementary materials.

Among individuals either without a history of depression, CVD or OSD, evolutions closely mirror those observed in the general population (described in **IV. 1. b**, Figure III. 3). However, clear deviations appear when comparing evolution in rates among groups of respondents with and without a history of depression, OSD, and CVD. These deviations concern both the overall levels of employment, NENR, and retirement, and the evolution of these statuses with age. They also reflect differences in trajectories between treated and control cohorts within each stratum.

Differences in levels of employment, NENR, and retirement, with respect to disease histories.

Between ages 55 and 62, individuals with a history of depression consistently display lower employment and higher NENR rates than those without, in both treated and control groups (all $p < 0.001$). This pattern aligns with existing evidence linking depression to weaker attachment to the labor market before retirement age. However, these differences narrow after age 62: within the treated group, employment rates between individuals with and without a history of depression are no longer significantly different at the 5% level (all $p > 0.7$). Similarly, differences in NENR rates fade at ages 63 and 64 ($p = 0.077$ and $p = 0.089$, respectively).

For OSD, differences between strata with and without these conditions vary across ages and cohorts. Within the control group, individuals with OSD show lower employment at ages 56 and 58 and higher NENR rates at ages 56 and 59 (all significant differences at the 5% level). Between ages 60 and 65, employment remains lower among those who reported OSD (all $p < 0.001$), while NENR rates converge between those with and without OSD (all $p > 0.2$). Retirement rates, however, are higher among those with OSD across ages 60 to 64 (all $p < 0.05$). This suggests that, in the control group, the lower employment of individuals with OSD was partly offset by transitions into retirement, consistent with access to disability-related retirement schemes that allow early exit at SEA for recognized conditions by the French social system, such as OSD.

In the treated group, a different pattern emerges for OSD. Employment rates are lower for individuals with OSD across all ages from 55 to 65, while NENR rates are higher at all ages except 62 ($p = 0.08$) and 65 ($p = 0.06$), where the differences are no longer significant at the 5% level. Retirement rates, by contrast, do not differ significantly between those with and without OSD at any age. This indicates that, among the treated cohorts, reduced employment among individuals with OSD was mainly compensated by transitions into NENR rather than retirement.

In regards to CVD, employment rates are lower among individuals with CVD than those without between ages 55 and 61 in the control group (all $p <0.01$) and NENR rates are higher up to age 60 and again at age 65. Within these cohorts, retirement rate is higher among those with CVD histories only at age 65 (while not significant at the 5% level, $p = 0.058$). For the treated group, employment is also lower among those with CVD between ages 57 and 65 (all $p<0.001$), and NENR rates are higher between ages 57 and 60 (all $p<0.001$). Retirement rates are higher between ages 61 and 63. This pattern suggests that, in the treated cohorts, individuals with CVD were more likely to exit employment through retirement rather than prolonged inactivity after reaching the new SEA, possibly reflecting access to health-related retirement schemes or disability pensions. (The share of the NENR category attributed to disability pensions was higher among the treated group across all ages than the control group, for those who had CVD).

Overall, differences in levels between individuals with and without a history of disease align with literature evidence: a history with chronic diseases is associated with lower employment, accompanied by either earlier retirement or a substitution towards NENR status. The decomposition of NENR across disease strata (Figure III. S.5 till Figure III. S.7 in supplementary materials) confirms that inactivity remains the dominant component, though disability pensions account for a higher share among individuals with a history of depression, OSD, or CVD, reaching around 13% before age 60, compared with approximately 5% in the general population. This is consistent with the stronger association between these conditions and the disability pensions. Yet, the extent and form of this substitution appear to vary by condition and cohort, reflecting differences in both health severity and access to alternative retirement or benefit schemes.

Differences in evolutions and in disparities between treated and control groups, across strata with disease histories.

Respondents with a history of depression follow trajectories that are broadly similar to the general population, particularly those of women (Figure III. 4). Employment declines steadily with age and remains higher among the treated group up to age 62, after which the gap between the treated and control groups becomes statistically insignificant (all $p > 0.1$). NENR rates rise up to ages 59 and 60 in the treatment and control groups, respectively, and remain higher in the control group across most ages (significant at 5% except at ages 59 and 61). By age 65, NENR rates are 21.4% in the control group and 22.8% in the treatment group ($p = 0.46$). Retirement rates increase progressively with age, and treated cohorts overtake control cohorts from age 63 onward ($p = 0.02$ at age 63; $p = 0.04$ at age 64). When controlling for covariates, what remains statistically significant at the 5% level are the differences in retirement rates between treated and control groups between ages 60 to 64, the higher employment rate among treated cohorts at age 61 only, and higher NENR rate at age 60.

Distinct patterns emerge among respondents with OSD or CVD. For those with OSD (Figure III. 7), employment gaps between treated and control groups at ages 55 to 59 are small and not statistically significant (all $p > 0.3$). NENR rates are slightly higher among the treated between ages 58 and 61, contrary to what is observed in the general

population, but these differences are minor and not statistically significant at the 5% level (all $p > 0.6$), except at age 60 ($p < 0.01$).

Among individuals with CVD (Figure III. 8), the evolution in employment and NENR across age diverge more markedly. Employment rates of the control group slightly exceed those of the treated group from age 62 onwards, though differences are not significant at the 5% level (all $p > 0.5$). Once gender and social covariates are taken into account, differences in employment rates between treated and control groups disappear across all ages. Another difference with the patterns of the overall sample stems from NENR slightly decreasing among treated individuals with CVD between ages 59 and 60. This reversal may reflect gender composition, as CVD is more prevalent among men whose NENR trajectories exhibit similar patterns (see Figure III. 5). The decline in inactivity could also stem from exits through health-related retirement pathways, such as disability or invalidity schemes; that could offer alternative routes out of employment for individuals with CVD.

Descriptive insights on heterogeneity in the impact of the increase in SEA with respect to disease histories.

At the statutory threshold (age 60), treatment–control gaps in employment, NENR, and retirement rates remain visible across all six strata. Employment and NENR rates are higher among the treated group at this age, while retirement rates are lower among them (all $p < 0.001$). The differences in NENR and retirement rates at age 60 remain statistically significant at the 5% level after controlling for gender, cohort effects, and social covariates. In terms of heterogeneity by health status, differences in NENR rates between treated and control groups are relatively larger within individuals with a history of depression and OSD (9 and 12 percentage points, respectively) than among those without these conditions (6 and 5.8 percentage points, for OSD and depression respectively). Overall, these descriptive differences suggest that the reform's impact towards being in the NENR status may have varied according to individuals' histories with depression and OSD. In contrast, for individuals with histories CVD, the difference in NENR rate at 60 between treated and control cohorts amounted to 6.3 percentage points, compared to 6.1 percentage points for those with no history of CVD.

Figure III. 6. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treatment groups, stratified by history with depression (between ages 40 and 55), based on CONSTANCES' medical data and CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups; **Different scales are used for every graph.**

Figure III. 7. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treatment groups stratified by history with OSD (between ages 40 and 55), based on CONSTANCES medical data and CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with OSD ("Osteo-articular diseases") between age 40 and 55 is identified based on CONSTANCES medical questionnaire; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups; **Different scales are used for every graph.**

Figure III. 8. Evolution in employment (A), NENR (B), and retirement (C) rates between ages 55 and 65 for control and treatment groups stratified by history with CVD, (between ages 40 and 55), based on CONSTANCES medical data and CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with CVD ("Cardiovascular diseases") between age 40 and 55 is identified based on CONSTANCES medical questionnaire; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups; **Different scales are used for every graph.**

IV. 2 Estimated impact of the reform on employment, NENR, and retirement rates at 60.

This section presents results from the fitted DiD models, following the same specifications used in previous studies investigating the reform's effects on employment, NENR, and retirement rates at age 60, without accounting for horizon effects. Results from the baseline models that exclude health histories are displayed in Table III. 3, while estimations from models including histories of depression, OSD, and CVD are shown in Table III. 5 to Table III. 7.

IV. 2. a. General impact of the reform.

The coefficient of interest, *Under SEA*, measures the effect of the reform by comparing rates between treated and control cohorts while adjusting for gender, social variables, age and cohort fixed effects, at age 60. Estimates show that the reform decreased the retirement rate at 60 by around 15 percentage points, while employment increased by about 6 points and NENR by 9 points. This suggests that the decline in retirement resulting from the reform, was compensated more by a rise in NENR than by a rise in employment, pointing to a substitution between employment and NENR at age 60.

Including control variables improved the precision of the estimates and confirmed their expected associations with labor-market status. Higher educational attainment was positively associated with employment and negatively with retirement, while its relation with NENR varied by level of education: Compared to individuals with "No diploma", individuals with vocational certificates were on average less likely to be fall in the NENR category while those who have completed undergraduate degrees were more likely to be NENR. As for nationality, being French, either since birth or by acquisition, was negatively associated with NENR and positively linked with retirement. Regarding gender, men were more often employed and retired, whereas women were more frequently in the NENR category, consistent with descriptive patterns. Besides, individuals who had started their history with contributions before age 18 were more likely to be retired, reflecting their possible eligibility for the early retirement scheme for long careers.

Table III. 3. Estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62).

	Employment (A)	NENR (B)	Retirement (C)
Difference in Difference estimator			
Under SEA	0.06*** (0.04, 0.08)	0.09*** (0.05, 0.13)	-0.15*** (-0.19, -0.12)
Control variables			
Age (Reference: Age = 55)			
Age = 56	-0.04*** (-0.05, -0.04)	0.04*** (0.04, 0.04)	0** (0, 0)
Age = 57	-0.09*** (-0.1, -0.08)	0.07*** (0.06, 0.08)	0.02*** (0.01, 0.03)
Age = 58	-0.15*** (-0.16, -0.14)	0.11*** (0.1, 0.12)	0.04*** (0.03, 0.06)
Age = 59	-0.2*** (-0.21, -0.19)	0.14*** (0.12, 0.15)	0.06*** (0.04, 0.08)
Age = 60	-0.27*** (-0.28, -0.26)	0.16*** (0.14, 0.17)	0.11*** (0.1, 0.12)
Age= 61	-0.44*** (-0.48, -0.4)	0.14*** (0.12, 0.17)	0.29*** (0.24, 0.35)
Age= 62	-0.54*** (-0.56, -0.52)	0.14*** (0.12, 0.15)	0.41*** (0.37, 0.44)
Highest educational attainment (Reference: *No diploma*)			
Vocational certificate	0 (-0.01, 0.02)	-0.02* (-0.04, -0.01)	0.02*** (0.02, 0.03)
High school diploma	0.04*** (0.03, 0.05)	0.05*** (0.03, 0.07)	-0.09*** (-0.1, -0.08)
Undergraduate degree	0.09*** (0.06, 0.12)	0.03** (0.01, 0.04)	-0.12*** (-0.13, -0.1)
Post-graduate degree	0.27*** (0.25, 0.3)	-0.1*** (-0.12, -0.08)	-0.17*** (-0.2, -0.15)
Geographical origin (Reference: Foreigner)			
French since birth	-0.02 (-0.07, 0.03)	-0.06* (-0.11, -0.01)	0.08*** (0.07, 0.1)
French by acquisition	0.02 (-0.03, 0.08)	-0.07** (-0.13, -0.02)	0.05*** (0.04, 0.07)
Cohort (Reference: Cohort 1948)			
Cohort 1949	0.03*** (0.03, 0.03)	-0.04*** (-0.04, -0.04)	0.02*** (0.02, 0.02)
Cohort 1950	0.04*** (0.04, 0.04)	-0.05*** (-0.05, -0.05)	0.01*** (0.01, 0.01)
Cohort 1951	0.05*** (0.05, 0.05)	-0.08*** (-0.08, -0.07)	0.02*** (0.02, 0.03)
Cohort 1952	0.08*** (0.08, 0.08)	-0.08*** (-0.08, -0.08)	0 (0, 0.01)
Cohort 1953	0.1*** (0.09, 0.1)	-0.07*** (-0.07, -0.07)	-0.03*** (-0.03, -0.02)
Contribution before age 18	-0.06*** (-0.07, -0.05)	-0.01 (-0.02, 0)	0.07*** (0.06, 0.08)
Gender			
Men	0.03*** (0.02, 0.05)	-0.07*** (-0.09, -0.06)	0.04*** (0.04, 0.05)
Constant	0.64*** (0.59, 0.68)	0.28*** (0.21, 0.34)	0.09*** (0.05, 0.13)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Overall, these results are consistent with earlier findings from earlier works (Dubois & Koubi, 2017; Rabaté & Rochut, 2020) , confirming that the 2010 reform increased employment at age 60 but also raised the share of individuals exiting through alternative routes, particularly NENR. The results support the existence of a substitution effect around the SEA for treated individuals. This substitution can occur through two main mechanisms. The first is an "active substitution", when individuals employed at age 59 move into NENR at age 60 when not yet eligible for retirement. The second is a "mechanical effect", when individuals who were already NENR at 59 remain in that status for an additional year before reaching retirement eligibility.

Estimated transition probabilities between statuses at ages 59 and 60, for individuals in the treated and control groups, shown in Table III. 4, provide evidence for both mechanisms. Among those employed at 59, the probability of being NENR at 60 is 9% for the treated group and 8% for the control group (not differing significantly at the 5% level, $p = 0.506$). This indicates that "active substitution" from employment to NENR occurred both among the treated group and control group. Regarding the "mechanical effect", among those already NENR at 59, the probability of remaining in this status at 60 reaches 92% for the treated group compared with 58% for the control group ($p < 0.001$). This suggests that, for treated individuals, the extension of NENR was more common, whereas for the control group, transition to retirement at 60 was more frequent (estimated probability 38% versus 5% for the treated group, $p < 0.001$). Overall, these results indicate that the reform's effect, that is an increase in employment coinciding with an increase in NENR at age 60, reflected more the likelihood of extension of NENR status at age 60 for treated individuals.

Table III. 4. Estimated transition probabilities between activity statuses from ages 59 to 60 (with 95% confidence intervals), among treated individuals (born between July 1st 1951 and December 31st 1953).

		Status at 60:		
		Employed	**NENR**	**Retired**
Treated group:				
Status at 59	**Employed**	0.90 (0.89, 0.91)	0.09 (0.08, 0.1)	0.02 (0.02, 0.03)
	NENR	0.03 (0.02, 0.05)	0.92 (0.90, 0.93)	0.05 (0.04, 0.06)
Control group:				
Status at 59	**Employed**	0.73 (0.71, 0.75)	0.08 (0.07, 0.09)	0.17 (0.15, 0.20)
	NENR	0.04 (0.03, 0.05)	0.58 (0.55, 0.61)	0.38 (0.34, 0.41)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents
Notes: Estimates correspond to average predicted probabilities of being in each activity status at age 60, conditional on activity status at age 59; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Probabilities are obtained from logistic regressions adjusted for educational attainment, nationality, birth cohort, gender, and contribution before age 18. 95% Confidence intervals (in parentheses) are based on asymptotic standard errors. Estimations are done using the *emmeans* R function from the *emmeans* package.

