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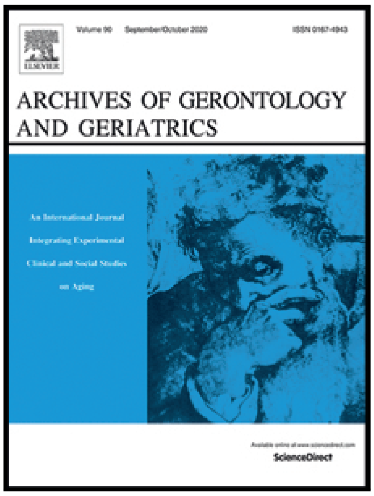

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Highlights

- Changes in morbidity prevalence across two samples 15 years apart with intersectional MAIHDA models.
- Overall morbidity prevalence increased, suggesting no general compression.
- Heart disease and functional limitations compressed mainly in multiply advantaged strata.
- Stroke showed no compression, while diabetes prevalence expanded across most strata.
- Intersectional social position stratified healthy life expectancy in Europe.

Is there a compression of morbidity and does it vary across social strata among older European adults? A retrospective cohort study of two waves 15 years apart

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Summary

Background Compression of morbidity may be linked to belonging to particular social strata defined by intersections of age, gender, migration and occupation. Extending the approach by Crimmins and Beltrán-Sánchez, we investigated compression of morbidity, defined as reduced socially stratified prevalence of self-reported heart disease, stroke, cancer, diabetes and functional limitations, using two samples 15 years apart.

Methods We used data of eleven European countries from the Survey of Health, Ageing and Retirement in Europe (SHARE), comparing 2004 (N = 29,224) and 2019/2020 (N = 46,498) samples, to apply multilevel logistic regressions within an intersectional MAIHDA (Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy) framework.

Findings Overall patterns did not show compression of morbidity in terms of lower prevalence after 15 years, but intersectional analyses revealed specific compression patterns. Certain strata showed reduced heart disease prevalence, with older men with migration background experiencing the strongest declines from initially high levels. However, no social stratum showed morbidity compression for stroke. Blue-collar low-skill men exhibited particularly increased cancer prevalence across waves. Among older men, diabetes prevalence increased substantially. Reductions in functional limitation prevalence emerged across waves for all female groups aged 70-79, and for blue-collar high-skill men.

Interpretation Overall, we found that compression of morbidity was largely intersectionally stratified, evidencing the impact of social inequalities in healthy life expectancy. This calls for stratified preventive measures at public health level in the future.

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Keywords: MAIHDA; Multimorbidity; Compression; Intersectionality; Social inequalities; Chronic disease

Introduction

Major demographic changes, characterized by an increase in life expectancy, have resulted in a significant increase of the proportion of older adults in Europe and worldwide [1,2]. This aging of the population has been argued to entail outstanding challenges for social and healthcare systems due to high levels of prevalence of multiple morbidities among the old [3]. Others have suggested that such concerns are disproportionate. Perhaps most prominently, Fries [4] advanced the so-called "compression of morbidity" hypothesis, which claims that the impacts of growing life expectancy on the collective morbidity burden are counterbalanced – and potentially fully offset – by concomitant increases in the age of onset of major chronic conditions. This theory posits that despite increased life expectancy, the length of time spent in a state of morbidity is shortened, based on the premise that the onset of chronic diseases may be occurring at advanced ages [5]. The concept has been critiqued by many such as Manton and Singer [6], who suggested that instead of a compression of morbidity, the distribution of disease types would shift as life expectancy increased, leading to more years with moderate health conditions and fewer years with severe disabilities [7].

There is mixed evidence supporting compression of morbidity. Geyer and Eberhard [8] identified three distinct trajectories in their review: morbidity compression, morbidity expansion and a mixed pattern where older adults experience compression while middle-aged adults show stagnation or expansion in morbidity. This dual pattern was observed for cardiovascular diseases and stroke, whereas type 2 diabetes showed clear morbidity expansion. Crimmins and Beltrán-Sánchez [9] similarly compared the prevalence of six major chronic conditions across an eight-year period (1998 and 2006) in the United States, finding minimal evidence of morbidity compression; prevalence increased for all the included diseases, although with variations across sex and age groups. In fact, their findings indicated an expansion of life with disease and disability, contradicting the idea of an increased healthy life expectancy in aging

societies. Other studies also found divergent patterns of morbidity compression, underscoring both the inherent complexity of the phenomenon, and the heterogeneity in healthy ageing and methodological approaches [10,11]. Although Fries' hypothesis focuses on shifts in the age of morbidity onset, many population-health studies assess potential compression through cohort differences in age-specific morbidity prevalence as an indicator [9]. This approach does not directly test the onset-based formulation but offers a complementary population-level perspective of whether morbidity distributions shift across the life course over time.

Intersectionality theory argues that the additive approach of classical stratification theory, which separately considers factors like age, gender and socioeconomic status, is insufficient because multiple social characteristics interact to create heterogeneous patterns of health inequalities, especially in later life [12]. Consequently, an adequate assessment of aging-related health inequalities requires considering combinations of social characteristics simultaneously. For example, in Crimmins and Beltrán-Sánchez [9], older men showed elevated prevalence for all the CVD conditions, while women had an increased stroke prevalence only among the oldest group. The authors, however, failed to account for socioeconomic status, overlooking intersections that may stratify the compression of morbidity. Recent epidemiological studies with an intersectional focus found substantial disparities in conditions such as type 2 diabetes and post-myocardial infarction survival, the highest risks observed among men with a migration background and low socioeconomic status [13,14]. Nonetheless, these studies did not evaluate changes in morbidity across time nor cohorts. Receiving little attention in the compression of morbidity literature, intersectional perspectives may offer important insights into whether societies are ageing with better health. Given the social gradient of major chronic conditions [2], groups in advantaged social positions experience may be more likely to experience compression of morbidity, while multiply disadvantaged groups may not. At the same time, disadvantaged groups may have greater potential to benefit from preventive measures, making them a particularly promising focus for further investigation.

Given the uncertainty about morbidity compression patterns, and coupled with the relevance of social inequalities in health, this article aims to unveil the intersectional nature of healthy life expectancy inequalities across European countries. Extending the work of Crimmins and Beltrán-Sánchez [9] with more recent European samples and an intersectional perspective, we aim to answer the following questions:

a) Are there health disparities in regard to disease prevalence; and, do some intersectional social strata display higher morbidity prevalence?
b) Does compression of morbidity occur as a function of belonging to particular intersectional social strata (i.e., intersection of age, gender, socioeconomic status and migration background)?

