Social inequalities in multimorbidity trajectories in Scotland: longitudinal study using linked census-linked administrative data from middle-aged and older adults

Authors: Katherine Keenan[1], Genevieve Cezard[1]

[1] School of Geography and Sustainable Development, University of St Andrews

Abstract (200 words)

Multimorbidity – the co-occurrence of at least two chronic diseases - is an important public health challenge in ageing societies, but most evidence is cross-sectional, and social disparities are poorly understood. We address this gap by investigating 18-year multimorbidity trajectories of adults aged 40-69, and whether there are disparities in accumulation by education, area deprivation, housing type, marital status and living arrangement. We use an extract of the Scottish Longitudinal Study including 2001 census data, further linked to hospitalization and disease registries for a 5.3% sample of the Scottish population. We selected a cohort of 97,019 individuals aged 40-69 at 2001 and observed them for 18 years, or until their emigration or death. The outcome was a multimorbidity score based on ICD10 codes, and we used growth curve modelling to estimate accumulation by age, cohort and gender, and the socio-demographic, economic and housing indicators above. Multimorbidity severity rises steeply with age, and is higher in men, especially at older ages. There was evidence for earlier multimorbidity onset in younger cohorts. In adjusted models, multimorbidity levels are higher, and trajectories are steeper, for those in lower educational groups, living in more deprived areas, the unmarried and those who lived in social housing.

Introduction

Multimorbidity – the co-occurrence of at least two chronic diseases in an individual- is an important public health challenge in ageing societies [1]. Previous reviews have demonstrated that multimorbidity prevalence increases with age, and is socially patterned, being higher in deprived areas, and in those with lower education [2–4]. Studies on the intersection of family structure, marital status and household size suggest that those living alone, who are unmarried, or single parents will accumulate worse health over the life course, but there is sparse evidence on multimorbidity differences by family, household structure and mixed evidence for education and gender. Moreover, the vast majority of multimorbidity research takes a cross-sectional approach, which ignores how multimorbidity develops over the life course [5]. To address this gap, this study aimed to investigate 18-year multimorbidity trajectories of middle aged and older adults (aged 40-69 at baseline) using linked administrative data in Scotland. The research questions were:

- How does multimorbidity develop with age over an 18-year period, and are there any gender and cohort differences in levels and accumulation of multimorbidity?
- Does multimorbidity accumulate more rapidly in some socio-demographic and economic groups?

Methods

Data and sample. We used data from the Scottish Longitudinal Study (SLS), which links three Scottish censuses (1991, 2001, and 2011) to a range of administrative data sources for a 5.3% sample of the Scottish population[6]. In this study, SLS was linked to inpatient hospitalization data, diabetes and cancer disease registries, exits from Scotland and mortality records from 2001 until 2019. We selected a cohort of 98,634 SLS participants aged 40-69 years who responded to the Scottish census in 2001, whom we observe for 18 years until 2019, or until their death or exit from the study. We additionally excluded 1615 individuals (17,222 observations) with missing data for covariates, mostly on education and marital status. This left a dataset of 97,019 individuals (1,581,047 yearly observations) where on average each cohort member contributed 16.3 observations to the analysis.

Disease identification. We identified the 17 diseases of the Charlson index from hospitalization data, based on the International Classification of Disease version 10 (ICD10) codes and the Quan et al. algorithm (ref Quan 2005). Additionally, we include details of diabetes and cancer onset from specialist registers. We set any first record of each disease as a first diagnosis and as a proxy for disease onset. We measured the year of onset for each disease and used this to construct an annual weighted multimorbidity index. Our index was based on the adapted Charlson index score by Quan et al. [7] and served as our main outcome. For some analyses, we created an ordinal version of the index classified into 0, 1, 2, or 3 or more conditions.