IV. 2. b. Heterogeneity in the impact of the reform with respect to disease histories.

Table III. 5 to Table III. 7 present estimates from models accounting separately for histories of depression, OSD, and CVD, reported between ages 40 and 55. For each model, the estimated effect of the reform (coefficient associated with "*UnderSEA*") among respondents without the specific condition closely matches the results from the general model and aligns with the descriptive findings. Among the general population, conditional on gender, social covariates, and age and cohort fixed effects, the reform reduced the retirement rate at age 60 by about 15 percentage points, while increasing employment and NENR rates by around 69 percentage points respectively.

When accounting for health histories, differences in labor-market outcomes are clear. From age 55 onward, individuals with a history of depression, OSD, or CVD were less likely to be employed and more likely to be NENR compared to those without the respective condition. Differences in retirement were smaller and generally non-

significant at any level below 5%, except among those with OSD, whose retirement rate was on average 3 percentage points higher than their counterparts ($p < 0.001$).

Turning to the heterogeneity of the reform's effect, the most relevant divergence by health status was observed for depression. The interaction terms (*History of depression*UnderSEA*) show that, for individuals with a history of depression, the employment gain associated with the reform at age 60 was attenuated by about 2 percentage points, while the increase in NENR at that age was amplified by 3 percentage points compared to those without depression. The effect on retirement did not differ significantly between these groups, as the corresponding interaction coefficient was close to zero. For respondents with OSD and CVD, a comparable though less pronounced pattern emerged. In both cases, the reform's impact on NENR was around 3 percentage points higher among those with a history of either condition relative to those without it. For OSD, the stronger rise in the NENR rate at age 60 was accompanied by a slightly larger reduction in the retirement rate (around –3 percentage points compared to those without OSD), while no significant difference was observed for employment. For CVD, the reform's impact on NENR was also higher, but the interaction terms for employment and retirement were not statistically significant at any level below 5%. Overall, these results converge on the insight that the reform's effect on increasing the likelihood of being NENR at age 60 was somewhat stronger among individuals with a history of depression, OSD, or CVD than among those without the respective conditions.

Figure III. 9 and Figure III. 10 further illustrate the observed differences by showing transition probabilities between activity statuses from ages 59 to 60 among treated individuals (those exposed to the reform), conditional on health history. Since the increase in NENR at age 60 was stronger among those with prior health conditions, compared to their counterparts, these estimated probabilities help clarify whether the substitution pattern mainly reflected an "active substitution" from employment to NENR or a "mechanical" extension of NENR status, from age 59 to 60.

For CVD, no significant differences in transition probabilities were found between those with and without the condition. For depression, the differences were more marked.

Among individuals who were NENR at age 59, the probability of remaining NENR at 60 was 94% for those with a history of depression, compared with 89% for those without ($p < 0.001$). The probability of moving from NENR to employment was also slightly lower for those with a history of depression (1% versus 4%, $p < 0.001$). For OSD, the probability of remaining NENR at age 60 did not differ significantly between groups. However, among those NENR at 59, individuals without OSD were marginally more likely to regain employment at 60 than their counterparts (4% versus 2%, $p = 0.029$). Concerning the group of employed at 59, differences across groups with and without health histories in the probability of transitioning to statuses other than employment were relatively small and not statistically significant at any level below 5%.

Altogether, these results indicate that the reform's heterogeneous effects by health status mainly reflected a mechanical extension of the NENR period rather than active transitions out of employment. This pattern was most evident among individuals with a history of depression, while for OSD and CVD, the differences were smaller and less insightful.

Table III. 5. Estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with depression (between ages 40 and 55).

	Employment (A)	NENR (B)	Retirement (C)
Coefficients of interest			
Under SEA	0.06*** (0.04, 0.09)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.01, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.03*** (-0.04, -0.02)	0.03** (0.01, 0.05)	0 (-0.01, 0.02)
Control variables			
Age (Reference: Age = 55)			
Age = 56	-0.04*** (-0.05, -0.04)	0.04*** (0.04, 0.04)	0** (0, 0)
Age = 57	-0.09*** (-0.1, -0.08)	0.07*** (0.06, 0.08)	0.02*** (0.01, 0.03)
Age = 58	-0.15*** (-0.16, -0.14)	0.11*** (0.1, 0.12)	0.04*** (0.03, 0.06)
Age = 59	-0.2*** (-0.21, -0.19)	0.14*** (0.12, 0.15)	0.06*** (0.04, 0.08)
Age = 60	-0.27*** (-0.28, -0.26)	0.16*** (0.14, 0.17)	0.11*** (0.1, 0.12)
Age= 61	-0.44*** (-0.48, -0.4)	0.14*** (0.12, 0.17)	0.29*** (0.24, 0.35)
Age= 62	-0.54*** (-0.56, -0.52)	0.14*** (0.12, 0.15)	0.41*** (0.37, 0.44)
Highest educational attainment (Reference: *No diploma*)			
Vocational certificate	0 (-0.01, 0.02)	-0.02* (-0.04, -0.01)	0.02*** (0.02, 0.03)
High school diploma	0.04*** (0.03, 0.05)	0.05*** (0.03, 0.07)	-0.09*** (-0.1, -0.08)
Undergraduate degree	0.09*** (0.06, 0.12)	0.03** (0.01, 0.04)	-0.12*** (-0.13, -0.1)
Post-graduate degree	0.27*** (0.25, 0.29)	-0.1*** (-0.12, -0.08)	-0.17*** (-0.2, -0.15)
Geographical origin (Reference: Foreigner)			
French since birth	-0.02 (-0.07, 0.03)	-0.06* (-0.11, -0.01)	0.08*** (0.07, 0.1)
French by acquisition	0.02 (-0.03, 0.08)	-0.07** (-0.13, -0.02)	0.05*** (0.04, 0.07)
Cohort (Reference: Cohort 1948)			
Cohort 1949	0.03*** (0.03, 0.03)	-0.04*** (-0.04, -0.04)	0.02*** (0.02, 0.02)
Cohort 1950	0.04*** (0.04, 0.04)	-0.05*** (-0.05, -0.05)	0.01*** (0.01, 0.01)
Cohort 1951	0.05*** (0.05, 0.05)	-0.08*** (-0.08, -0.07)	0.02*** (0.02, 0.03)
Cohort 1952	0.08*** (0.08, 0.08)	-0.08*** (-0.09, -0.08)	0 (0, 0.01)
Cohort 1953	0.1*** (0.09, 0.1)	-0.07*** (-0.07, -0.07)	-0.03*** (-0.03, -0.02)
Contribution before age 18	-0.06*** (-0.07, -0.05)	-0.01 (-0.02, 0)	0.07*** (0.06, 0.08)
Gender			
Men	0.03*** (0.02, 0.04)	-0.07*** (-0.09, -0.05)	0.04*** (0.04, 0.05)
Constant	0.61*** (0.57, 0.65)	0.27*** (0.2, 0.33)	0.12*** (0.08, 0.17)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. 6. Estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with OSD (between ages 40 and 55).

	Employment (A)	NENR (B)	Retirement (C)
Coefficients of interest			
Under SEA	0.06*** (0.03, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with OSD	-0.04*** (-0.05, -0.02)	0.01** (0, 0.02)	0.03** (0.01, 0.04)
History with OSD* Under SEA	0 (-0.03, 0.04)	0.03* (0, 0.05)	-0.03** (-0.05, -0.01)
Control variables			
Age (Reference: Age = 55)			
Age = 56	-0.04*** (-0.05, -0.04)	0.04*** (0.04, 0.04)	0** (0, 0)
Age = 57	-0.09*** (-0.1, -0.08)	0.07*** (0.06, 0.08)	0.02*** (0.01, 0.03)
Age = 58	-0.15*** (-0.16, -0.14)	0.11*** (0.1, 0.12)	0.04*** (0.03, 0.06)
Age = 59	-0.2*** (-0.21, -0.19)	0.14*** (0.12, 0.15)	0.06*** (0.04, 0.08)
Age = 60	-0.27*** (-0.28, -0.26)	0.16*** (0.14, 0.17)	0.11*** (0.1, 0.12)
Age= 61	-0.44*** (-0.48, -0.4)	0.14*** (0.12, 0.17)	0.29*** (0.24, 0.35)
Age= 62	-0.54*** (-0.56, -0.52)	0.14*** (0.12, 0.15)	0.41*** (0.37, 0.44)
Highest educational attainment (Reference: *No diploma*)			
Vocational certificate	0 (-0.01, 0.02)	-0.02* (-0.04, -0.01)	0.02*** (0.02, 0.03)
High school diploma	0.04*** (0.03, 0.05)	0.05*** (0.03, 0.07)	-0.09*** (-0.1, -0.08)
Undergraduate degree	0.09*** (0.06, 0.12)	0.03** (0.01, 0.04)	-0.12*** (-0.13, -0.1)
Post-graduate degree	0.27*** (0.25, 0.29)	-0.1*** (-0.12, -0.08)	-0.17*** (-0.2, -0.15)
Geographical origin (Reference: Foreigner)			
French since birth	-0.02 (-0.07, 0.03)	-0.06* (-0.11, -0.01)	0.08*** (0.07, 0.1)
French by acquisition	0.02 (-0.03, 0.08)	-0.07** (-0.13, -0.02)	0.05*** (0.04, 0.07)
Cohort (Reference: Cohort 1948)			
Cohort 1949	0.03*** (0.03, 0.03)	-0.04*** (-0.04, -0.04)	0.02*** (0.02, 0.02)
Cohort 1950	0.04*** (0.04, 0.04)	-0.05*** (-0.05, -0.05)	0.01*** (0.01, 0.01)
Cohort 1951	0.05*** (0.05, 0.05)	-0.08*** (-0.08, -0.07)	0.02*** (0.02, 0.03)
Cohort 1952	0.08*** (0.08, 0.08)	-0.08*** (-0.08, -0.08)	0 (0, 0.01)
Cohort 1953	0.1*** (0.09, 0.1)	-0.07*** (-0.07, -0.07)	-0.03*** (-0.03, -0.02)
Contribution before age 18	-0.06*** (-0.07, -0.05)	-0.01 (-0.02, 0)	0.07*** (0.06, 0.08)
Gender			
Men	0.03*** (0.02, 0.04)	-0.07*** (-0.09, -0.06)	0.04*** (0.04, 0.05)
Constant	0.61*** (0.57, 0.65)	0.27*** (0.21, 0.33)	0.12*** (0.08, 0.17)

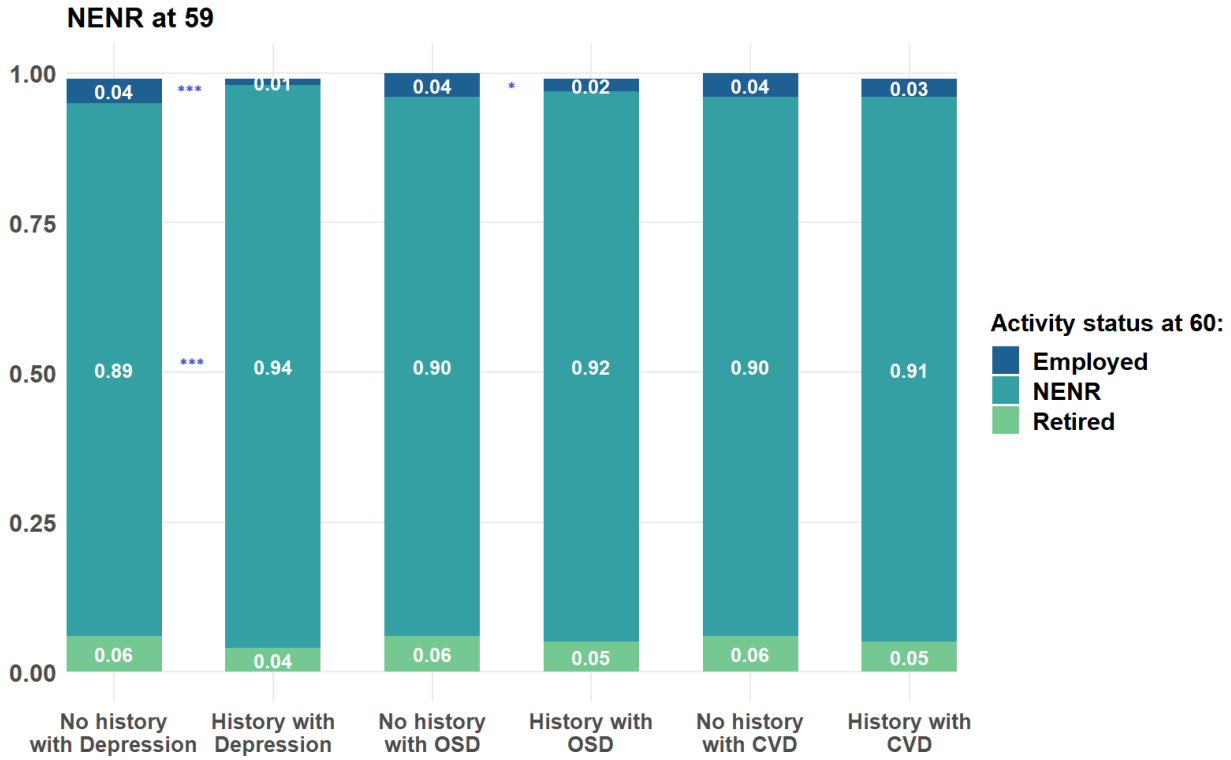
Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. 7. Estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with CVD (between ages 40 and 55).