Methods

Data and Sample

The two samples were drawn from wave 1 (2004) and wave 8 (2019/2020) of the Survey of Ageing, Retirement and Health in Europe (SHARE). SHARE is the largest cross-national panel study in Europe, providing comprehensive longitudinal data on demographic, socioeconomic and self-reported health variables for adults over 50 years old and their co-residential family members [15]. We selected respondents with available data on the outcomes, strata-defining variables and covariates, leaving out those who participated in both waves to avoid individual-level confounding between the two cross-sectional samples (N = 734, 0.96% of all the observed individuals). This prevents within-individual trajectory analyses, which was not the focus of our study. This subgroup shows very similar sociodemographic characteristics and chronic diseases prevalence in both waves as the full samples

(Table S2), suggesting that selective mortality or survivor bias are unlikely to account for differences in morbidity between waves. The final samples consisted of N = 29,224 in wave 1 and N = 46,498 in wave 8.

Outcome

We investigated prevalence estimates of the four most prominent chronic conditions causing death: heart disease, stroke, cancer and diabetes across cohorts. Additionally, we included an indicator of functional limitations based on instrumental activities of daily living (IADL). All outcome measures were self-reported, following a design comparable to that used by Crimmins and Beltrán-Sánchez [9]. Self-reported diagnoses are a widely accepted measure, as multiple studies show high concordance with objective diagnosis, especially regarding physical chronic conditions [16].

The prevalence of *heart disease*, *stroke*, *cancer* and *diabetes* was assessed as a binary outcome (No = 0; Yes = 1), following a consistent methodological approach. In both wave 1 and wave 8, respondents were categorized as having the condition if they answered positively to the question "*Have you ever been diagnosed with [heart disease including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure/stroke/cancer/diabetes or high blood sugar]? With this we mean that a doctor has told you that you have this condition, and that you are either currently being treated for or bothered by this condition"*. Additionally, in wave 8 respondents were asked "*had a [heart attack/stroke/cancer] since last interview*", which was then counted as well.

Finally, the prevalence of *functional limitations* was measured as a binary outcome (No = 0; Yes = 1), defined by a validated IADL scale [17]. Respondents were classified as functionally limited if they had an IADL score ≥1, meaning that they reported functional limitations in at least one of the following daily activities: dressing, walking across a room, showering, eating, getting in/out of bed, using the toilet, using a map, preparing a hot meal, shopping for groceries, telephone calls, taking medications, doing housework or gardening.

Intersectional social strata

We constructed 64 intersectional strata based on the unique combinations of sex (male/female), age (4 groups), migration background (no/yes) and socioeconomic status (4 occupations) (2x4x2x4=64) [18]. *Sex/gender* was the self-reported binary sex available in SHARE. *Age* was categorized in the following four groups: 50-59 years, 60-69 years, 70-79 years and ≥80 years. *Migration background* was coded as a binary variable derived from the question "*Were you born in [country of interview]?*". *Occupation* was the self-reported present or last-held work position, categorized in four groups according to the International Standard Classification of Occupations (ISCO-88): white-collar high-skill (WCHS), white-collar low-skill (WCLS), blue-collar high-skill (BCHS), and blue-collar low-skill (BCLS). The selection of these combinations of social determinants as strata-defining variables follows the PROGRESS-Plus framework [19], which identifies key social factors that systematically stratify health outcomes and equity. All strata had sufficient cases to detect meaningful differences: in 2004, over 50% of strata had N>100, while only four of them had N<50 (minimum N=23); in 2019/2020, almost 75% of strata had N>100, while only four of them had N<50 (minimum N=23) (see Table S3)[20].

Statistical Analysis

We used Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy (MAIHDA), a multilevel modelling technique that assesses intersectional effects by treating individuals (Level 1) as nested in their intersectional social strata (Level 2) [21]. MAIHDA applies shrinkage, producing reliable estimates in smaller strata; full methodological details are described elsewhere [20]. Given the binary nature of the outcomes, we applied multilevel logistic regression throughout to investigate differences in age-specific morbidity, especially at younger ages. We added a random intercept for the strata and no random slopes, since this was repeated cross-sectional data. Analyses were performed separately for the 2004 and 2019/2020 samples to compare changes in age-specific disease prevalence of all outcomes across the 15 years period.

We estimated the following sequence of models for each outcome and time point: We first fitted a null model (Model 1), aiming to map intersectional inequalities in prevalence change and therefore assess whether compression or expansion of morbidity had occurred. Model 1 also serves to calculate the Variance Partition Coefficient (VPC), a measure of discriminatory accuracy analogous to the Intraclass Correlation Coefficient (ICC) which captures the between-strata variance in the outcome, that is, how much of the outcome differences are due to belonging to a certain stratum [18]. Second, we fitted a model adjusted for the strata-defining variables as fixed effects (Model 2). Model 2 serves to calculate an adjusted VPC and the Proportional Change in Variance (PCV), which quantifies the proportion of between-strata outcome variance explained by additive effects. When Model 2 cannot explain the total between-strata variance (PCV < 100%), the remaining variance is due to intersectional interaction effects (i.e., multiplicative effects). We included indicators of co-occurring conditions as covariates in Model 2 for each disease (see coefficients in Table S4), given the interdependencies between existing chronic conditions and their relationship to mortality. In addition, we added country dummies to account for cross-national differences, while also including (see Table S4). Because MAIHDA is exploratory rather than hypothesis-testing, we interpret results descriptively using non-overlapping 95% confidence intervals as a conservative indicator of meaningful differences. All analyses were conducted in Stata® 18.0.

Results

Table 1 presents the distribution of social characteristics among both waves. The distribution of sex was comparable between the two samples, with a slight predominance of women. The 2004 sample exhibited a larger proportion of respondents with a migrant background (11.81%). The distribution of occupational classes was similar in both waves, with 58.61% and 62.99% of respondents engaged in white-collar occupations. The 2004 sample was younger, with a larger share of individuals aged 50-59, whereas the 2019/2020 group included more individuals in their sixties and seventies.

The prevalence of all chronic conditions was higher in the 2019/2020 sample, as was the percentage of people with functional limitations, showing no overall evidence of compression of morbidity. This effect persisted when sociodemographic factors such as age, sex, migration background and occupation were accounted for (see intercept estimates in Table 2), indicating that the increase cannot be attributed to sociodemographic variabilities across waves.

Table 1. Distribution of characteristics and prevalence of the analysed chronic conditions in 2004 (N = 29,224) and 2019/2020 (N = 46,498).