Covariates. As well as age measured in years, and gender, we used other socio-demographic factors measured in 2001: marital status (single, married or partnered, divorced or separated, widowed), household type (living alone, couple, single parent, communal or other), education (no qualifications, low (secondary school level), medium (further education e.g. advanced highers), high (higher education)), tenure type (owns or does not pay rent, social renter, private renter) and Scottish Index for Multiple Deprivation (SIMD) quintiles, an area-based measure of socioeconomic status.

Analysis strategy. To assess changes in multimorbidity, we employ growth curve modelling (GCM), which enables us to model multimorbidity trajectories over time and distinguish within- and between-individual heterogeneity [89]. We use polynomial regression, and tested different age specifications (linear, quadratic and cubic), assessing their fit using AIC/BIC values. We also tested interactions with gender, birth cohort and the other covariates. We used a random 25% sample to generate some of the preliminary results.

Results

The full sample was 47% male, with slightly more females in age categories 60 and over (Table 1). The majority had no qualifications, were married or partnered, and living in a couple, and owned their own property. Mean multimorbidity scores were higher among women, at older ages, among those with no qualifications, who were widowed, living in communal households, social renters, and in the most deprived SIMD quintile. The most common comorbidity experienced over the 18-year period was cancer (24%), and cardiovascular-related morbidity (17%).

Table 1: Sample description for full sample

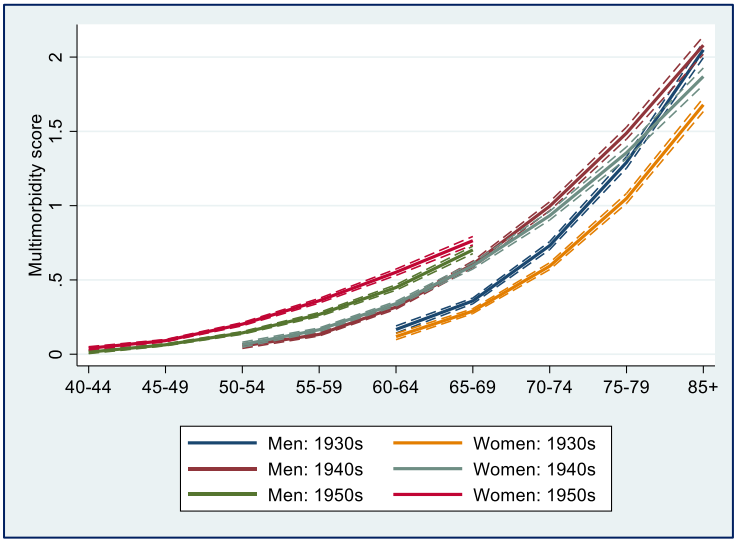
		Males (N=46,880)		Females (N=50,139)	
Measured in 2001 (baseline)		Percent	MM score Mean	Percent	MM score Mean
Age groups	40-44	20.4	0.03	20.2	0.05
	45-49	18.5	0.04	18.2	0.06
	50-54	18.9	0.06	18.7	0.09
	55-59	16.0	0.1	15.5	0.12
	60-64	13.9	0.18	14.3	0.15
	65-69	12.4	0.22	13.2	0.18
Education	No qualifications	44.1	0.13	47.4	0.12
	Low	17.4	0.07	20.3	0.08
	Medium	17.7	0.06	13.2	0.07
	High	20.8	0.06	19.0	0.08
Marital status	Single	9.5	0.09	6.9	0.11
	Married/partnered	78.2	0.09	71.0	0.09
	Separated	9.6	0.12	13.5	0.1
	Widowed	2.7	0.17	8.5	0.16
Household type	Single person	15.1	0.11	16.7	0.14
	Living in couple	76.1	0.09	69.1	0.09
	Living with child (lone parent)	4.0	0.09	10.5	0.08
	Communal /other	4.8	0.14	3.7	0.16
Tenure	Owns	76	0.08	75	0.09
	Social renter	20.5	0.15	22.2	0.14
	Private renter / other	3.5	0.07	2.8	0.09
SIMD	(1) Most deprived	17.8	0.14	18.4	0.13
	(2)	18.9	0.1	19.4	0.11
	(3)	19.8	0.09	19.9	0.09
	(4)	20.9	0.08	20.6	0.1
	(5) Least deprived	22.5	0.07	21.8	0.08
TOTAL		100.0	0.09	0.10	100.0