	Employment (A)	NENR (B)	Retirement (C)
Coefficients of interest			
Under SEA	0.06*** (0.04, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with CVD	-0.05*** (-0.08, -0.02)	0.04* (0.01, 0.07)	0.02 (-0.02, 0.05)
History with CVD* Under SEA	0 (-0.03, 0.03)	0.03* (0.01, 0.06)	-0.03 (-0.06, 0.01)
Control variables			
Age (Reference: Age = 55)			
Age = 56	-0.04*** (-0.05, -0.04)	0.04*** (0.04, 0.04)	0** (0, 0)
Age = 57	-0.09*** (-0.1, -0.08)	0.07*** (0.06, 0.08)	0.02*** (0.01, 0.03)
Age = 58	-0.15*** (-0.16, -0.14)	0.11*** (0.1, 0.12)	0.04*** (0.03, 0.06)
Age = 59	-0.2*** (-0.21, -0.19)	0.14*** (0.12, 0.15)	0.06*** (0.04, 0.08)
Age = 60	-0.27*** (-0.28, -0.26)	0.16*** (0.14, 0.17)	0.11*** (0.1, 0.12)
Age= 61	-0.44*** (-0.48, -0.4)	0.14*** (0.12, 0.17)	0.29*** (0.24, 0.35)
Age= 62	-0.54*** (-0.56, -0.52)	0.14*** (0.12, 0.15)	0.41*** (0.37, 0.44)
Highest educational attainment (Reference: *No diploma*)			
Vocational certificate	0 (-0.01, 0.02)	-0.02** (-0.04, -0.01)	0.02*** (0.02, 0.03)
High school diploma	0.04*** (0.03, 0.05)	0.05*** (0.03, 0.07)	-0.09*** (-0.1, -0.07)
Undergraduate degree	0.09*** (0.06, 0.12)	0.03** (0.01, 0.04)	-0.12*** (-0.13, -0.1)
Graduate degree	0.27*** (0.25, 0.29)	-0.1*** (-0.12, -0.08)	-0.17*** (-0.2, -0.15)
Geographical origin (Reference: Foreigner)			
French since birth	-0.02 (-0.07, 0.03)	-0.06* (-0.11, -0.01)	0.08*** (0.07, 0.1)
French by acquisition	0.02 (-0.03, 0.08)	-0.07** (-0.13, -0.02)	0.05*** (0.04, 0.07)
Cohort (Reference: Cohort 1948)			
Cohort 1949	0.03*** (0.02, 0.03)	-0.04*** (-0.04, -0.04)	0.02*** (0.02, 0.02)
Cohort 1950	0.04*** (0.04, 0.04)	-0.05*** (-0.05, -0.05)	0.01*** (0.01, 0.01)
Cohort 1951	0.05*** (0.05, 0.05)	-0.08*** (-0.08, -0.07)	0.02*** (0.02, 0.03)
Cohort 1952	0.08*** (0.08, 0.08)	-0.08*** (-0.08, -0.08)	0 (0, 0.01)
Cohort 1953	0.1*** (0.09, 0.1)	-0.07*** (-0.07, -0.07)	-0.03*** (-0.03, -0.02)
Contribution before age 18	-0.06*** (-0.07, -0.05)	-0.01 (-0.02, 0)	0.07*** (0.06, 0.08)
Gender			
Men	0.03*** (0.02, 0.05)	-0.07*** (-0.09, -0.06)	0.04*** (0.04, 0.05)
Constant	0.61*** (0.57, 0.65)	0.27*** (0.21, 0.33)	0.12*** (0.08, 0.17)

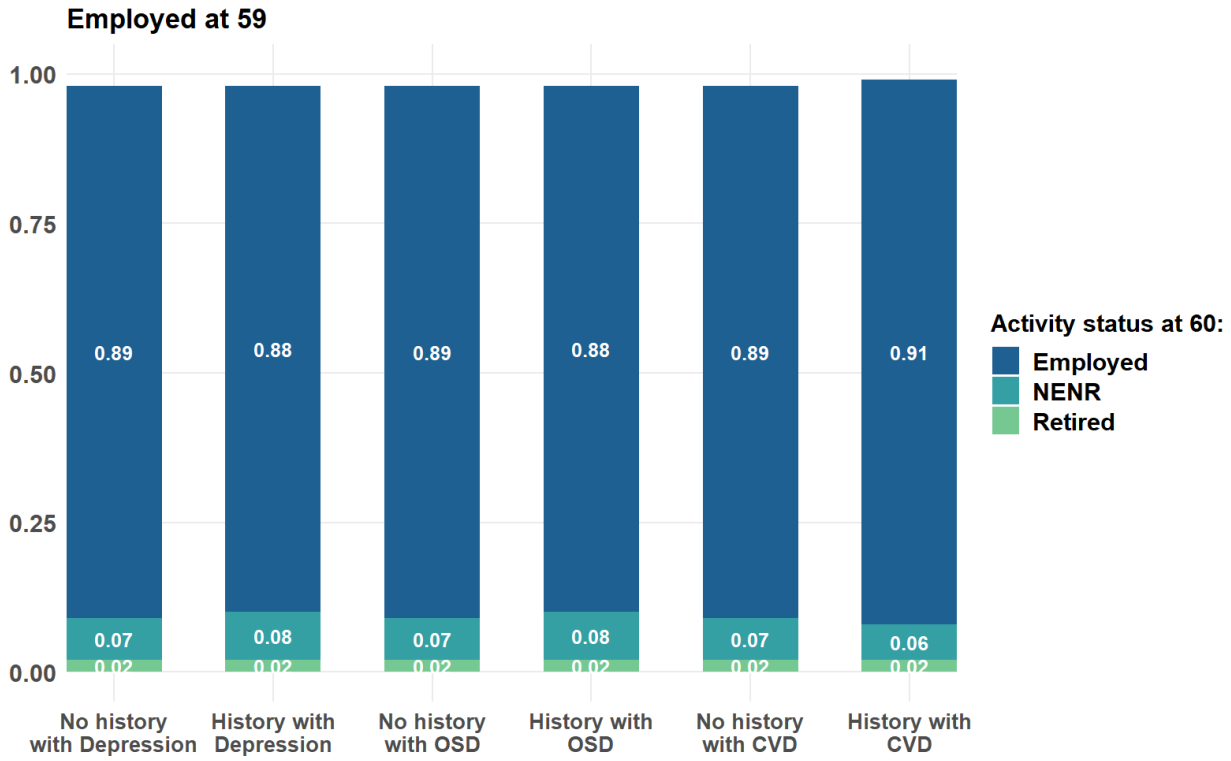
Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Figure III. 9. Estimated probabilities of activity statuses at age 60 among treated individuals (born between July 1st 1951 and December 31st 1953) who were NENR at age 59, conditional on history with depression, OSD, or CVD.



Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62) of the treated group (N= 9691), with 67,837 observations.
Notes: Estimates correspond to average predicted probabilities of being in each activity status at age 60, conditional on activity status at age 59; Cohorts born between July 1st 1951 and 1953 are included in the treatment group; Probabilities are obtained from logistic regressions adjusted for educational attainment, nationality, birth cohort, gender, and contribution before age 18. 95% Confidence intervals (in parentheses) are based on asymptotic standard errors. Estimations are done using the *emmeans* R function from the *emmeans* package.

Figure III. 10. Estimated probabilities of activity statuses at age 60 among treated individuals (born between July 1st 1951 and December 31st 1953) who were employed at age 59, conditional on history with depression, OSD, or CVD.



Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62) of the treated group (N= 9691), with 67,837 observations.
Notes: Estimates correspond to average predicted probabilities of being in each activity status at age 60, conditional on activity status at age 59; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Probabilities are obtained from logistic regressions adjusted for educational attainment, nationality, birth cohort, gender, and contribution before age 18. 95% Confidence intervals (in parentheses) are based on asymptotic standard errors. Estimations are done using the *emmeans* R function from the *emmeans* package.

V. Robustness checks.

Several robustness checks were conducted to assess the stability of the results and to verify that the main findings were not driven by specific design choices. All analyses relied on the same difference-in-differences framework described in the Methods section and included the same set of control variables unless stated otherwise.

V. 1 Narrowing the cohort bandwidth around the reform threshold.

In the main analysis, the control group included cohorts born before July 1st , 1951 (1948–first half of 1951), and the treated group included those born between July 1st , 1951 and December 31st, 1953 (second half of 1951–1953). To examine whether the results were sensitive to the selected bandwidth around the reform cutoff, we re-estimated the models using narrower cohort ranges which include the following bandwidths: (a) 1949–1953, (b) 1949–1952, and (c) 1950–1952. Across all three specifications (D) , the evidence on a heterogeneity in the impact of the reform, particularly on increasing NENR rates at age 60, with respect to a history of depression remained robust. The interaction term between "*History of depression"* and "*Under SEA"* remained statistically significant at the 5% level, with an estimated magnitudes close to that of the baseline model. In contrast, when the bandwidth was reduced to options (b) and (c), the coefficients of the interactions for histories of OSD and CVD were no longer significantly different from zero at the same level. This might reflect the loss of statistical precision due to smaller sample sizes in the restricted windows rather than substantive changes in the underlying associations.

V. 2 Alternative definitions of annual activity status.

The main analysis classified individuals' annual activity status using validated quarters from CNAV records. A year was coded as "Retired" when the individual claimed and began receiving a retirement pension, and as NENR when at least two quarters were spent in unemployment, disability, or periods without any pension contribution. All other cases were classified as "Employed," including periods of private-sector work, military service, sick leave, or contributions to other pension schemes. A second robustness check was

done to assess whether the main findings were sensitive to the way activity statuses were defined. Models were re-estimated the models using four alternative specifications: (a′) including sick leave within the NENR category, (b′) classifying a year as "NENR" when at least one quarter was spent in NENR, (c′) classifying a year as "Employed" when at least one quarter was spent in employment, and (d′) identifying a year as "Retired" only when the pension was received for more than half of the year. Across all these specifications, the conclusions remained unchanged. The heterogeneity in the impact of the reform by history of depression and OSD persisted, while results for CVD were more consistent with those obtained under narrower bandwidths.

V. 3 Using socio-occupational class instead of education.

As an additional robustness check, we replaced the indicator of highest educational attainment with the variable describing the longest occupied socio-occupational class (described in Methods section). This test verified that the results were not dependent on the particular measure of social position used in the models. The estimated effects of *Under SEA* and its interactions with disease histories were consistent with those obtained in the main models.

V. 4 Alternative age window for identifying depression.

Finally, to ensure that the identified cases of depression were not temporally close to the reform, we used a narrower age window to define depression history. Instead of identifying depression diagnoses between ages 40 and 55, we restricted this range to 30–45 years. This restriction aimed to exclude cases where depressive episodes might have coincided with or been influenced by the reform period, which could introduce reverse causality. The results remained consistent with the main specification: the interaction between *History of depression* and *Under SEA* continued to be statistically significant and of similar magnitude.

Overall, the robustness analyses confirm that the main conclusions of this study are not sensitive to reasonable alternative specifications. The 2010 increase in the statutory

eligibility age (SEA) was associated with a higher probability of being NENR at age 60, and this effect was more pronounced among individuals with a history of depression. The evidence for heterogeneity by OSD and CVD was weaker and less stable across specifications, likely reflecting differences in precision and suggesting that investigation heterogeneity with respect to these disease deserves further explorations.

V. 5 Allowing age and cohort effects to vary by health status.

The main specification assumes that age and cohort effects are common across health groups, while allowing the reform effect to differ by health condition. Since exposure to the reform is defined by a cohort-by-age interaction, this restriction could be strong if age-related or cohort-related trends in activity status differ systematically between individuals with and without a given condition. To assess the sensitivity of the results to this assumption, we re-estimated the models including interaction terms between age dummies and health status, and between cohort dummies and health status, for each condition separately (main results displayed in Table III. S.10 of supplementary materials). For depression, the results remained robust: the estimated interaction between the reform and depression history on NENR at age 60 was stable in magnitude and significance. This suggests that the main finding for depression is not driven by differential age or cohort trends across health groups. For OSD and CVD, the results were not robust to this relaxation. This may reflect differential age or cohort trends across health groups. Descriptive trends are consistent with this interpretation, as age-related patterns in employment and NENR appeared more similar across treated and control groups among individuals with and without depression than among those with and without OSD or CVD. However, it can also stem from insufficient statistical power given the smaller number of affected individuals.

VI. Short investigation on “horizon effects”.

VI. 1. Evolution in rates in the general population.

The descriptive analysis revealed several differences between treated and control cohorts in employment, NENR, and retirement rates beyond the age directly affected by the reform, that is age 60. For some post-reform ages for instance, NENR rates were higher among the control group than among the treated group, and these differences remained statistically significant after accounting for gender and social variable, particularly at age 63. To examine whether these patterns reflected possible horizon effects of the reform, we estimated an event-study model following the approach used in another work that has investigated horizon effects following an Italian reform implemented in 2011 that has raised normal retirement ages (Serrano-Alarcón et al., 2023). Using age 59 as the reference, corresponding to the pre-reform period, the model we have applied compared, for each age, the difference in employment, NENR, and retirement rates between treated and control cohorts relative to the differences observed at age 59. The specification included interaction terms between treatment status and age categories, with fixed effects for both age and birth cohort, and controlled for gender, nationality, educational attainment, and contribution history before age 18. Standard errors were clustered by cohort level.

The results showed no evidence of horizon effects for employment. The difference in employment rates between treated and control cohorts remained broadly similar to that observed at age 59 for all ages, except at ages 60 and 61, the ages directly affected by the increase in the statutory eligibility age. For NENR, however, the results indicated variations in the treated–control gap relative to age 59: At age 60, the treated group had a higher probability of being NENR than the control group relative to the pre-reform gap. Between ages 62 and 64, the sign of the coefficients reversed, with the control group showing higher NENR rates than the treated group, and these gaps were larger than the gaps observed age 59. At age 65, the difference again turned positive, with the treated group more often NENR. These variations pointed to a possibility of horizon effects. However, given the complexity of the mechanisms involved, these results should be interpreted with caution. A potential explanation could relate to differences in contribution histories between cohorts. As shown in the descriptive section, the control group already had a higher rate of NENR at age 55, and this difference exceeded that observed at age 59. This may reflect more incomplete contribution histories among

control cohorts, leading to delayed retirement eligibility, even if they have started their contributions prior to age 18. Consequently, these individuals may have been more likely to retire at the end-of-penalty age (EPA, 65 years) rather than the SEA. Consistent with this, at age 65 the treated group displayed a higher NENR rate than the control group, possibly reflecting later retirement transitions. This hypothesis would merit further investigation using detailed data on individual contribution trajectories.

Overall, this complementary analysis on horizon effects suggest that employment patterns were not subject to horizon effects, while NENR patterns showed some post-reform variation that may partly reflect cohort-specific characteristics rather than direct behavioral responses to the reform.

VI. 2. Heterogeneity with respect to health status.

As the main objective of this study was to estimate heterogeneity in responses to the reform by health status, the exploration of horizon effects by disease history was limited. Two strategies were tested. The first added a triple interaction term between treatment, age, and health history within the same event-study specification, allowing direct contrasts across health groups. However, models including triple interaction terms are known to be difficult to interpret, as the resulting coefficients represent higher-order differences that depend on scale and functional form (Ai & Norton, 2003; Mize, 2019). In addition, when applied to event-study frameworks, the accumulation of interaction terms may reduce precision and complicate inference, particularly when subgroup sizes are limited (Schmidheiny & Siegloch, 2023). The second approach estimated separate event-study models by health status, enabling visual comparison of patterns across subgroups. As standard errors were estimated separately, coefficients could not be compared directly, thus heterogeneity could not be correctly assessed. However, both approaches were applied, and results showed no evidence of significant differences in post-reform trajectories by health status.

VII. Discussion.

VII. 1. Main insights.

Extending prior analyses of the 2010 French pension reform, which raised the statutory eligibility age (SEA) from 60 to 62, this chapter examined how its impact on employment, NENR, and retirement rates varied by health history. The focus was on the probability of being in the NENR category at age 60, and on how this differed between individuals with and without prior history of depression, OSD, or CVD. The analysis compared adjacent cohorts born between 1948 and 1953, those whose SEA remained 60 to those whose SEA increased up to age 61 (cohorts born after July 1st 1951).

Baseline results, not accounting for health history, confirmed earlier findings in the literature: at age 60, retirement rates fell among treated cohorts, while both employment and NENR rates rose. The reform effectively postponed retirement but did not translate into an equivalent rise in employment at age 60. Rather, part of the extension of working life was absorbed through longer periods of inactivity, unemployment, or disability, all grouped under NENR. Transition analyses showed that these effects mostly reflected extensions of NENR status across ages 59 to 60. The descriptive analysis of NENR composition further showed that inactivity, rather than unemployment or disability, accounted for the vast majority of NENR throughout the age range, exceeding 75% before age 60 and rising above 88% by age 61. This indicates that most individuals in the NENR category were not receiving compensating income from unemployment benefits or disability pensions, but were instead in a situation with no income from any source.