Variable	**Category**	**2004**	**2019/2020**	
		N (%)	**N (%)**	**p-value**
Total sample		29,224 (100.00)	46,498 (100.00)	
Age	50-59	10,977 (37.56)	5,997 (12.90)	<0.001
	60-69	9,213 (31.53)	16,832 (36.20)	
	70-79	6,311 (21.60)	15,163 (32.61)	
	80+	2,723 (9.32)	8,506 (18.29)	
Sex	Male	13,390 (45.82)	19,824 (42.63)	<0.001
	Female	15,834 (54.18)	26,674 (57.37)	
Migration Background	No	25,733 (88.19)	42,408 (91.45)	<0.001
	Yes	3,447 (11.81)	3,965 (8.55)	
Occupation	White-collar high-skill	9,037 (35.17)	10,695 (32.20)	<0.001
	White-collar low-skill	6,021 (23.44)	10,227 (30.79)	
	Blue-collar high-skill	4,651 (18.10)	5,515 (16.60)	
	Blue-collar low-skill	5,983 (23.29)	6,781 (20.41)	
Education	Advanced Education	5,332 (18.43)	10,472 (22.65)	<0.001
	Secondary Education	8,490 (29.35)	19,579 (42.35)	
	Primary Education	15,108 (52.22)	16,183 (35.00)	
Heart disease prevalence		3,697 (12.72)	6,277 (13.54)	<0.001
Stroke prevalence		1,120 (3.85)	2,337 (5.04)	<0.001
Cancer prevalence		1,587 (5.46)	3,025 (6.53)	<0.001
Diabetes prevalence		3,014 (10.37)	6,909 (14.90)	<0.001
Functional limitations prevalence		4,933 (16.97)	9,385 (20.24)	<0.001

Notes: p values from two-tailed t-tests for continuous variables and two-tailed chi-square tests for categorical variables.

The patterns of change in prevalence were heterogeneous across sex and age for each major chronic condition. Figure 1 displays the difference in prevalence of the considered five major chronic conditions (i.e., heart disease, stroke, cancer, diabetes and functional limitations) over 15 years (see

Table S1). Consistent with the compression of morbidity hypothesis, the prevalence of heart disease decreased across all age and sex groups (except young men), although the overall prevalence slightly increased. The prevalence of stroke remained fairly stable for men across all ages bar a slight increase in the younger group, whereas it increased for women in most age groups. For cancer, all male age groups showed increasing prevalence, whereas women experienced a decline across most ages. Diabetes prevalence increased for both sexes, particularly in older adults. Finally, the percentage of people with functional limitations decreased between both time points, especially for respondents aged 70-79.

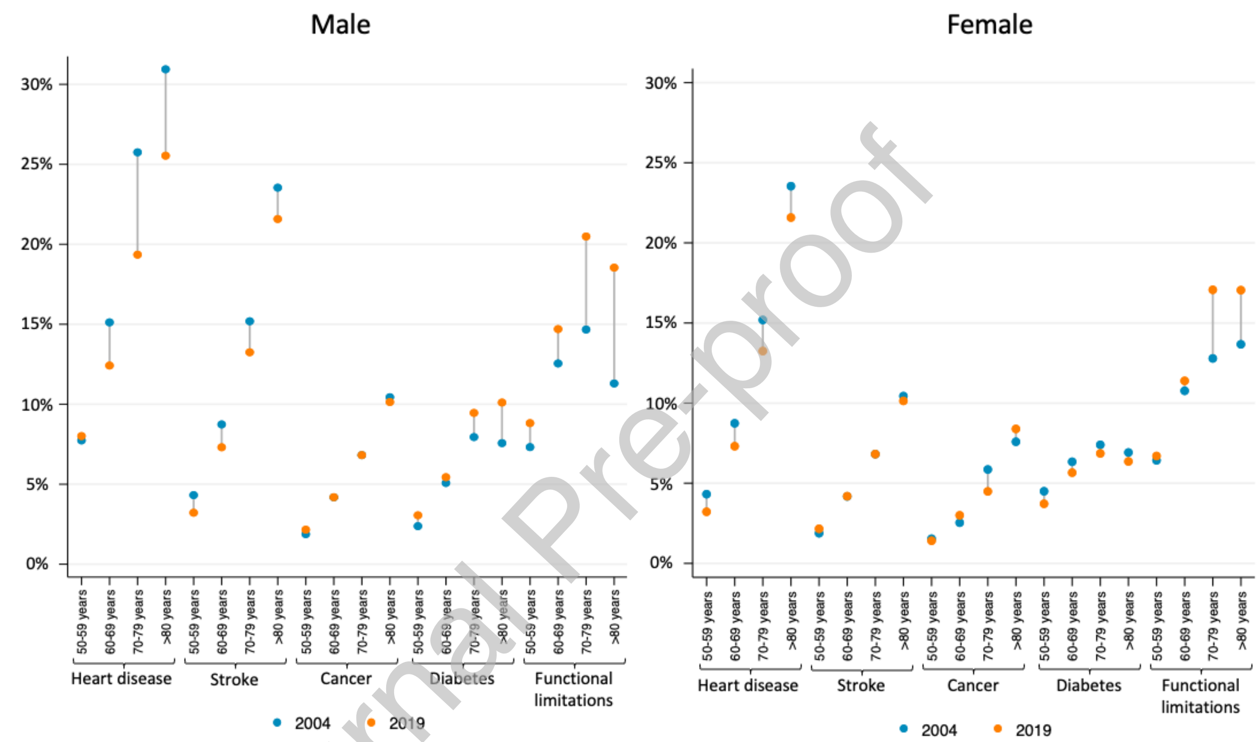

Figure 1. Prevalence (percent) of self-reported Heart Disease, Stroke, Cancer, Diabetes and Functional limitations by Age and Sex in European older adults in the 2004 (N = 29,224) and in 2019/2020 (N = 46,498) samples. Functional limitations were measured with the Instrumental Activities of Daily Living assessment (IADL).

Table 2 depicts the results obtained from the MAIHDA models, with the average fixed effects of the stratum-defining variables and the discriminatory accuracy measurements for each outcome and wave. The large VPC values for the null models (ranging from 4.57% and 25.55%, with six out of eight being above 10%) suggested a substantial proportion of variance explained at the stratum level, meaning there was considerable variance in the outcomes across intersectional social strata. Particularly, prevalence estimates in heart disease, stroke and functional limitations displayed large differences across intersectional strata, with excellent discriminatory accuracy of the stratum-defining variables (VPCs ranging between 13.11% and 25.55%). For instance, a VPC of 15.85% indicates that 15.85% of the total variance in heart disease prevalence is attributable to between-stratum heterogeneity. These values remained fairly constant across waves. After adjusting for the main effects in Model 2, all VPCs decreased to values between 0.00% and 1.00%. This, aligned with PCV values close to 100.00% in most cases, revealed that the between-strata differences were due to the additive effects mainly. A 99.37% PCV value suggests that 99.37% of the heart disease prevalence variance is explained by the additive main effects of the strata-defining variables. Tables S5-S9 display the change in predicted prevalences across waves for each intersectional social stratum.

Table 2. Results from MAIHDA models predicting the prevalence of chronic disease/limitations for the 2004 and 2019/2020 samples.