Source: Scottish Longitudinal Study

Multimorbidity development by age, cohort and gender. The best fitting polynomial model judged by lowest AIC/BIC scores, were those with linear, quadratic and cubic age effects. Using this specification, we estimated multimorbidity growth curves by age, gender and cohort (Figure 1). Multimorbidity starts to accumulate faster with older age, and is much steeper in the over 65s. Each successive birth cohort has higher multimorbidity scores at the same age than the earlier born cohorts. Among the cohorts born in the 1930s and 40s, men had higher multimorbidity scores than women and the gender gap widened with increased age. Gender disparities started to emerge earlier in the 1930s cohort compared with the 1940s. On the other hand, among the 1950s birth cohort, women had higher multimorbidity scores from age 50-54, although there is some indication of convergence.

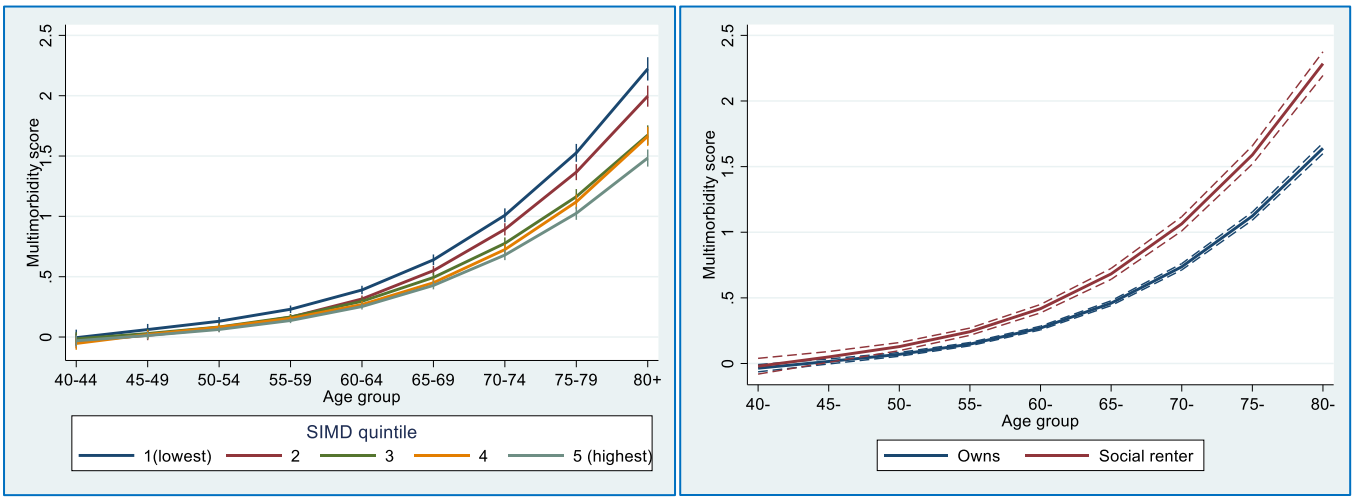
Socio-demographic and economic disparities in multimorbidity development. Growth curve models adjusted for age and gender, showed that accumulation disparities existed by levels of education, SIMD, marital status, household type, and tenure. Multimorbidity score disparities by SIMD quintile and tenure group widen significantly with age (Figures 2A and 2B). Being a social renter compared with owning the property where you live, was associated with higher multimorbidity and faster accumulation, controlled for gender, education and area deprivation (Figure 2B). Educational differences started to emerge at earlier ages in the more recently born cohorts, and also widen with age (Figure 3). Marital status differences persist after adjustment for education and deprivation. Married/partnered individuals have lower multimorbidity scores compared with the unmarried (single and divorced/separated), but the gap is wider among women than men (Figure 4). Individuals living in communal housing (mainly care homes) had higher multimorbidity and steeper trajectories.