Introducing health histories revealed that the highlighted effects were not uniform. The increase in NENR at age 60 following the reform was more pronounced among individuals with a prior history of depression, OSD, or CVD. After accounting for narrower cohort bandwidths, the heterogeneity remained statistically robust for depression. This indicates that the reform disproportionately affected those with prior mental health conditions: among these individuals, the likelihood of remaining NENR at age 60 increased more than among their counterparts without such history. In practical terms, workers with a history of depression were less likely to transition back to employment and more likely to remain in prolonged non-employment when facing a delayed pension eligibility.

This finding is consistent with well-documented mechanisms in the literature. Depression affects both work capacity and employability over the life course. Individuals with a history of depression tend to experience more frequent absences, job instability, and earlier withdrawal from employment. They are also less likely to return to work after job loss, especially at older ages, due to reduced productivity, and barriers in re-entering the labor market. Over time, these patterns lead to more fragmented careers and incomplete contribution histories. For these individuals, the increase in the SEA extends the period during which they have no access to pension income, a mechanism that Garrouste & Perdrix (2022) identify as the income effect of reforms delaying retirement. As shown in the NENR composition analysis, most individuals in this situation are in uncompensated inactivity, meaning that re-employment is the only way to restore income during this gap. Yet this is precisely the option that a history of depression makes least accessible. The French disability pension system does provide coverage for psychiatric disorders, which are in fact the leading cause of disability pension awards (Cuerq et al., 2008; Mette et al., 2023), but eligibility requires a reduction in work capacity of at least two-thirds. Many individuals with a depression history who do not meet this threshold therefore remain in uncompensated inactivity, fully exposed to the income gap. This financial precarity may in turn compound their situation: income loss and economic insecurity have been identified as risk factors for depression and psychological distress (Ridley et al., 2020; Thomson et al., 2022), which further reduces the likelihood of re-employment. The reform may thus trigger a reinforcing process for this group, where delayed eligibility prolongs a financially precarious period that worsens the condition preventing exit from it. The observed persistence of NENR spells at age 60 among individuals with depression is consistent with this interpretation.

The patterns observed for OSD and CVD point to a different dynamic. The interaction terms for these conditions were positive but less stable across specifications, suggesting weaker or more context-dependent heterogeneity. This does not imply that these conditions are unimportant. The relatively small number of affected individuals in the sample (less than 10% for each) likely reduced the statistical power to detect robust differences. Beyond sample size, however, the institutional context may also partly explain why these conditions did not produce the same pattern as depression. Unlike

psychiatric disorders, OSD and CVD are more readily linked to occupational exposures — physical demands, repetitive movements, or harmful working conditions — which makes them more likely to qualify for early retirement through the permanent disability scheme (*retraite anticipée pour incapacité permanente*) or for disability pension recognition through occupational disease channels. The NENR composition analysis is consistent with this: disability pensions account for a higher share of NENR among individuals with OSD or CVD (around 13% before age 60) than in the general population (around 5%), suggesting that a fraction of these individuals accessed compensating pathways that partially shielded them from the uncompensated inactivity that characterizes most of NENR. Although these schemes remained limited in scale — only around 1,300 individuals benefited from the early retirement scheme in 2011 — even modest coverage may have been sufficient to attenuate the observable heterogeneity in a small subsample. Overall, our findings indicate that, while the reform effectively postponed retirement, it did not reduce disparities in the way individuals experienced the years preceding retirement. For many workers in good health, the extension translated into longer employment, whereas for those with health problems, it more often meant a longer period without employment or pension income. In this sense, the reform's effects were uneven across health groups.

Finally, the results mainly reflect outcomes at the statutory age threshold. The complementary analysis on horizon effects did not show clear differences in employment beyond age 60, but suggested some variation in NENR patterns at later ages, likely linked to cohort-specific characteristics rather than direct reform responses. These patterns indicate that the short-term consequences of postponing retirement were concentrated around the eligibility threshold, with limited evidence of persistent effects at later ages. Overall, the findings highlight that the immediate impact of the reform was not uniform across health groups, and encourages further investigations for horizon effects.

VII. 2. Study limitations.

Several limitations should be acknowledged. The most relevant limitation concerns the sample size (N= 22,324), which constrained the ability to test alternative specifications

and explore additional sources of heterogeneity. Due to this limitation, it was not possible to have separate outcomes for the components of NENR (Unemployment, disability, and no activity) in the DiD analysis. The limited sample also prevented further restricting the disease age windows or conducting stratified analyses by gender or socio-occupational class while preserving statistical power. Larger samples would allow more refined specifications and improved precision. It also remains challenging to access large datasets that combine both administrative and detailed health information.

A second limitation concerns health information. Medical histories were extracted from participants' "*Carnet de santé*" (health history records) which may underreport conditions that were not formally diagnosed or treated. For depression, underreporting is particularly plausible among men, while women are more likely to receive a diagnosis, reflecting differences in help-seeking behavior. Moreover, the measure captures *treated* depression, meaning episodes serious enough to require medical attention, so it reflects a subset of clinically meaningful cases rather than self-reported distress. Despite this, depression remained the condition most strongly associated with heterogeneity in the response to the reform, suggesting that any underreporting likely biases results downward.

Relatedly, health was used exclusively as an explanatory variable in this study, not as an outcome. This is because health information was drawn from the CONSTANCES inclusion waves and was reconstructed retrospectively for most individuals, many of whom were already retired at the time of enrollment. It was therefore not possible to observe changes in health status around the reform threshold. The analysis captures how health histories shaped labor-market responses to the reform, but cannot assess whether the resulting period of uncompensated NENR itself affected health, a channel worth exploring in future works.

Another limitation relates to the CONSTANCES cohort not being fully representative of the entire French population as health centers where enrollment took place are very selected. This limits external validity, though the distributions of employment and health indicators in the sample remain close to those observed in national data. The direction

and magnitude of estimated effects are consistent with prior national-level studies of the same reform, which lends credibility to the results.

An additional limitation relates to the analysis period which overlaps with other policy adjustments affecting early retirement and disability benefits. The estimated effects therefore reflect the net result of the 2010 SEA increase within this evolving institutional environment. The goal of this study was not to isolate a pure causal effect of a single policy but to understand how the reform, as implemented, interacted with health heterogeneity in real-world conditions. Besides, the causal effect of the reform was already shown in other works.

Finally, a methodological limitation concerns the parallel-trends assumption underlying the difference-in-differences framework. For employment, pre-reform age related trends between treated and control cohorts were broadly parallel. For NENR, there was some divergence, meaning that results for this outcome should be interpreted with caution. However, the inclusion of age and cohort fixed effects, the narrow bandwidth of compared cohorts, and validation using event-study models all help to address this concern. Descriptive results showed that control cohorts had higher NENR levels before the reform, and that the difference between treated and control groups narrowed slightly with age before 60. This means that, in the absence of the reform, the two groups would likely have continued to follow similar or converging trajectories in NENR. The reform, however, reversed this pattern, leading to higher NENR rates among the treated group. As a result, any remaining deviation from strictly parallel trends would tend to make the estimated reform effect smaller than its true value. In this sense, the reported effect on NENR can be considered conservative, it likely underestimates rather than exaggerates the reform's true impact.

VII. 3. Concluding remarks.

Overall, the 2010 French pension reform achieved its intended goal of postponing retirement but also revealed important heterogeneity in its consequences. For individuals in good health, the reform translated into extended employment, but for those with a

history of depression, it meant a longer period outside the labor market before retirement eligibility. This finding underscores the importance of considering health, especially mental health, in assessing the broader effects of pension reforms.

These results highlight that extending working life is not merely a matter of shifting the statutory retirement age. Without complementary measures that support continued employment for people with health limitations, reforms risk widening inequalities in late-career outcomes. Preventive and corrective policies, such as workplace adaptations, flexible work arrangements, and mental health support, are essential to ensure that longer careers are achievable for all groups, not just for the healthiest workers.

Although the evidence for OSD and CVD was less consistent, these conditions remain central to understanding the diversity of responses to retirement-age reforms. Future research should examine them using larger samples and longer follow-ups, ideally linking detailed occupational data to explore how physical demands and working conditions mediate health-related vulnerabilities.

In summary, this chapter provides empirical evidence that reforms extending retirement ages can have uneven short-term effects across health groups. The findings underline the importance of accounting for health heterogeneity when evaluating the impact of pension reforms on employment and non-employment before retirement. While the French case provides a specific institutional setting, similar mechanisms are likely to operate in other contexts where eligibility ages are raised. Continued research using linked administrative and health data will be essential to monitor how these reforms affect workers with health limitations over time and to identify factors that help maintain labor-market attachment as retirement ages increase.

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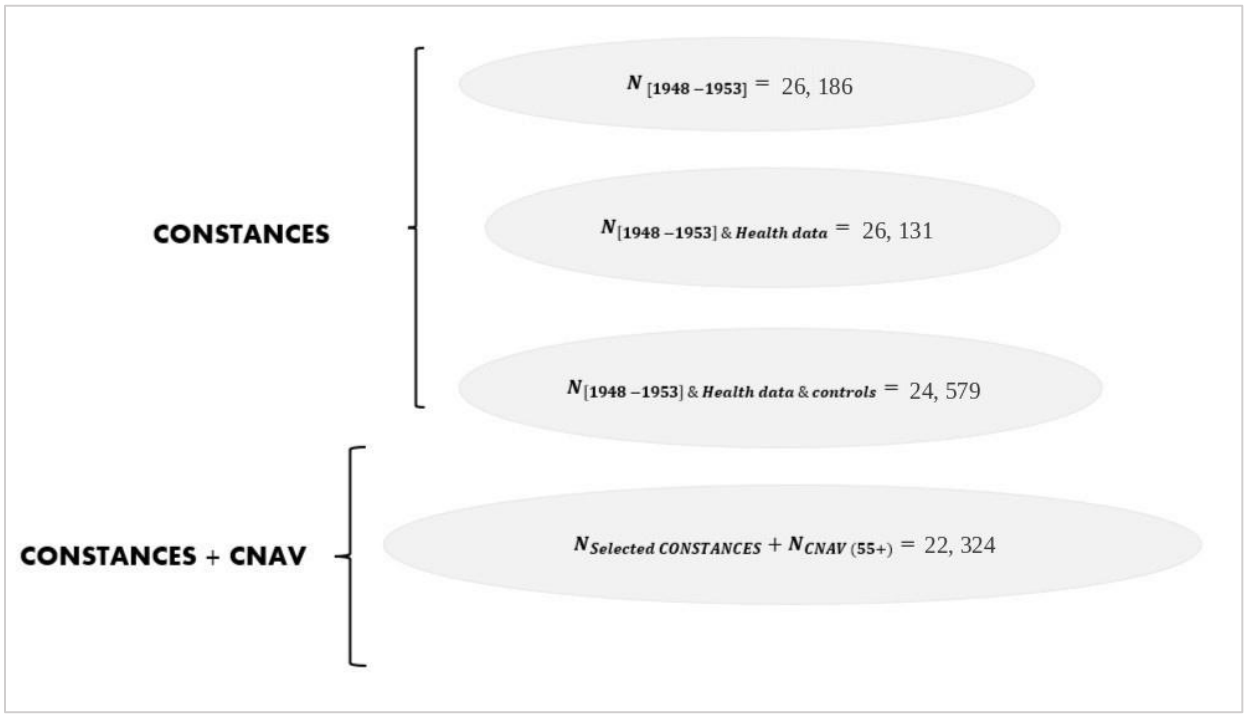
Chapter 3. Supplementary materials.

(A) Sample constructions.

Figure III. S.1. Flowchart of sample construction from CONSTANCES data and CNAV records.



(B) Estimated rates of employment, NENR, and retirement between ages 55 and 65.

Table III. S.1. Rates of employment, NENR, and retirement, between ages 55 and 65 for control and treated groups based on CNAV records.

	Employment rate		NENR rate		Retirement rate	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	78.43%	83.15%	21.57%	16.85%	0%	0%
56	74.59%	78.39%	25.16%	21.26%	0.25%	0.35%
57	69.30%	73.30%	28.03%	24.77%	2.67%	1.93%
58	63.54%	68%	31.37%	28.96%	5.09%	3.04%
59	59%	63.13%	33.99%	32.50%	7.01%	4.37%
60	45.47%	56.22%	26.98%	33.30%	27.56%	10.48%
61	25.55%	37.44%	25.19%	23.35%	49.26%	39.21%
62	18.28%	23.02%	25.73%	20.63%	55.99%	56.35%
63	13.72%	16.17%	25.83%	20.60%	60.45%	63.23%
64	10.61%	11.77%	25.53%	20.85%	63.86%	67.37%
65	6.59%	8.29%	19.15%	20.58%	74.26%	71.14%

Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

Table III. S.2. Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups within women, based on CNAV records.

	Employment rate		NENR rate		Retirement rate	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	74.12%	79.38%	25.88%	20.62%	0%	0%
56	70.29%	75.84%	29.68%	24%	0.03%	0.16%
57	66.43%	71.66%	32.73%	27.65%	0.84%	0.69%
58	61.62%	67.09%	36.55%	31.89%	1.84%	1.02%
59	57.92%	62.66%	39.19%	35.87%	2.88%	1.47%
60	43.61%	55.98%	31.32%	37.96%	25.07%	6.06%
61	23.22%	37.45%	29.42%	26.84%	47.37%	35.71%
62	16.36%	21.51%	30.35%	24.35%	53.29%	54.14%
63	12.29%	14.66%	30.43%	24.14%	57.28%	61.19%
64	9.25%	10.83%	30.13%	24.39%	60.62%	64.78%
65	5.67%	7.67%	20.86%	23.88%	73.47%	68.45%

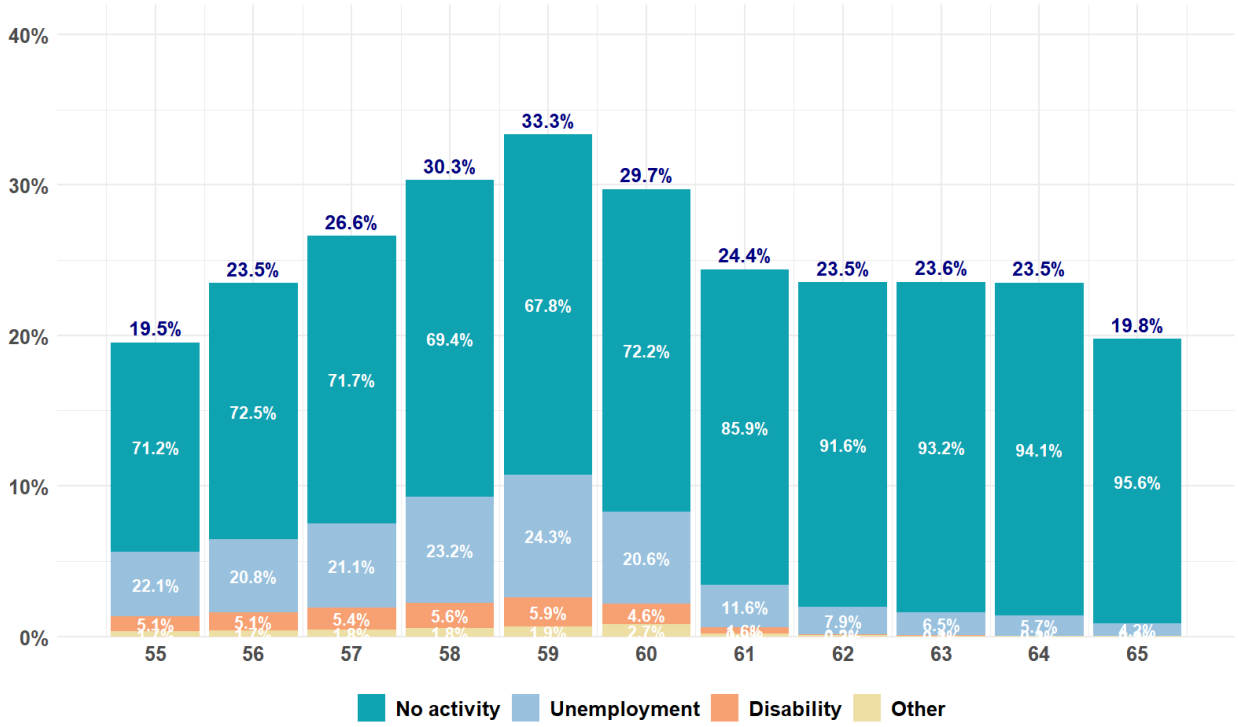
Source: Sample of merged data from CONSTANCES, including 11324 women born between 1948 and 1953, matched with their employment histories from CNAV (124502 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

Table III. S.3. Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups within men, based on CNAV records.