	Heart disease		Stroke		Cancer		Diabetes		Functional limitations	
	2004 (N = 25,646)	**2019/2020 (N = 33,116)**	**2004 (N = 25,646)**	**2019/2020 (N = 33,116)**	**2004 (N = 25,646)**	**2019/2020 (N = 33,116)**	**2004 (N = 25,646)**	**2019/2020 (N = 33,116)**	**2004 (N = 25,646)**	**2019/2020 (N = 33,116)**
Model 1 (null)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Intercept	0.13 (0.11, 0.16)	0.18 (0.14, 0.21)	0.09 (0.07, 0.12)	0.11 (0.08, 0.14)	0.06 (0.05, 0.07)	0.07 (0.06, 0.08)	0.04 (0.03, 0.05)	0.06 (0.04, 0.07)	0.11 (0.07, 0.15)	0.15 (0.11, 0.19)
Random effects										
Variance between-strata	0.58 (0.39, 0.85)	0.62 (0.41, 0.94)	0.50 (0.31, 0.81)	0.50 (0.31, 0.79)	0.21 (0.13, 0.36)	0.16 (0.09, 0.27)	0.16 (0.10, 0.25)	0.27 (0.18, 0.42)	1.04 (0.72, 1.51)	1.13 (0.78, 1.64)
VPC (%)	14.95%	15.85%	13.27%	13.11%	6.13%	4.58%	4.57%	7.64%	24.07%	25.55%
Model 2 (main effects)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Fixed effects										
Intercept	0.04 (0.04, 0.05)	0.07 (0.07, 0.08)	0.01 (0.01, 0.02)	0.02 (0.01, 0.02)	0.04 (0.03, 0.04)	0.04 (0.04, 0.05)	0.06 (0.05, 0.07)	0.06 (0.05, 0.07)	0.03 (0.02, 0.04)	0.04 (0.04, 0.05)
Age										
50-59	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
60-69	**2.08 (1.83, 2.36)**	**2.39 (2.01, 2.85)**	**1.91 (1.57, 2.33)**	**2.35 (1.79, 3.09)**	**1.80 (1.48, 2.18)**	**1.62 (1.34, 1.96)**	**1.76 (1.54, 2.00)**	**1.96 (1.69, 2.27)**	**1.56 (1.41, 1.73)**	**1.61 (1.39, 1.87)**
70-79	**4.19 (3.68, 4.75)**	**4.33 (3.65, 5.14)**	**3.77 (3.12, 4.56)**	**4.14 (3.17, 5.41)**	**2.53 (2.08, 3.08)**	**2.49 (2.07, 3.01)**	**2.16 (1.88, 2.47)**	**3.25 (2.81, 3.76)**	**3.54 (3.20, 3.91)**	**3.29 (2.84, 3.81)**
80+	**6.26 (5.42, 7.23)**	**7.13 (5.99, 8.49)**	**5.50 (4.43, 6.81)**	**7.12 (5.44, 9.31)**	**2.54 (2.01, 3.21)**	**2.48 (2.03, 3.02)**	**1.92 (1.62, 2.27)**	**2.83 (2.43, 3.29)**	**10.74 (9.58, 12.03)**	**12.29 (10.61, 14.25)**
Sex										
Men	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Women	**0.55 (0.50, 0.60)**	**0.63 (0.58, 0.68)**	**0.67 (0.58, 0.76)**	**0.69 (0.62, 0.77)**	**1.25 (1.08, 1.45)**	**0.81 (0.73, 0.90)**	**0.83 (0.74, 0.92)**	**0.75 (0.69, 0.81)**	**1.84 (1.71, 1.99)**	**1.70 (1.56, 1.84)**
Migration background										
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	**1.41 (1.25, 1.58)**	**1.18 (1.05, 1.32)**	1.11 (0.92, 1.35)	**1.25 (1.07, 1.47)**	1.05 (0.87, 1.26)	1.15 (0.99, 1.34)	**1.47 (1.30, 1.67)**	**1.35 (1.21, 1.50)**	**1.26 (1.13, 1.40)**	**1.21 (1.08, 1.34)**
Occupation										
WCHS	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
WCLS	1.05 (0.92, 1.20)	1.07 (0.96, 1.19)	1.53 (1.27, 1.84)	**1.31 (1.14, 1.51)**	0.94 (0.78, 1.13)	0.95 (0.83, 1.08)	**1.25 (1.08, 1.45)**	**1.22 (1.09, 1.36)**	**1.38 (1.24, 1.53)**	**1.37 (1.23, 1.53)**
BCHS	**1.13 (1.00, 1.29)**	**1.28 (1.14, 1.44)**	1.25 (1.04, 1.51)	**1.21 (1.04, 1.41)**	0.63 (0.51, 0.78)	0.84 (0.72, 0.98)	**1.38 (1.20, 1.60)**	**1.39 (1.23, 1.56)**	**1.97 (1.77, 2.19)**	**1.73 (1.54, 1.94)**
BCLS	0.97 (0.86, 1.10)	**1.43 (1.28, 1.60)**	1.32 (1.10, 1.58)	**1.54 (1.34, 1.78)**	0.68 (0.56, 0.82)	0.90 (0.78, 1.03)	**1.58 (1.38, 1.80)**	**1.75 (1.57, 1.96)**	**2.07 (1.88, 2.29)**	**2.21 (1.98, 2.46)**
Random effects										
Variance between-strata	0.01 (0.00, 0.04)	0.00 (0.00, 0.03)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.02 (0.01, 0.07)	0.01 (0.00, 0.05)	0.01 (0.00, 0.04)	0.01 (0.00, 0.02)	0.00 (0.00, 0.04)	0.01 (0.00, 0.02)
VPC (%)	0.17%	0.12%	0.00%	0.00%	0.62%	0.17%	0.23%	0.17%	0.00%	0.17%
PCV (%)	99.03%	99.37%	100.00%	100.00%	90.49%	96.41%	95.20%	97.95%	100.00%	99.52%

Notes: WCHS: White-collar high-skill; WCLS: White-collar low-skill; BCHS: Blue-collar high-skill; BCLS: Blue-collar low-skill; VPC: Variance Partition Coefficient; PCV: Proportional Change in Variance. Bold coefficients indicate statistical significance, with p-value <0.05.

Figure 2 displays the results for heart disease, which showed the clearest signs of intersectionally patterned compression. Particularly, this trend was more pronounced amongst the most privileged intersectional strata. In both waves age was a strong predictor of heart disease prevalence (i.e., older groups showing higher prevalence), followed by sex (i.e., men having higher prevalence) and migration background (i.e., those with a migration background having higher prevalence of heart disease). These results are aligned with the average estimates in Table 2. The multiply disadvantaged group of blue-collar low-skill occupations seem to have a slightly higher prevalence of heart disease, mostly in the 2019/2020 cohort. Through the intersectional lens, advantaged white-collar high skill men with a migration background (which constituted a disadvantage) and over 70 and 80 years showed the strongest decrease in prevalence across time (almost 13% reductions). In contrast, multiply disadvantaged blue-collar low skill older men without a migration background or any blue collar (high and low skill) older women without a migration background showed minimal or no reduction in heart disease (increases between 1% and 2%). Overall, the widest prevalence difference between advantaged and disadvantaged strata reached 15%, underscoring how compression is unevenly distributed across social positions.