Figure 1: Predicted multimorbidity scores and 95% CIs by gender and birth cohort (full sample)



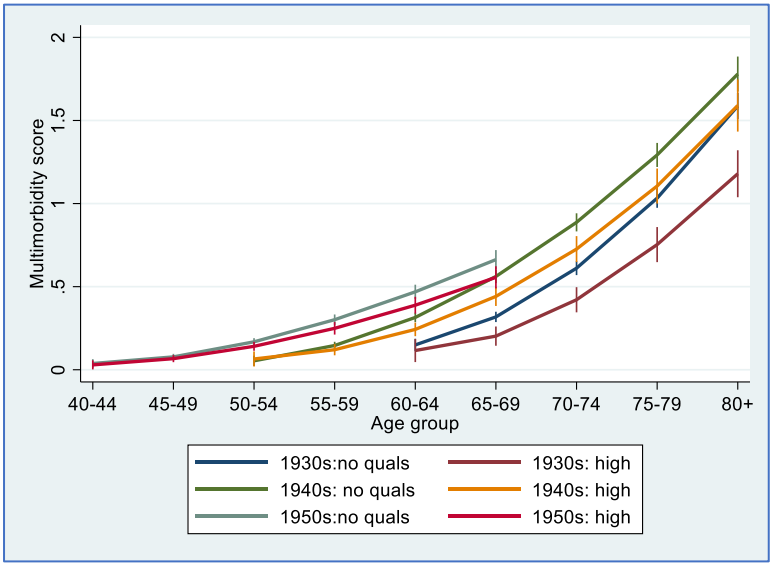
Source: Scottish Longitudinal Study

Figure 2A and B: Predicted multimorbidity scores and 95% Cis by SIMD quintile and Tenure group (25% sample)



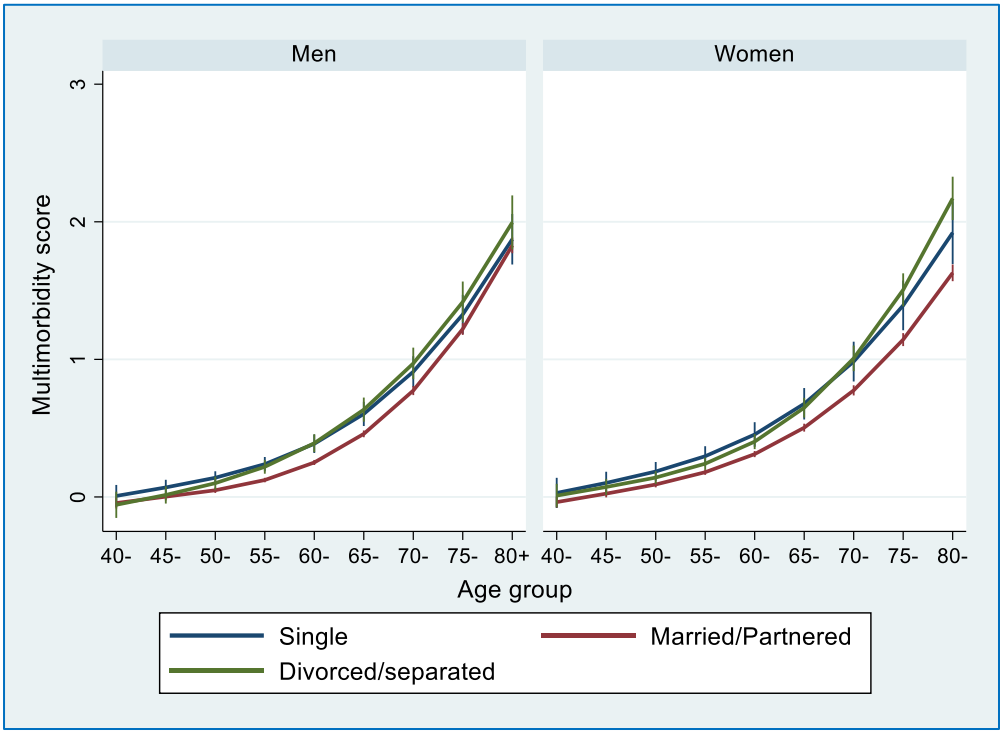
Source: Scottish Longitudinal Study. All adjusted for age and sex. Tenure plot 2B adjusted for SIMD and education.