	Employment rate		NENR rate		Retirement rate	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	82.88%	87.02%	17.12%	12.98%	0%	0%
56	79.03%	81%	20.50%	18.46%	0.47%	0.54%
57	72.25%	74.98%	23.19%	21.82%	4.56%	3.20%
58	65.53%	68.94%	26.02%	25.96%	8.45%	5.10%
59	60.12%	63.62%	28.61%	29.05%	11.27%	7.34%
60	47.38%	56.47%	22.49%	28.53%	30.12%	15.01%
61	27.96%	37.44%	20.83%	19.77%	51.21%	42.79%
62	20.26%	24.57%	20.96%	16.82%	58.78%	58.61%
63	15.19%	17.72%	21.08%	16.97%	63.72%	65.32%
64	12.01%	12.74%	20.78%	17.23%	67.21%	70.02%
65	7.55%	8.92%	17.38%	17.19%	75.07%	73.89%

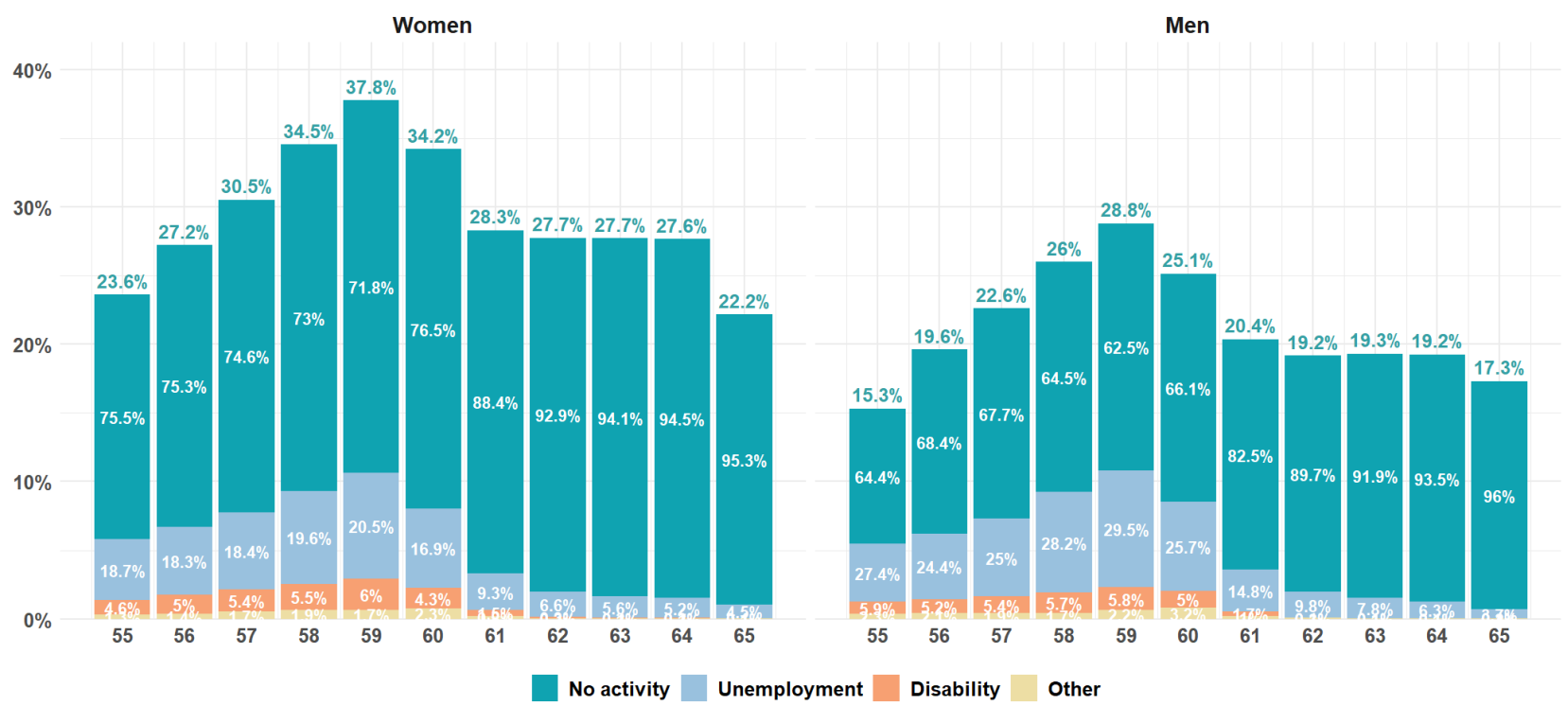
Source: Sample of merged data from CONSTANCES, including 11000 men born between 1948 and 1953, matched with their employment histories from CNAV (120962 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; Dashed lines correspond to employment, NENR, and retirement rates at age 60 across control and treated groups.

Figure III. S.2. NENR rates and their composition by detailed status between ages 55 and 65 in the general selected population, based on CNAV records.



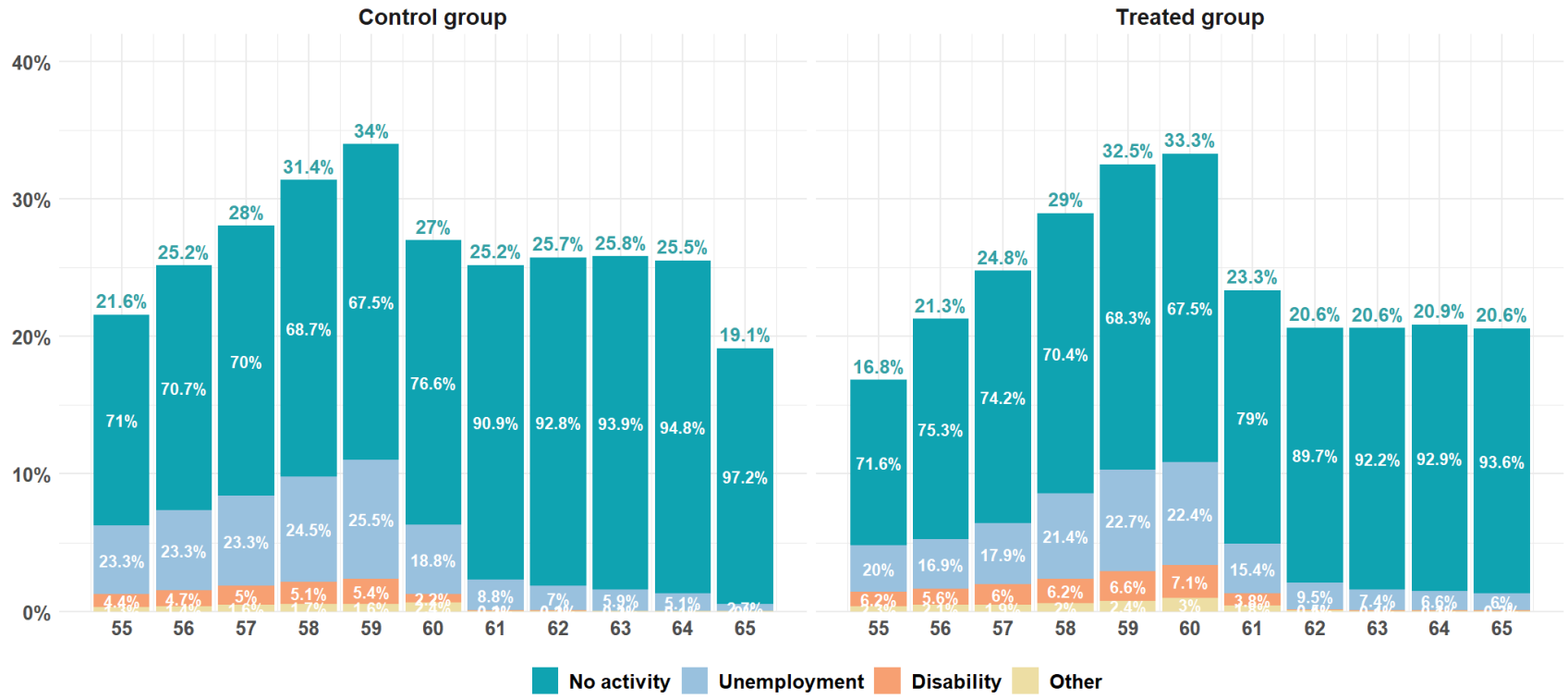
Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records.
Example of interpretation: According to CNAV records, at age 55, 19.5% of respondents were classified as NENR. 71.2% of respondents in this category had no records of professional activity, 22.1% were receiving unemployment benefits, 5.1% were on disability pensions, and 1.7% had mixed years of the different statuses (labelled as the category Other).

Figure III. S.3. NENR rates and their composition by detailed status between ages 55 and 65 by gender, based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records.
Example of interpretation: According to CNAV records, at age 55, 23.6% of respondents among women were classified as NENR. 75.5% of women in this category had no records of professional activity, 18.7% were receiving unemployment benefits, 4.6% were on disability pensions, and 1.5% had mixed years of the different statuses (labeled as the category Other).

Figure III. S.4. NENR rates and their composition by detailed status between ages 55 and 65 by treatment group, based on CNAV records.



Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records. Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group;
Example of interpretation: According to CNAV records, at age 55, 21.6% of respondents of the control group were classified as NENR. 71% of respondents in this category had no records of professional activity, 23.3% were receiving unemployment benefits, 4.4% were on disability pensions, and 1.3% had mixed years of the different statuses (labeled as the category Other).

(C) Estimated rates of employment, NENR, and retirement between ages 55 and 65, stratified by disease histories.

Table III. S.4. Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with depression (between ages 40 and 55) based on CNAV records.

	Strata: History with depression (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	69.53%	80.48%	30.47%	19.52%	0%	0%
56	66.91%	74.76%	33.09%	24.88%	0%	0.36%
57	60.98%	69.62%	37.55%	29.07%	1.46%	1.32%
58	57.32%	63.16%	39.64%	34.81%	3.03%	2.03%
59	53.81%	58.49%	42.53%	38.76%	3.66%	2.75%
60	42.17%	51.08%	32.36%	41.39%	25.47%	7.54%
61	22.55%	35.05%	29.33%	27.63%	48.12%	37.32%
62	15.14%	20.22%	30.17%	23.33%	54.70%	56.46%
63	11.90%	14%	30.27%	22.97%	57.83%	63.04%
64	9.19%	10.29%	29.33%	23.56%	61.48%	66.15%
65	5.22%	6.82%	21.40%	22.85%	73.38%	70.33%

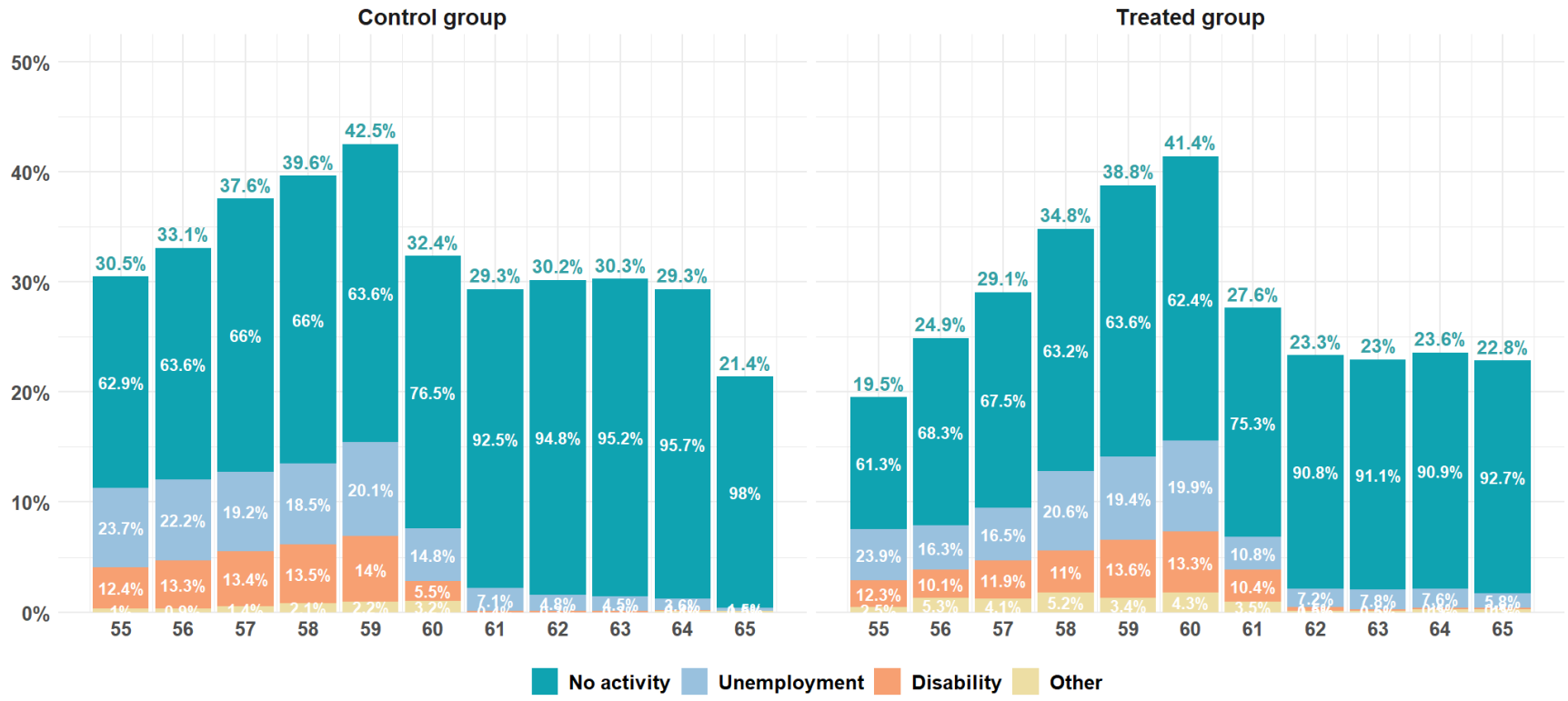
Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire.