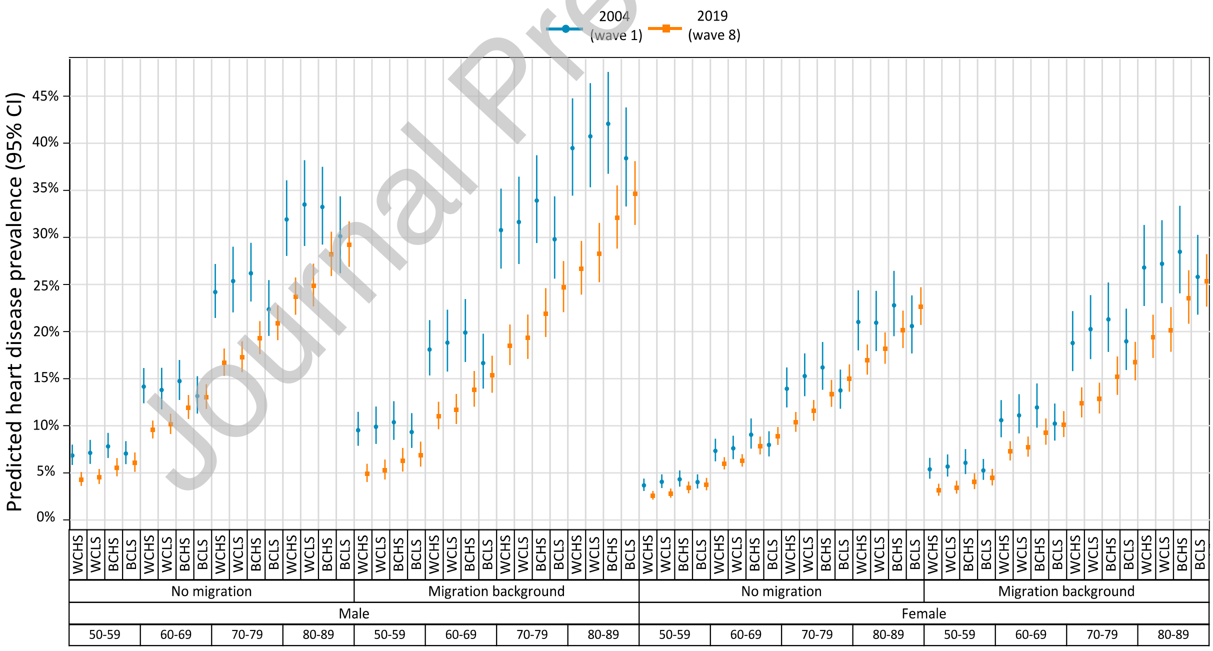

Figure 2. Differences in heart disease predicted prevalence across intersectional social strata in the 2004 (N = 25,464) and 2019/2020 (N = 30,116) samples. Results obtained from MAIHDA Model 2.

Stroke prevalence revealed no clear compression across any social strata (Figure 3). With a strong age and sex gradient in both waves, prevalence remained the highest amongst multiply disadvantaged groups (i.e., blue-collar low-skill men with migration background and aged 80+). Inversely, multiply advantaged strata (i.e., white-collar high-skill men and women without migration background) consistently showed the lowest prevalences in both waves. Migration background and occupation had a stronger gradient in the 2019/2020 cohort only, pointing towards an increase in the intersectional effects for multiply disadvantaged groups.

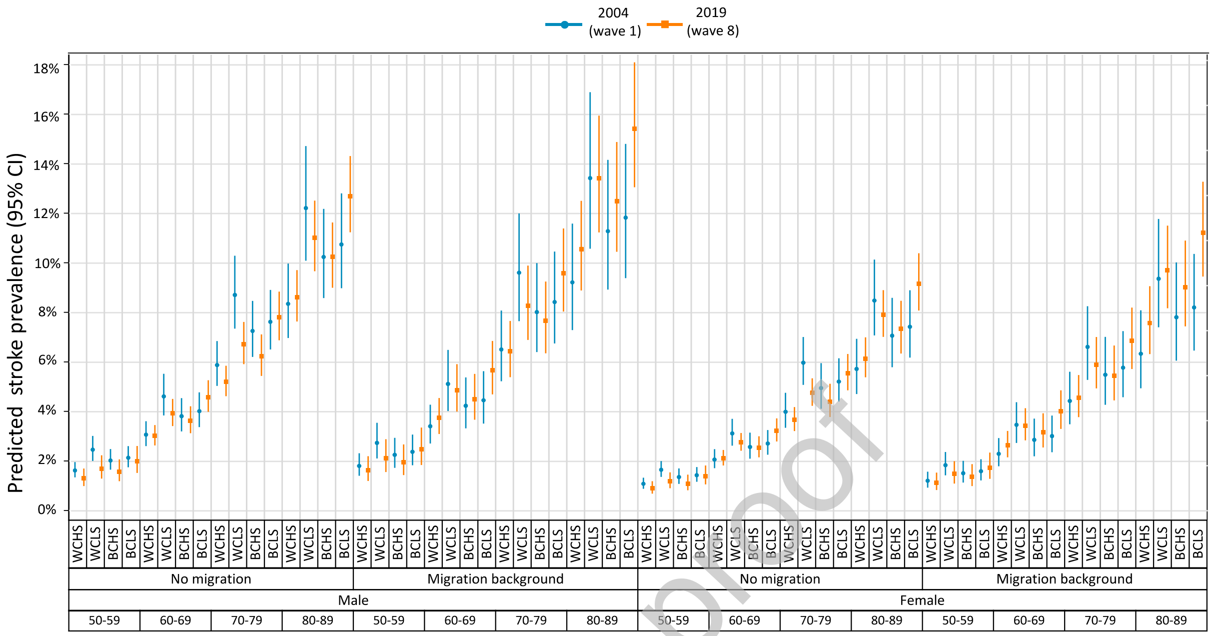

Figure 3. Differences in stroke predicted prevalence across intersectional social strata in the 2004 (N = 25,464) and 2019/2020 (N = 30,116) samples. Results obtained from MAIHDA Model 2.