Figure 3: Predicted multimorbidity scores and 95% CIs by educational group and cohort (25% sample)



Source: Scottish Longitudinal Study. NB. Adjusted for age and sex.

Figure 4: Predicted multimorbidity scores and 95% CIs by marital status, by age and sex (25% sample)



Source: Scottish Longitudinal Study. NB. Adjusted for age, SIMD and education.

Discussion

This study is the first to use population-level administrative data to study social inequalities in multimorbidity longitudinally in the UK. It provides evidence that multimorbidity *accumulation* throughout the life course varies by gender, birth cohort, socioeconomic status and previously understudied socio-demographic factors such as marital status and household tenure. The most striking finding are substantial cohort level differences: younger cohorts are experiencing earlier onset, and social disparities emerge at earlier age. It remains to be seen whether this is related to better and earlier diagnosis (i.e. improved healthcare) and perhaps levels will converge with older cohorts over time. It also highlights risks related to family and household characteristics: the unmarried, and those living in social rented housing develop worse comorbidities over the life course even after adjustment for individual and area-level socio-economic status. Further investigation is needed to understand whether multimorbidity inequalities are wider in younger generations and if so, the reasons behind this. We will extend this study in the following ways to address some limitations. Given the skewness of the multimorbidity score, we will conduct sensitivity checks with Poisson and negative binomial distributions. We will test further age specifications using exact year of age and employ piecewise linear modelling with splines. Finally, we will test further interaction effects to investigate intersectional disadvantages by gender, cohort and other covariates.

References

1. Academy of Medical Sciences. *Multimorbidity: A Priority for Global Health Research*. https://acmedsci.ac.uk/file-download/82222577 (2018).
2. Barnett, K. *et al.* Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* **380**, 37–43 (2012).
3. Pathirana, T. I. & Jackson, C. A. Socioeconomic status and multimorbidity: a systematic review and meta-analysis. *Aust. N. Z. J. Public Health* **42**, 186–194 (2018).
4. Dekhtyar, S. *et al.* Association Between Speed of Multimorbidity Accumulation in Old Age and Life Experiences: A Cohort Study. *Am. J. Epidemiol.* **188**, 1627–1636 (2019).
5. Xu, X., Mishra, G. D. & Jones, M. Mapping the global research landscape and knowledge gaps on multimorbidity: a bibliometric study. *J. Glob. Health* **7**, 010414 (2017).
6. Boyle, P. J. *et al.* Cohort profile: The Scottish longitudinal study (SLS). *Int. J. Epidemiol.* **38**, 385–392 (2009).
7. Quan, H. *et al.* Updating and Validating the Charlson Comorbidity Index and Score for Risk Adjustment in Hospital Discharge Abstracts Using Data From 6 Countries. *Am. J. Epidemiol.* **173**, 676–682 (2011).
8. Luo, Y., Zhang, L. & Pan, X. Neighborhood Environments and Cognitive Decline among Middle-Aged and Older People in China. *Journals Gerontol. - Ser. B Psychol. Sci. Soc. Sci.* **74**, e60–e71 (2019).
9. Rabe-Hesketh, S. & Skrondal, A. *Multilevel and Longitudinal Modeling Using Stata*. vol. 1 (Stata Press, 2012).