Table III. S.4. (*Continued)* Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with depression (between ages 40 and 55) based on CNAV records.

	Strata: No history with depression (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	79.16%	83.41%	20.84%	16.59%	0%	0%
56	75.22%	78.73%	24.52%	20.92%	0.27%	0.35%
57	69.98%	73.65%	27.25%	24.36%	2.77%	1.99%
58	64.05%	68.46%	30.69%	28.41%	5.26%	3.13%
59	59.43%	63.57%	33.29%	31.91%	7.28%	4.52%
60	45.74%	56.71%	26.54%	32.54%	27.73%	10.76%
61	25.80%	37.67%	24.85%	22.94%	49.35%	39.39%
62	18.54%	23.29%	25.36%	20.37%	56.10%	56.34%
63	13.87%	16.38%	25.47%	20.37%	60.66%	63.25%
64	10.72%	11.91%	25.22%	20.60%	64.06%	67.49%
65	6.71%	8.42%	18.96%	20.36%	74.33%	71.21%

Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire.

Figure III. S.5. NENR rates and their composition by detailed status between ages 55 and 65 by treatment group, based on CNAV records, in the selected sample of respondents with history of depression.



Source: Sample of merged data from CONSTANCES, including respondents with history of depression (N=1,794) born between 1948 and 1953, matched with their employment histories from CNAV (19,722 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records. Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group;
Example of interpretation: According to CNAV records of respondents with history of depression, at age 55, 30.5% of those in the control group were classified as NENR. 62.9% of respondents in this category had no records of professional activity, 23.7% were receiving unemployment benefits, 12.4% were on disability pensions, and 1% had mixed years of the different statuses (labeled as the category Other).

Table III. S.5. Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with OSD (between ages 40 and 55) based on CNAV records.

	Strata: History with OSD (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	76.94%	77.43%	23.06%	22.57%	0%	0%
56	70.98%	73.29%	28.76%	26.43%	0.26%	0.29%
57	66.71%	67.86%	30.83%	30.29%	2.46%	1.86%
58	60.23%	61.57%	34.46%	35.43%	5.31%	3%
59	54.79%	54.86%	37.95%	39.71%	7.25%	5.43%
60	40.16%	48.29%	28.76%	40.86%	31.09%	10.86%
61	20.34%	30.71%	25.91%	28.43%	53.76%	40.86%
62	13.21%	18%	26.68%	23.14%	60.10%	58.86%
63	9.72%	11.14%	26.30%	23.57%	63.99%	65.29%
64	6.87%	7.29%	26.04%	24.29%	67.10%	68.43%
65	4.53%	5.14%	18.76%	23.29%	76.71%	71.57%

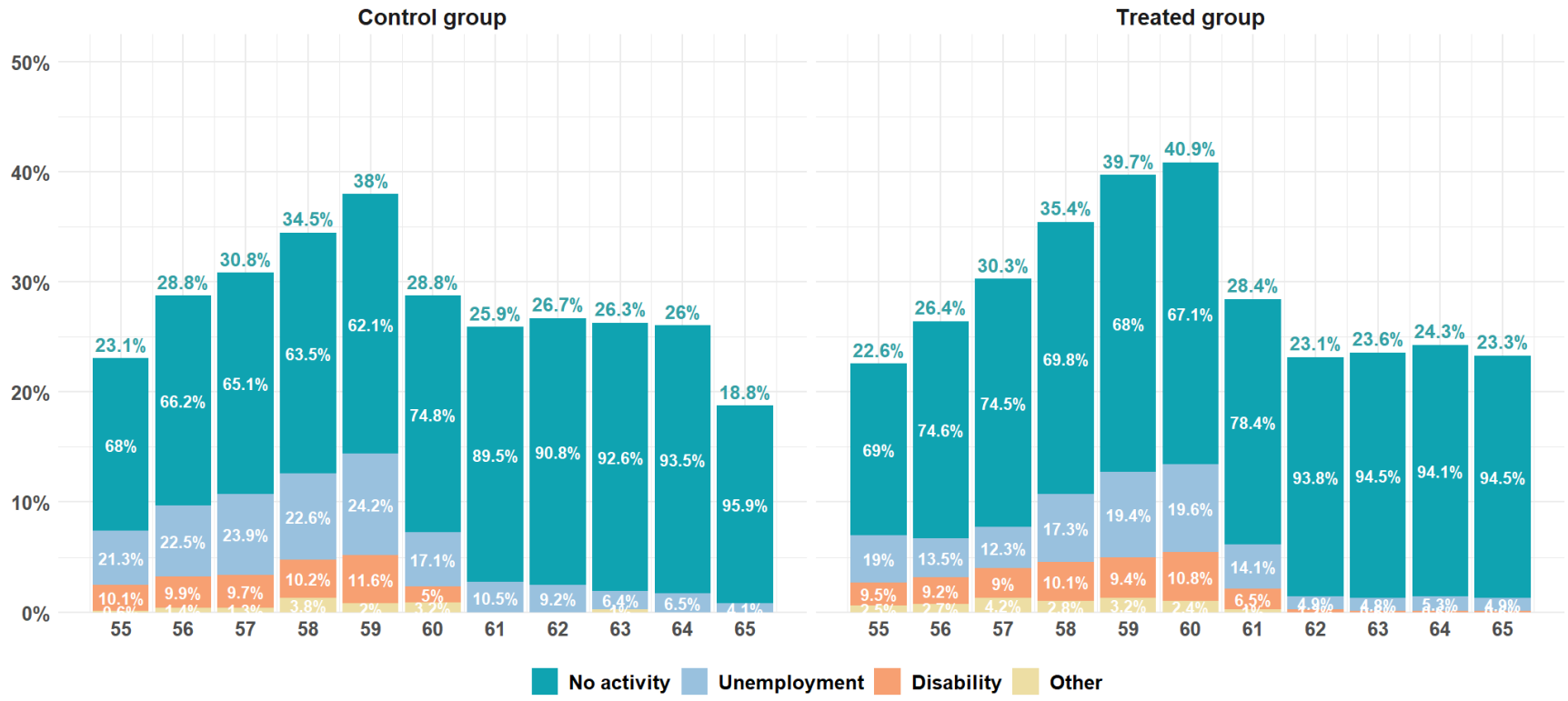
Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with OSD between age 40 and 55 is identified based on CONSTANCES medical questionnaire.

Table III. S.5. ***(Continued)*** **Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with OSD (between ages 40 and 55) based on CNAV records.**

	Strata: No history with OSD (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	78.52%	83.60%	21.48%	16.40%	0%	0%
56	74.82%	78.78%	24.93%	20.86%	0.24%	0.36%
57	69.47%	73.72%	27.85%	24.34%	2.68%	1.94%
58	63.76%	68.50%	31.17%	28.46%	5.08%	3.04%
59	59.28%	63.78%	33.73%	31.94%	6.99%	4.28%
60	45.81%	56.84%	26.86%	32.71%	27.33%	10.45%
61	25.89%	37.97%	25.15%	22.95%	48.96%	39.08%
62	18.61%	23.41%	25.67%	20.43%	55.73%	56.15%
63	13.98%	16.56%	25.80%	20.37%	60.22%	63.07%
64	10.85%	12.12%	25.50%	20.59%	63.65%	67.29%
65	6.73%	8.53%	19.17%	20.36%	74.10%	71.10%

Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with OSD between age 40 and 55 is identified based on CONSTANCES medical questionnaire

Figure III. S.6. NENR rates and their composition by detailed status between ages 55 and 65 by treatment group, based on CNAV records, in the selected sample of respondents with history of OSD.



Source: Sample of merged data from CONSTANCES, including respondents with history of OSD (N=1,794), born between 1948 and 1953, matched with their employment histories from CNAV (16,193 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records. Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group;
Example of interpretation: According to CNAV records of respondents with history of OSD, at age 55, 23.1% of those in the control group were classified as NENR. 68% of respondents in this category had no records of professional activity, 21.3% were receiving unemployment benefits, 10.1% were on disability pensions, and 0.5% had mixed years of the different statuses (labeled as the category Other).

Table III. S.6. Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with CVD (between ages 40 and 55) based on CNAV records.

	Strata: History with CVD (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	74.59%	81.96%	25.41%	18.04%	0%	0%
56	69.01%	75.95%	30.81%	24.05%	0.18%	0%
57	62.34%	67.54%	34.59%	30.46%	3.06%	2%
58	55.32%	61.92%	38.92%	34.27%	5.77%	3.81%
59	49.91%	54.51%	42.34%	39.48%	7.75%	6.01%
60	39.82%	49.10%	32.61%	38.68%	27.57%	12.22%
61	20.36%	29.26%	27.39%	25.25%	52.25%	45.49%
62	16.58%	15.23%	27.39%	21.24%	56.04%	63.53%
63	12.25%	10.42%	26.85%	20.44%	60.90%	69.14%
64	9.55%	8.22%	27.03%	20.64%	63.42%	71.14%
65	5.95%	5.41%	23.24%	21.04%	70.81%	73.55%

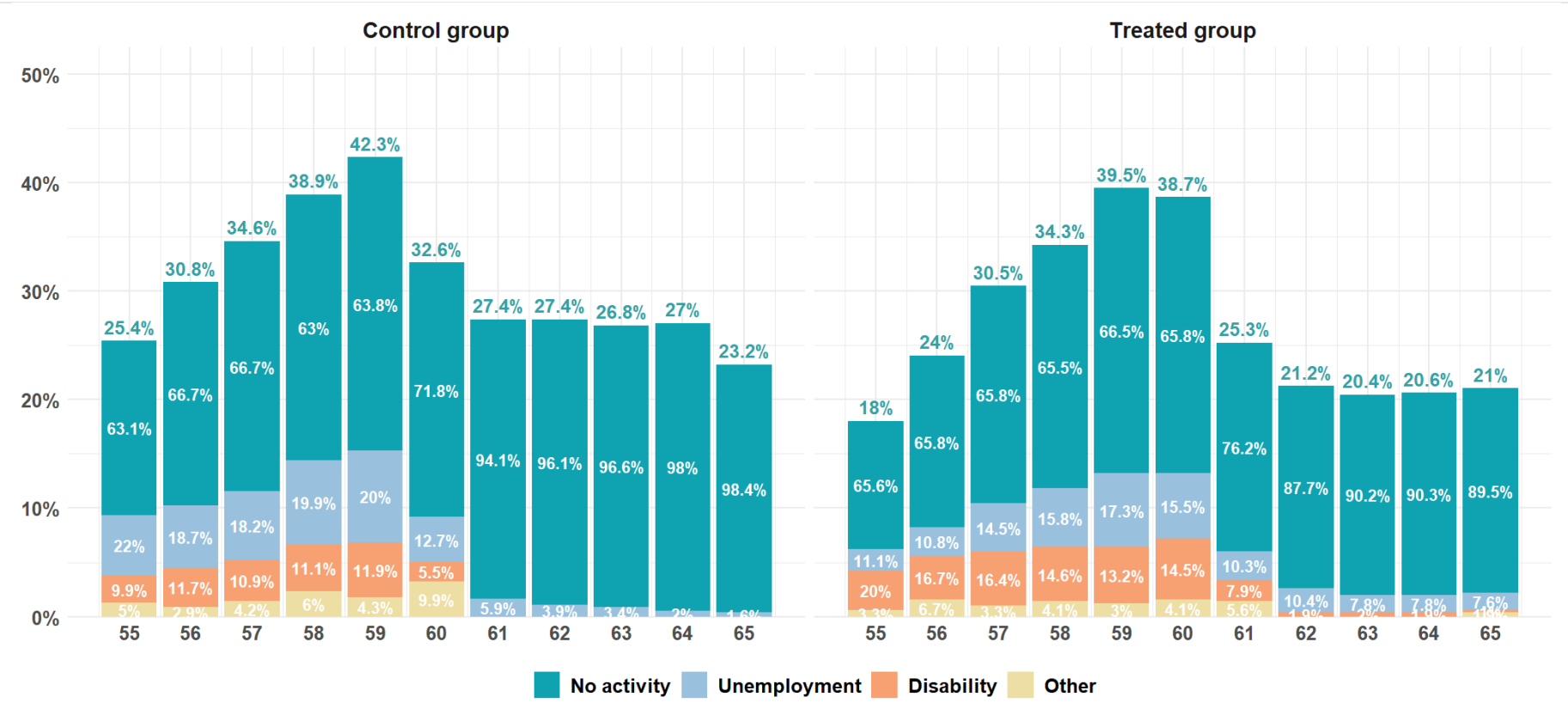
Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with CVD between age 40 and 55 is identified based on CONSTANCES medical questionnaire

Table III. S.6. ***(Continued)*** **Rates employment, NENR, and retirement, between ages 55 and 65 for control and treated groups stratified by history with CVD (between ages 40 and 55) based on CNAV records.**

	Strata: No history with CVD (between ages 40 and 55)					
	Employment rate		**NENR rate**		**Retirement rate**	
	Control group	Treated group	Control group	Treated group	Control group	Treated group
Age						
55	78.60%	83.22%	21.40%	16.78%	0%	0%
56	74.85%	78.52%	24.90%	21.11%	0.25%	0.37%
57	69.62%	73.61%	27.73%	24.46%	2.65%	1.93%
58	63.92%	68.33%	31.02%	28.67%	5.06%	2.99%
59	59.42%	63.60%	33.60%	32.12%	6.97%	4.28%
60	45.73%	56.61%	26.72%	33.01%	27.56%	10.38%
61	25.79%	37.89%	25.09%	23.24%	49.12%	38.87%
62	18.36%	23.45%	25.65%	20.60%	55.99%	55.96%
63	13.79%	16.48%	25.78%	20.61%	60.43%	62.91%
64	10.66%	11.97%	25.46%	20.87%	63.88%	67.17%
65	6.62%	8.44%	18.96%	20.55%	74.42%	71.01%

Source: Sample of merged data from CONSTANCES, including 22,324 respondents born between 1948 and 1953, matched with their employment histories from CNAV (245,464 yearly observations).
Notes: Activity status is derived from yearly contribution records from CNAV, as described in the Methods section. Respondents are classified as *Retired* in the year they claim their pension; as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records while receiving unemployment or disability benefits; and as *Employed* otherwise; Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group; History with CVD between age 40 and 55 is identified based on CONSTANCES medical questionnaire

Figure III. S.7. NENR rates and their composition by detailed status between ages 55 and 65 by treatment group, based on CNAV records, in the selected sample of respondents with history of CVD.