Cancer prevalence (Figure 4) varied markedly across intersectional strata with a strong age gradient, but there were no clear differences across both waves. Being a woman was associated with a higher cancer prevalence in 2004, yet with lower prevalence in 2019/2020 compared to men (odds ratio of 1.25 and 0.81 respectively, see Table 2). In the context intersectional comparisons, increases in prevalence were concentrated among multiply disadvantaged male strata (blue-collar low-skill with and without migration background) and among multiply disadvantaged women aged 50–69 with migration background. On the other hand, several advantaged female strata (i.e., white-collar high skill without a migration background aged between 50-79 years) experienced morbidity declines. These contrasting patterns reflect the multidimensional ways privilege and disadvantage intersect to shape cancer prevalence.

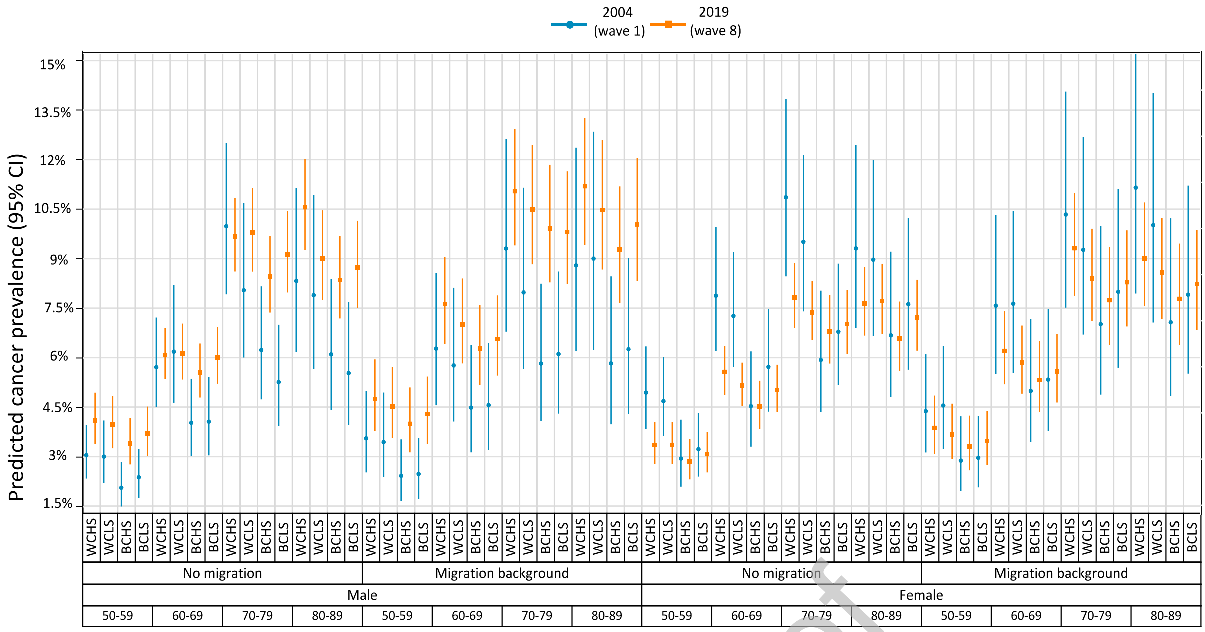

Figure 4. Differences in cancer predicted prevalence across intersectional social strata in the 2004 (N = 25,464) and 2019/2020 (N = 30,116) samples. Results obtained from MAIHDA Model 2.

Diabetes prevalence increased across most strata (Figure 5), with the steepest rises amongst older (70+), multiply disadvantaged men, namely blue-collar and low-skill occupations with migration background. From an intersectional viewpoint, among women 70+, increases were present mainly for those without a migration background. Only a few multiply advantaged female strata (i.e., white-collar high-skill women 70-79 years) showed relative stagnation in the prevalence.

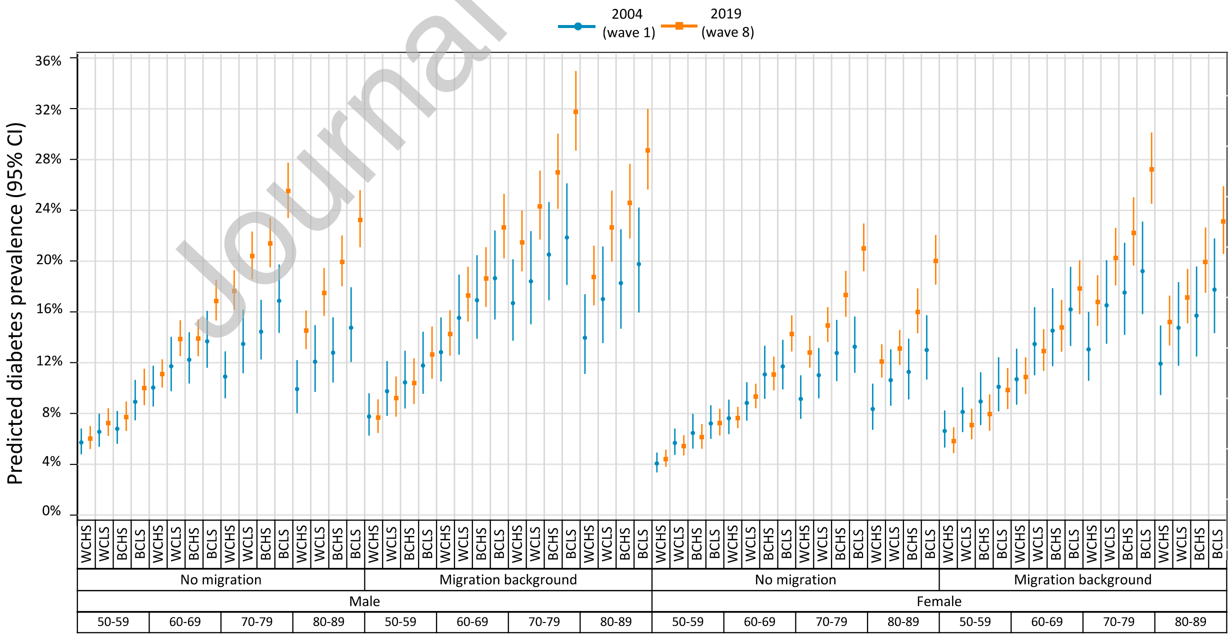

Figure 5. Differences in diabetes predicted prevalence across intersectional social strata in the 2004 (N = 25,464) and 2019/2020 (N = 30,116) samples. Results obtained from MAIHDA Model 2.

Functional limitations were highest amongst multiply disadvantaged strata (Figure 6), especially blue-collar low-skill migrant women aged 80+. Reductions across waves were limited and largely found in relatively advantaged strata, particularly women aged 70–79 and high-skill blue-collar men. These patterns illustrate how functional ageing processes intersect with social position to produce divergent trajectories of late-life functional limitation.