Source: Sample of merged data from CONSTANCES, including respondents with history of CVD (N=1,054), born between 1948 and 1953, matched with their employment histories from CNAV (11,594 yearly observations over the period of 2003 till 2018).
Notes: Respondents are classified as *NENR* ("Neither Employed Nor Retired") if they spend at least half of the year without employment records, while receiving unemployment or disability benefits or not having activity records. Cohort born between 1948 and June 30th 1951 are included in the control group, and cohorts born between July 1st 1951 and 1953 are included in the treatment group;
Example of interpretation: According to CNAV records of respondents with history of CVD, at age 55, 23.1% of those in the control group were classified as NENR. 68% of respondents in this category had no records of professional activity, 21.3% were receiving unemployment benefits, 10.1% were on disability pensions, and 0.5% had mixed years of the different statuses (labeled as the category Other).

(D) Results of main robustness checks.

Table III. S.7. Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with depression (between ages 40 and 55), from the different specifications across robustness checks.

	Employment (A)	NENR (B)	Retirement (C)
Standard model			
Under SEA	0.06*** (0.04, 0.09)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.01, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.03*** (-0.04, -0.02)	0.03** (0.01, 0.05)	0 (-0.01, 0.02)
Model with restricting history of depression to ages 30-45			
Under SEA	0.03*** (0.02, 0.05)	0.08*** (0.06, 0.1)	-0.11*** (-0.15, -0.08)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.02, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.03*** (-0.04, -0.02)	0.03** (0.01, 0.05)	0.01 (-0.01, 0.02)
Model with selected cohorts born between 1949 & 1953			
Under SEA	0.07*** (0.04, 0.1)	0.09*** (0.07, 0.12)	-0.16*** (-0.21, -0.11)
History with Depression	-0.02*** (-0.04, -0.01)	0.03*** (0.01, 0.05)	-0.01 (-0.02, 0.01)
History with Depression * Under SEA	-0.03*** (-0.04, -0.02)	0.03** (0.01, 0.05)	0 (-0.01, 0.02)
Model with selected cohorts born between 1949 & 1952			
Under SEA	0.07*** (0.05, 0.1)	0.09*** (0.06, 0.12)	-0.16*** (-0.22, -0.11)
History with Depression	-0.02* (-0.04, -0.01)	0.02* (0, 0.04)	0 (-0.01, 0.02)
History with Depression * Under SEA	-0.03*** (-0.05, -0.02)	0.04** (0.02, 0.06)	-0.01 (-0.02, 0)
Model with selected cohorts born between 1950 & 1952			
Under SEA	0.08*** (0.03, 0.13)	0.09*** (0.04, 0.13)	-0.17*** (-0.25, -0.08)
History with Depression	-0.03* (-0.05, -0.001)	0.02 (-0.01, 0.05)	0 (-0.01, 0.02)
History with Depression * Under SEA	-0.03*** (-0.04, -0.01)	0.04** (0.01, 0.06)	-0.01 (-0.02, 0)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,322 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire
Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.7. ***(Continued)*** **Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with depression (between ages 40 and 55), from the different specifications across robustness checks.**

	Employment (A)	**NENR (B)**	**Retirement (C)**
Model with the specification of accounting for sick leave in the NENR category			
Under SEA	0.06*** (0.04, 0.09)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.01, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.04*** (-0.05, -0.02)	0.04** (0.01, 0.06)	0 (-0.01, 0.02)
Model where "Employment" = 1 conditional on validation of at least 1 quarter of "Employment"			
Under SEA	0.04*** (0.02, 0.07)	0.11*** (0.09, 0.13)	-0.15*** (-0.19, -0.12)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.02, 0.04)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.03*** (-0.04, -0.01)	0.02** (0.01, 0.04)	0 (-0.01, 0.02)
Model where "NENR" = 1 conditional on validation of at least 1 quarter of "NENR"			
Under SEA	0.07*** (0.05, 0.09)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with Depression	-0.03*** (-0.04, -0.01)	0.03*** (0.01, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.04*** (-0.05, -0.02)	0.03** (0.01, 0.06)	0 (-0.01, 0.02)
Model where Retirement = 1 when retirement pension was claimed and received for at least two quarters			
Under SEA	0.03*** (0.02, 0.05)	0.08*** (0.06, 0.1)	-0.11*** (-0.15, -0.08)
History with Depression	-0.02*** (-0.03, -0.01)	0.03*** (0.02, 0.05)	-0.01 (-0.02, 0)
History with Depression * Under SEA	-0.03*** (-0.04, -0.02)	0.03** (0.01, 0.05)	0.01 (-0.01, 0.02)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,322 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.8. Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with OSD (between ages 40 and 55), from the different specifications across robustness checks.

	Employment (A)	**NENR (B)**	**Retirement (C)**
Standard model			
Under SEA	0.06*** (0.03, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with OSD	-0.04*** (-0.05, -0.02)	0.01** (0, 0.02)	0.03** (0.01, 0.04)
History with OSD* Under SEA	0 (-0.03, 0.04)	0.03* (0, 0.05)	-0.03** (-0.05, -0.01)
Model with selected cohorts born between 1949 & 1953			
Under SEA	0.06*** (0.03, 0.9)	0.09*** (0.07, 0.12)	-0.16*** (-0.21, -0.11)
History with OSD	-0.04* (-0.06, -0.03)	0.01* (0, 0.02)	0.03** (0.01, 0.05)
History with OSD * Under SEA	0.0 (-0.03, 0.04)	0.03* (-0.01, 0.06)	-0.03* (-0.06, -0.01)
Model with selected cohorts born between 1949 & 1952			
Under SEA	0.07*** (0.05, 0.1)	0.09*** (0.06, 0.12)	-0.16*** (-0.21, -0.1)
History with OSD	-0.05* (-0.06, -0.03)	0.01* (0, 0.03)	0.03** (0.01, 0.05)
History with OSD * Under SEA	0.01 (-0.04, 0.06)	0.03 (-0.01, 0.07)	-0.04 (-0.07, 0)
Model with selected cohorts born between 1950 & 1952			
Under SEA	0.08*** (0.03, 0.12)	0.09*** (0.04, 0.13)	-0.17*** (-0.25, -0.08)
History with OSD	-0.04* (-0.07, -0.02)	0.02*** (0.01, 0.03)	0.02* (0.01, 0.04)
History with OSD * Under SEA	0.01 (-0.06, 0.07)	0.02 (-0.02, 0.06)	-0.02 (-0.06, 0.01)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,322 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with OSD between age 40 and 55 is identified based on CONSTANCES medical questionnaire.
Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.8. ***(Continued)*** **Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with OSD (between ages 40 and 55), from the different specifications across robustness checks.**

	Employment (A)	**NENR (B)**	**Retirement (C)**
Model with the specification of accounting for sick leave in the NENR category			
Under SEA	0.06*** (0.03, 0.08)	0.09*** (0.07, 0.12)	-0.15*** (-0.19, -0.11)
History with OSD	-0.04* (-0.05, -0.02)	0.01* (0, 0.02)	0.03** (0.01, 0.04)
History with OSD * Under SEA	0.0 (-0.03, 0.03)	0.03* (0.01, 0.05)	-0.03** (-0.05, -0.01)
Model where "Employment" = 1 conditional on validation of at least 1 quarter of "Employment"			
Under SEA	0.04** (0.01, 0.07)	0.11*** (0.09, 0.13)	-0.15*** (-0.19, -0.11)
History with OSD	-0.04*** (-0.06, -0.03)	0.01* (0.01, 0.02)	0.03** (0.01, 0.04)
History with OSD * Under SEA	0.01 (-0.02, 0.04)	0.02** (0.01, 0.04)	-0.03** (-0.05, -0.01)
Model where "NENR" = 1 conditional on validation of at least 1 quarter of "NENR"			
Under SEA	0.06*** (0.03, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with OSD	-0.04* (-0.05, -0.02)	0.01* (0, 0.02)	0.03** (0.01, 0.04)
History with OSD * Under SEA	0.0 (-0.03, 0.04)	0.03* (0.001, 0.05)	-0.03** (-0.05, -0.01)
Model where Retirement = 1 when retirement pension was claimed and received for at least two quarters			
Under SEA	0.03*** (0.01, 0.05)	0.08*** (0.06, 0.11)	-0.11*** (-0.15, -0.08)
History with OSD	-0.04* (-0.06, -0.02)	0.02*** (0.01, 0.03)	0.02* (0.01, 0.04)
History with OSD * Under SEA	0.01 (-0.03, 0.04)	0.02 (0, 0.05)	-0.03* (-0.05, 0)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,322 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with OSD between age 40 and 55 is identified based on CONSTANCES medical questionnaire.
Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.9. Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with CVD (between ages 40 and 55), from the different specifications across robustness checks.

	Employment (A)	**NENR (B)**	**Retirement (C)**
Standard model			
Under SEA	0.06*** (0.04, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with CVD	-0.05*** (-0.08, -0.02)	0.04* (0.01, 0.07)	0.02 (-0.02, 0.05)
History with CVD* Under SEA	0 (-0.03, 0.03)	0.03* (0.01, 0.06)	-0.03 (-0.06, 0.01)
Model with selected cohorts born between 1949 & 1953			
Under SEA	0.06** (0.03, 0.09)	0.09*** (0.07, 0.12)	-0.16*** (-0.21, -0.11)
History with CVD	-0.05** (-0.09, -0.02)	0.03 (-0.01, 0.07)	0.02 (-0.02, 0.06)
History with CVD * Under SEA	0 (-0.03, 0.03)	0.03 (0, 0.06)	-0.03 (-0.07, 0.01)
Model with selected cohorts born between 1949 & 1952			
Under SEA	0.07** (0.04, 0.1)	0.09*** (0.06, 0.12)	-0.16*** (-0.22, -0.1)
History with CVD	-0.04* (-0.08, -0.01)	0.04 (0, 0.08)	0 (-0.03, 0.04)
History with CVD * Under SEA	-0.01 (-0.04, 0.03)	0.02 (-0.01, 0.06)	-0.02 (-0.05, 0.01)
Model with selected cohorts born between 1950 & 1952			
Under SEA	0.08** (0.03, 0.12)	0.09*** (0.05, 0.13)	-0.17*** (-0.25, -0.08)
History with CVD	-0.06** (-0.08, -0.04)	0.05** (0.01, 0.1)	0.01 (-0.04, 0.05)
History with CVD * Under SEA	0.01* (0, 0.02)	0.01 (-0.03, 0.04)	-0.02 (-0.06, 0.02)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,322 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with CVD between age 40 and 55 is identified based on CONSTANCES medical questionnaire
Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.9. ***(Continued)*** **Summary of estimated coefficients of variables of interest (with 95% confidence intervals) from fitted DiD models on employment (A), NENR (B), and retirement (C) rates (between ages 55 and 62), accounting for a history with CVD (between ages 40 and 55), from the different specifications across robustness checks.**

	Employment (A)	**NENR (B)**	**Retirement (C)**
Model with the specification of accounting for sick leave in the NENR category			
Under SEA	0.06** (0.03, 0.08)	0.1*** (0.07, 0.12)	-0.15*** (-0.19, -0.11)
History with CVD	-0.05** (-0.08, -0.02)	0.04* (0, 0.07)	0.02 (-0.02, 0.05)
History with CVD * Under SEA	-0.01 (-0.04, 0.02)	0.04* (0.01, 0.07)	-0.03 (-0.06, 0.01)
Model where "Employment" = 1 conditional on validation of at least 1 quarter of "Employment"			
Under SEA	0.04** (0.01, 0.07)	0.11*** (0.09, 0.13)	-0.15*** (-0.19, -0.11)
History with CVD	-0.05** (-0.09, -0.02)	0.04* (0.01, 0.07)	0.02 (-0.02, 0.05)
History with CVD * Under SEA	0.01 (-0.02, 0.03)	0.02 (0, 0.05)	-0.03 (-0.06, 0.01)
Model where "NENR" = 1 conditional on validation of at least 1 quarter of "NENR"			
Under SEA	0.06** (0.04, 0.08)	0.9*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with CVD	-0.05*** (-0.08, -0.03)	0.04* (0.01, 0.06)	0.02 (-0.02, 0.05)
History with CVD * Under SEA	-0.01 (-0.03, 0.02)	0.03** (0.01, 0.06)	-0.03 (-0.06, 0.01)
Model where Retirement = 1 when retirement pension was claimed and received for at least two quarters			
Under SEA	0.03*** (0.01, 0.05)	0.08*** (0.06, 0.1)	-0.11*** (-0.15, -0.08)
History with CVD	-0.06*** (-0.08, -0.03)	0.03* (0.01, 0.06)	0.02 (-0.01, 0.06)
History with CVD * Under SEA	0 (-0.03, 0.0")	0.03** (0.01, 0.06)	-0.03* (-0.06, -0.01)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with CVD between age 40 and 55 is identified based on CONSTANCES medical questionnaire. Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table III. S.10. Estimated coefficients of interest from models accounting for heterogeneity in age and cohort effects by history of diseases (by adding interaction terms between age, birth years, and health histories).

	Employment (A)	NENR (B)	Retirement (C)
Model of heterogeneity with respect to a history with Depression			
Under SEA	0.06*** (0.04, 0.09)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.11)
History with Depression	-0.02 (-0.05, 0.01)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
History with Depression * Under SEA	-0.05*** (-0.07, -0.03)	0.06*** (0.04, 0.08)	-0.01 (-0.03, 0.01)
Model of heterogeneity with respect to a history with CVD			
Under SEA	0.06*** (0.04, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with CVD	-0.02 (-0.04, 0.01)	0.05*** (0.03, 0.07)	-0.03** (-0.05, -0.01)
History with CVD * Under SEA	-0.02 (-0.04, 0)	0.02 (0, 0.04)	0 (-0.02, 0.02)
Model of heterogeneity with respect to a history with OSD			
Under SEA	0.06*** (0.04, 0.08)	0.09*** (0.07, 0.11)	-0.15*** (-0.19, -0.12)
History with OSD	0.01 (-0.02, 0.03)	-0.02 (-0.07, 0.02)	0.02 (-0.05, 0.08)
History with OSD * Under SEA	-0.01 (-0.04, 0.03)	0.04 (0, 0.08)	-0.03 (-0.09, 0.03)

Source: Sample of merged data from CONSTANCES and CNAV records (for ages 55 to 62), including 178,495 observations for 22,324 respondents.
Notes: Reported coefficients correspond to estimates from fitted linear models for each outcome defining the three mutually exclusive states: Employment (A), NENR (B), and Retirement (C). Confidence intervals are calculated using clustered standard errors at the respondent and cohort levels, accounting for intra-individual and cohort-level correlations. History with depression between age 40 and 55 is identified based on CONSTANCES medical questionnaire.
Stars labels correspond to significance levels such that: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

General conclusion.

Understanding gender disparities in healthy ageing is a relevant concern for public policy. Women live longer than men, yet their longevity advantage does not translate into an equivalent advantage in years lived in good health: they spend more of their additional years with activity restrictions, and even at comparable ages starting mid-adulthood, they report higher rates of limitations in daily activities and in social participation, including employment. Identifying the sources of these disparities is essential for informing interventions that promote healthy ageing, and particularly for addressing the persistent disadvantage that women face.

This thesis focused on disentangling the contribution of specific health and social conditions to gender disparities in healthy ageing in France, through three complementary studies. The first study investigated the contribution of a broad set of chronic diseases to activity limitation among older adults, examining how their prevalence and disabling impact account for gender and socio-occupational disparities. Building on the finding that musculoskeletal diseases and depression emerged as the conditions most relevant to the gender gap in activity limitation, the second study narrowed the focus to these conditions in mid-adulthood, examining their association with both general activity limitation and employment restrictions. The third study brought these health vulnerabilities into dialogue with pension policy, examining whether individuals with histories of depression, osteoarticular diseases, or cardiovascular diseases face a higher risk of being "Neither employed nor retired" (NENR) when retirement ages are raised. The analyses drew on recent and complementary French data sources, combining cross-sectional and longitudinal designs to allow for a more robust assessment of the direction of effects between health conditions and activity restrictions. The scope of the thesis extended to mid-adulthood, where gender disparities in healthy ageing begin to take shape, and broadened the outcomes of interest to encompass

employment-related restrictions, thereby connecting the analysis of diseases and disability with the labor market and the policy domain.

Summary and discussion of findings.

Overall, the findings from the three studies converged on the argument, well established in the literature (Crimmins et al., 2011; Hosseinpoor et al., 2012; Nusselder, Cambois, et al., 2019; Oksuzyan et al., 2009; Palazzo et al., 2019), that musculoskeletal diseases and poor mental health are the conditions most relevant to understanding gender disparities in healthy ageing, and particularly women's disadvantage in activity restrictions.

Across the analyses, musculoskeletal diseases, depression, and depressive symptoms were found to increase the risk of limitations in general activities, whether measured as cross-sectional associations, onset, or persistence of activity limitation, and to increase the risk of falling into the NENR status prior to retirement. In the case of depression, the consequences extended further: individuals with a prior history of depression faced a disproportionately higher risk of remaining in the NENR status and extending their period of non-employment when retirement ages were raised, with the pension reform prolonging an already precarious situation rather than generating new entries into non-employment. These findings document a cumulative pathway through which musculoskeletal diseases and poor mental health affect healthy ageing from mid-adulthood onward: from activity limitation, to employment exits, to amplified vulnerability when working lives are extended by policy reform.

A central finding of this thesis is that women's disadvantage in activity restrictions is attributable to their higher prevalence of musculoskeletal diseases and depression, rather than to a stronger disabling impact of these conditions among them. In the first study, decomposition analyses showed that gender differences in activity limitation were primarily driven by differences in the prevalence of these conditions. In the second study, analyses stratified by gender showed that the associations between musculoskeletal conditions, depressive symptoms, and activity restrictions, whether in general activities or employment, were of comparable magnitude for men and women, with no evidence of gender differences in disabling impact. When men and women are affected by the same conditions, they experience similar consequences in terms of activity restrictions; thus,

the gender gap arises because women are more frequently affected. In the third study, although the analysis could not be stratified by gender due to sample size constraints, the NENR status was more prevalent among women, and the condition that showed the most robust interaction with pension reform, that is depression, is itself more prevalent among women. While this does not constitute a direct test of gender-specific effects, it is consistent with the interpretation that women's greater exposure to depression underlies their higher risk of experiencing and remaining in the NENR status. This convergence across studies using different data sources, different age ranges, and different analytical designs strengthens the robustness of the conclusion and extends, with more recent data, earlier findings on the predominance of the prevalence channel in driving gender disparities in healthy ageing (Nusselder, Wapperom, et al., 2019; Palazzo et al., 2019).

The analyses additionally showed that cardiovascular diseases are important contributors to activity limitation overall, even among women for whom they were the second largest contributor after musculoskeletal diseases. Yet, they were more prevalent among men and contributed more to men's burden of activity limitation than to women's. Along the social gradient, cardiovascular diseases, alongside musculoskeletal diseases, were primary drivers of socio-occupational disparities in activity limitation, given their higher prevalence among manual workers and farmers compared to highly skilled workers. In the analysis of pension reform, a prior history of cardiovascular diseases was also associated with a higher risk of being NENR when retirement ages were raised, though the evidence was less stable than for depression. These findings indicate that the role of specific health conditions in driving inequalities in healthy ageing extends beyond the gender dimension and includes the social gradient, a direction that deserves further investigation.

Policy implications.

The findings of this thesis carry several implications for public policy, relating to prevention, disease management, and pension reform design.

Since gender disparities in healthy ageing are primarily driven by the higher prevalence of musculoskeletal diseases and depression among women, and cardiovascular diseases among men, prevention of these conditions represents a powerful lever for reducing these disparities, and improving healthy ageing. As documented in the literature,

women's higher prevalence of these conditions has been attributed to biological factors, social factors, and their interaction (Cambois et al., 2017; Campos-Serna et al., 2013; Khadilkar, 2019; Oksuzyan et al., 2008). From a biological perspective, hormonal changes associated with menopause independently increase women's vulnerability to musculoskeletal conditions such as osteoporosis and osteoarthritis, and hormonal fluctuations contribute to women's higher susceptibility to depression. These biological pathways are not directly amenable to prevention, which makes early detection and effective disease management essential to limit their progression toward activity restriction. Ensuring access to timely and adapted treatment for musculoskeletal conditions, including rehabilitation and physical activity programs, can help limit their functional consequences. For depression, access to appropriate care is essential to reduce its chronicity and its downstream effects on activity and employment. More broadly, ensuring that disease management strategies reach women across all social groups, including those in less advantaged positions who may face greater barriers to care, is important for reducing disability.

From a social perspective, women's greater exposure to biomechanical risk factors in the workplace across a range of occupations (Guignon, 2008; Yung et al., 2020), among which psychosocial risk factors such as high job strain (Campos-Serna et al., 2013), their disproportionate burden of cumulative domestic and caregiving responsibilities (Beaufils et al., 2023; Hosseinpoor et al., 2012; Cambois et al., 2017) , each constitute modifiable risk factors for both musculoskeletal conditions and depression. Some results of this thesis are consistent with this interpretation: musculoskeletal diseases contributed substantially to activity limitation among women across all occupational groups, including those in higher-skilled positions. This pattern suggests that occupational exposures affecting women in these groups, as well as exposures beyond the workplace such as domestic work, contribute to the burden of musculoskeletal diseases across the social spectrum.

These social determinants of gender disparities in healthy ageing point to concrete prevention strategies. For musculoskeletal diseases, strengthening workplace ergonomic standards is one relevant avenue, with particular attention to female-dominated

occupations where biomechanical exposures may receive less recognition. Occupations where women are overrepresented, including care work, cleaning, and service-sector jobs involving prolonged standing or repetitive tasks, involve substantial physical demands that warrant specific attention in occupational health policies (European Agency for Safety and Health at Work., 2013).

Beyond the workplace, policies that promote a more equal distribution of domestic and caregiving responsibilities would address a source of both physical and psychological strain that affects women across all occupational groups, and that is not captured by workplace-focused interventions alone. For depression, prevention strategies should target the social determinants that contribute to women's higher prevalence, including occupational stressors, job insecurity, and the strain of combining professional and family responsibilities. Integrating mental health prevention into occupational health strategies, rather than treating mental and physical occupational health as separate domains, would help address these risk factors (World Health Organization, 2022). Cardiovascular diseases, while more relevant to men's burden of activity limitation, were also the second most important contributor to activity limitation among women and a primary driver of socio-occupational disparities. Prevention of cardiovascular diseases therefore remains important for all groups, for reducing the overall burden of activity limitation, for narrowing social inequalities in healthy ageing, and for addressing risks that affect both men and women, albeit to different degrees. This involves tackling the risk factors that drive their unequal distribution, including occupational exposures, psychosocial stressors, and behavioral risk factors such as smoking, poor diet, and limited physical activity, which are themselves socially patterned (Mackenbach et al., 2019; OECD/European Commission, 2024).

The findings from the last part of this thesis also carry implications for pension reform design. The evidence that individuals with a history of depression face a disproportionately higher risk of remaining in the NENR status when retirement ages are raised points to a specific gap in the current institutional framework. The French pension system provides early retirement pathways for individuals with recognized physical disabilities or incapacity, but comparable provisions for mental health

conditions remain limited. This asymmetry means that workers, whose capacity to sustain employment is compromised by depression, may lack institutional pathways for early exit, while also being unable to maintain their position in the labor market. Extending early retirement provisions to encompass mental health conditions, or developing alternative mechanisms such as transitional employment arrangements and enhanced occupational health support in the years preceding retirement, would help mitigate the unequal impact of reforms extending working lives. More broadly, accounting for health heterogeneity in the design of pension reforms, including the differential effects of raising retirement ages across groups with different health profiles, would help anticipate and prevent the deepening of inequalities. Given that the conditions amplifying vulnerability to such reforms are more prevalent among women, these considerations are directly relevant to the gender dimension of healthy ageing.

Broader relevance: why does promoting healthy ageing matter?

Beyond the specific findings on gender disparities, this thesis also speaks to the broader question of why promoting healthy ageing matters for society as a whole. From a public health and economic perspective, reducing activity restrictions limits the costs of healthcare and long-term care, reduces reliance on disability pensions, and supports longer and more productive working lives (Bloom et al., 2015; Okamoto et al., 2023). From the perspective of the individuals concerned, healthy ageing means higher well-being and sustained capacity to participate in social and economic life, both during and after the working years. It also means avoiding the cycle, documented in this thesis, whereby health conditions lead to the NENR status, which in turn generates economic precarity that can limit access to care, foster unhealthy behaviors, and worsen restrictions over time (D'Isanto et al., 2018).

The benefits of promoting healthy ageing also extend across generations. Older adults who age in good health can take on social roles. For example, healthy grandparents can help working-age parents, and especially women, manage the dual responsibilities of childcare and employment (Arpino et al., 2014). In this way, promoting healthy ageing among the older generation could also contribute to reducing the same risk factor, the cumulative strain of domestic and caregiving responsibilities, that drive the higher

prevalence of musculoskeletal diseases and depression among women in the next generation. Conversely, when older adults age with restrictions, they are more likely to require informal care, a role that disproportionately falls on women (Cattaneo et al., 2025; Hosseinpoor et al., 2012), further adding to their burden. Future research is encouraged to explore this intergenerational dimension further.

Limitations and perspectives for future research

While this thesis drew on recent and complementary data sources and novel analytical approaches, several overarching limitations deserve acknowledgment, which also open directions for future research.

A first limitation concerns the measurement of health conditions. Chronic diseases in the data sources used were based on self-reported diagnoses or validated screening instruments, which, while standard in population health research, remain subject to reporting and recall bias, including possible underdiagnosis of certain conditions which may vary by population groups. Future research using clinical or administrative health data could help address this limitation.

Another limitation concerns the measurement of activity restriction. The Global Activity Limitation Indicator (GALI), used in the first two studies, captures whether individuals report being limited in their usual activities but does not distinguish between types or severities of limitation. The same response of being "limited" may encompass very different functional realities. While the GALI was chosen for its breadth, its capacity to capture restrictions emerging before severe disability, and its availability across the data sources used, future research would benefit from examining more detailed dimensions of activity restriction, such as individual items from the ADL and IADL scales, or from exploiting the ordinal structure of the GALI which was not done in this work, to facilitate the comparability of results of chapters 1 and 2.

The limitation of the analytical capacity to fully exploit longitudinal data is also worthy of mentioning. While the second study drew on repeated measurements to examine transitions in activity limitation and employment status over time, and the third study

used administrative records to track employment trajectories, the follow-up period in the second study was limited to one year: health conditions could not be measured as time-varying variables across all waves due to data constraints. Dynamic panel data models, which could more comprehensively address bidirectional relationships between diseases and activity restrictions, could not be implemented. Longer observation periods and data allowing health and labor market outcomes to be measured simultaneously at multiple time points would strengthen future research on these questions.
The issue of representativeness additionally deserves acknowledgment. While the first study drew on nationally representative data using CARE surveys, the second and third studies relied on the CONSTANCES cohort, which, despite its large size and diversity of social and health situations, is not fully representative of the French population. Nonetheless, the study based on CONSTANCES helps exploring mechanisms rather than directly address population's actual health paths. Furthermore, consistency of findings across these different data sources suggests that the patterns documented are not driven by sample composition.

Another limitation concerns the inability to examine the intersection of gender and social gradients in all parts of the thesis. Only the first study could simultaneously explore both dimensions, given the richness of the data and the analytical framework employed. Future research with larger and more detailed datasets could further investigate how gender and socio-occupational position interact in shaping the contribution of specific diseases to inequalities in healthy ageing.
An additional limitation concerning the last part of the thesis relates to sample size, even with CONSTANCES, due to the methods used, which prevented stratification by gender. Although the preceding chapters established that the conditions amplifying vulnerability to this reform are more prevalent among women, direct evidence on whether the reform's heterogeneous effects differ between men and women could not be produced.

Finally it is relevant to mention that the data used in this thesis, though recent, mostly covers periods preceding the COVID-19 pandemic. The pandemic and its aftermath have reshaped several of the risk factors examined here. The widespread adoption of remote

work may have mitigated some occupational exposures associated with musculoskeletal conditions, while the increase in sedentary behavior, social isolation, and psychological distress may have exacerbated risks for both musculoskeletal conditions and poor mental health. How these developments interact with the patterns documented in this thesis, and whether they have altered the contribution of specific conditions to gender disparities in healthy ageing, constitutes a relevant question for future research.

Concluding remarks.

Gender disparities in healthy ageing persist in France. With more recent data and complementary analytical approaches, this thesis found that musculoskeletal diseases, depression, and depressive symptoms are the conditions most responsible for women's disadvantage in activity restrictions, and that they contribute to this disadvantage through their higher prevalence among women rather than through a stronger disabling impact. The higher prevalence of these conditions among women reflects biological vulnerabilities, social circumstances, including occupational exposures, domestic responsibilities, and the cumulative strain of combining professional and family duties and the interaction between the two. Prevention of the social risk factors that drive the higher prevalence of these conditions among women represents a potential lever for reducing gender disparities in healthy ageing, while effective disease management is essential to limit the onset of diseases and the progression from biological vulnerability to disability. Cardiovascular diseases, though more relevant to men's burden of activity limitation and to the social gradient, were also important contributors to activity limitation among women and deserve continued attention in future research. The findings further underscore the importance of accounting for health vulnerabilities, particularly mental health, in the design of pension reforms aimed at extending working lives, given that these reforms can prolong precarious employment situations for individuals with depression. More broadly, promoting healthy ageing is not only a matter of reducing healthcare costs and narrowing inequalities, but also of enabling older adults to contribute to society and to the well-being of younger generations, in ways that may in turn help reduce the risk factors that produce gender disparities in healthy ageing.

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