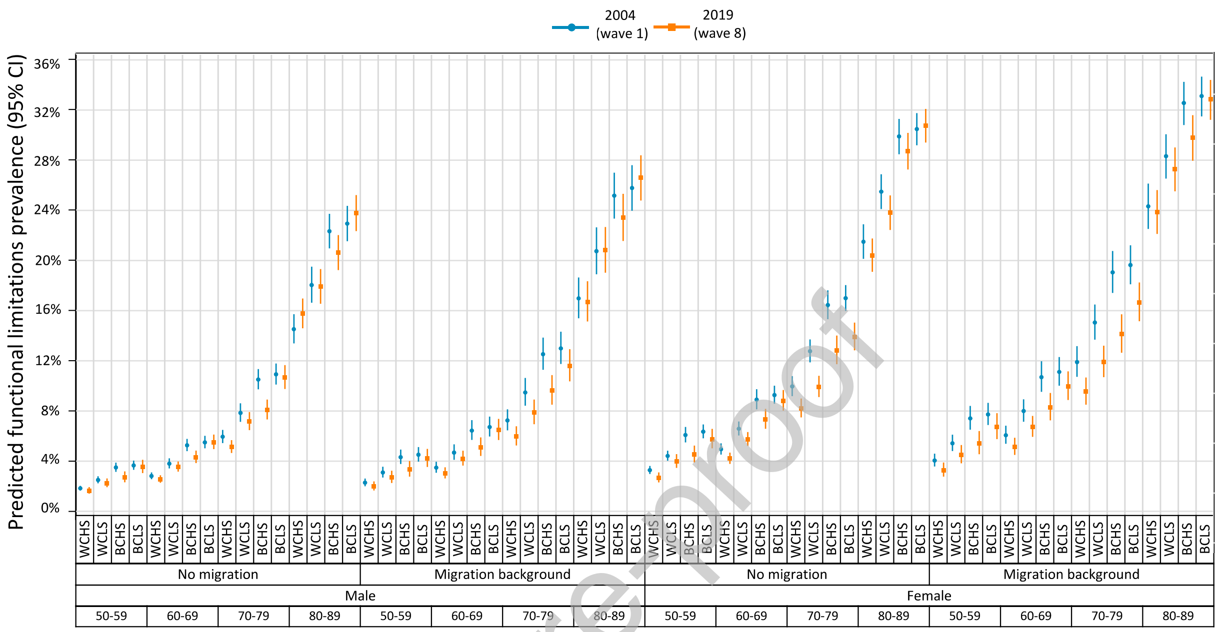

Figure 6. Differences in functional limitations predicted prevalence across intersectional social strata in the 2004 (N = 25,464) and 2019/2020 (N = 30,116) samples. Results obtained from MAIHDA Model 2.

Discussion

The present study aimed to address the existing uncertainty surrounding the hypothesis that increased life expectancy has led to compression of morbidity in Europe. Applying an intersectional perspective, we analysed differences in prevalence estimates of European older adults 50 years and older over 15 years (2004 to 2019/2020) of five major chronic diseases and functional disability across social strata intersections. While the overall pattern did not demonstrate compression of morbidity, stratifications by age and gender revealed compression patterns. In further analyses of detailed intersectional strata, we identified specific morbidity compression patterns for common chronic conditions such as heart disease, cancer and functional limitations, but not for stroke and diabetes. These compression patterns varied considerably across strata, which evidences the critical impact of social inequalities on healthy life expectancy. Our findings indicated that compression of morbidity is a heterogeneous phenomenon, shaped by the intersection of social determinants across different population groups.

We found a dichotomous trend for heart disease, with morbidity compression at older age and expansion at middle age. This is aligned with findings from a study on the age of first myocardial infarction in Germany [22]. Migration background, especially among men in high-skilled occupations, was associated with elevated rates of heart disease; however, this group experienced significant morbidity compression across waves — a trend not observed among men in low-skill occupations or women. While overall rates of heart disease in Europe are declining over time, this trend is heterogeneous among migrants, with some groups showing similar declines and others having disproportionally higher prevalence rates [23,24]. We identified high rates of heart disease in male migrants, which, as described in the literature, have been linked to acculturation as a risk factor for first-generation immigrants [25] and refugee experiences as independent CVD risk factors [26]. However, the observed reductions in heart disease prevalence indicate the complexity of morbidity compression patterns, defying one-dimensional interpretations.

The prevalence of stroke remained fairly stable for men across all ages with a slight increase in the youngest group (50-59 years), whereas it increased for all the women age groups. Our results are aligned with comparable studies in the U.S. and Europe [27,28]. In terms of differences across waves, there was no clear morbidity compression patterns in stroke prevalence in any of the social strata, although we found substantial prevalence differences between strata within waves, but not a particular stratified pattern of prevalence increases or decreases across waves.

Regarding cancer, all male age groups showed elevated levels of prevalence across waves. In contrast, the prevalence decreased for women across all age groups. Further, we found that older ages were associated with higher prevalence in both waves. There were some multiplicative effects explaining the between-strata differences in cancer prevalence for both cohorts. This opens the door to further investigations of heterogeneity across strata, as the persisting health disparities in cancer prevalence, although varying across cancer types, have been outlined in a recent review [29].

For type 2 diabetes, both men and women showed increases in prevalence between waves, which was more pronounced in older age groups. We found a clear pattern of morbidity expansion across intersectional strata. The increase in both prevalence and life expectancy of type 2 diabetes over time has been previously documented, with our results aligning with Safieddine, Sperlich [30], who identified an increased type 2 diabetes prevalence in both genders and all age groups.

With regard to functional limitations, the prevalence decreased across waves, a trend that was particularly evident for those aged 70-79. This pattern echoes findings from a study that found a trend of compression of functional impairments among German older adults [31]. Moreover, we found strong level differences across strata, but in terms of change across waves, we observed only few and small reductions in functional limitations for some strata. Our results align with a recent modelling study highlighting the important influence of socioeconomic status on quantity and quality of ADL disability-free life, with the most socioeconomically disadvantaged individuals having functional limitations 11 years earlier for men and 12 years earlier for women, compared to those least disadvantaged [32].

Our findings underscore the value of adopting an intersectional lens for understanding morbidity patterns. Rather than acting independently, age, sex, migration background and occupational class combine to produce social positions with differing levels of advantage or disadvantage. Compression of morbidity was more common among multiply advantaged strata, whereas several multiply disadvantaged groups showed stable or increasing prevalence. Some particular configurations (e.g., morbidity compression among certain higher-skilled migrants aged 70-79) illustrate that intersecting forms of privilege and disadvantage do not always align with single-axis expectations. These patterns highlight the complexity of health trajectories across social positions and the utility of MAIHDA for identifying which groups are at highest and lowest risks of a healthy life expectancy.

Strengths and limitations

This study makes a distinctive contribution to the existing literature by providing a comprehensive overview on the socially stratified compression of morbidity for four major chronic conditions and for functional limitations across a 15-year period. A further strength is the use of a large population-based sample with multiple European countries. Additionally, the application of the MAIHDA framework to estimate the intersectional strata effects constitutes a state-of-the-art approach to the research question on health disparities in the compression of morbidity.

There are limitations to take into consideration when interpreting the findings. Firstly, we restricted our analyses to a set of major chronic conditions and functional limitations, as we built upon the Crimmins and Beltrán-Sánchez [9] study design. Future studies should broaden the scope to include conditions such as mental health disorders, including dementia and depression, as well as multimorbidity. Thus, we also added conditions as confounders, yet there should be caution against interpreting the condition-specific prevalence rates as independent of broader multimorbidity processes. Secondly, conditions were measured through retrospective self-report, which is subject to recall bias that may vary across social groups. Although self-reported diagnoses are well-accepted in health survey research and have been shown to be reasonable valid [16], diagnosis awareness and access to medical evaluation may differ by educational level or occupation, potentially leading to socially patterned reporting differences. Future studies should replicate our findings with administrative data or clinical measures. Thirdly, while we followed the outcome choice by Crimmins and Beltrán-Sánchez [9] and focused on prevalence estimates, more extended analyses should investigate onset and life span differentials by social strata to get even closer to the original propositions by Fries [4]. Fourthly, while we made use of a cross-national representative sample, we cannot rule out that minority groups including those with migration background constitute a selective sample which is not entirely representative of the underlying respective subpopulation. Fifthly, our study was not longitudinal. As we compared two independent cross-sectional samples, survivor bias or selective mortality may be less relevant than in the longitudinal sense. Although the (excluded) 734 respondents observed in both waves showed morbidity patterns similar to the full samples, future longitudinal research would be required to assess onset and trajectories of morbidity compression. Finally, although we controlled for cross-national differences in the models, our pooled sample does not explicitly examine differences in intersectional patterns across European welfare regimes and healthcare systems. Against the background of macro-level social inequalities, future studies should include country-level analyses to distinguish such effects.

Impact and future directions

Our findings indicate that compression of morbidity is stratified across social groups, with aggregate patterns masking important subgroup differences. In many cases, subgroup differences diverged from overall trends, even after controlling for sociodemographic factors across waves. This phenomenon reflects the Simpson's paradox, where a trend observed within subgroups differs in direction or magnitude when the subgroups are pooled in an overall estimate [33]. In our study, subgroup-specific improvements were hidden by the aggregation of strata with divergent changes (e.g., functional limitations worsened for women in their 50s overall, but those with blue-collar high-skill occupations showed a decreasing prevalence). These masked dynamics call for public health prevention measures tailored to specific social subgroups, whose structural needs and risk profiles may differ. Future causal analyses should incorporate systematic knowledge of social stratification, given that access to care, early detection and prevention resources vary substantially across strata and structural barriers.

The hypothesis of compression of morbidity provides a framework to guide and evaluate preventive public health measures as expansion or compression is associated with population ageing but also with the effectiveness of preventive strategies. While this theory suggests that compression is possible in principle, the absence of compression, on average or in certain disadvantaged groups, highlights the need for countermeasures including tailored health promotion programs, inclusive city planning, and easy access to preventive health care.

By focusing on preventing or delaying the onset of chronic diseases such as heart disease, diabetes, and cancer, policymakers and public health professionals need to create environments that foster long-term health. Effective prevention strategies, including improved nutrition, physical activity, sleep, mental health support, and access to healthcare, can all contribute to compressing morbidity and ensuring that older adults live healthier, more independent lives. However, the benefits of compressing morbidity should be equitably distributed across all social groups. Health disparities based on the belonging to a particular social stratum can exacerbate the uneven distribution of health outcomes, meaning that some populations may experience a prolonged period of illness and disability due to a lack of access to preventive care and resources. To ensure that the compression of morbidity is achieved in an equitable manner, it is essential to address these social determinants of health. Prevention efforts must prioritize vulnerable groups by improving access to healthcare, promoting education about healthy lifestyles, and tackling systemic inequalities that contribute to poor health outcomes.

Conclusion

By testing the compression of morbidity across social strata, our findings indicate that social inequalities and the resulting intersectional social position have a critical role in shaping changes in morbidity patterns. The heterogeneous and complex trends for each chronic condition call for nuanced approaches that consider how cumulative inequalities act as mechanisms to explain differences in healthy life expectancy. To gain a deeper understanding, further theoretical and empirical advances aimed at improving the understanding of morbidity compression patterns would benefit from incorporating an intersectional perspective on social inequalities.

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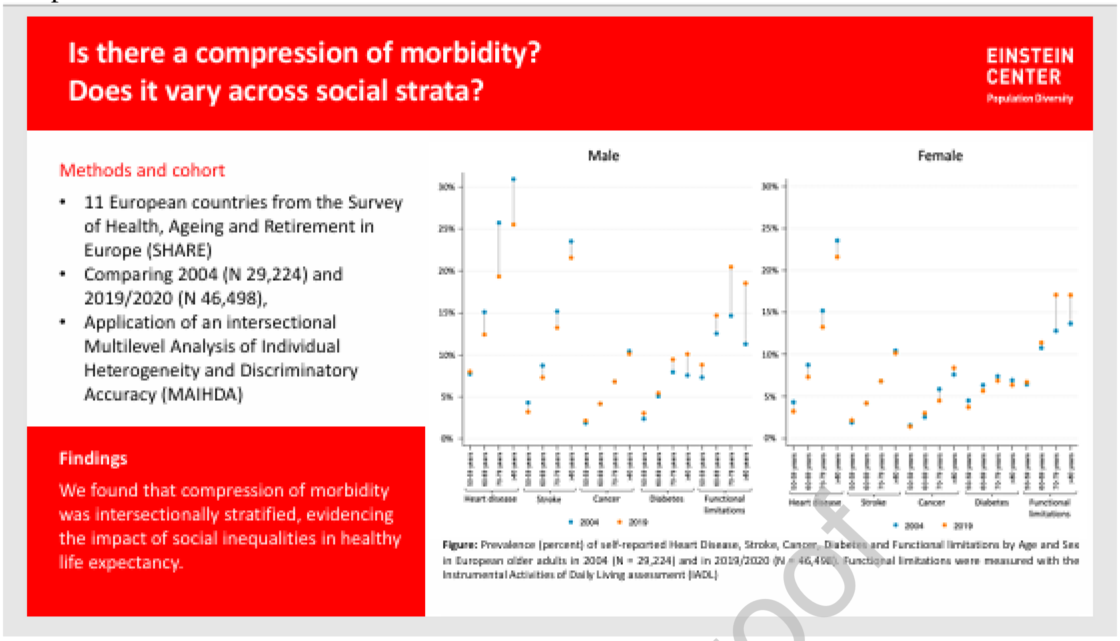
Graphical abstract



Declaration of Competing interests

The authors have no competing interest to declare.