

Educational inequalities in multimorbidity among older adults in China: an underreporting-corrected analysis using CHARLS

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Abstract

Background

Educational attainment is a key social determinant of health inequalities in later life. However, most previous studies of the relationship between education and multimorbidity have relied on self-reported physician diagnoses. Such reliance may underestimate the true burden of chronic conditions and bias the assessment of education-related inequalities.

Methods

We analyzed five waves (2011–2020) of the China Health and Retirement Longitudinal Study, comprising an analytic sample of 6,906 adults aged 60 years or older at baseline. Self-reported multimorbidity was defined from participants' reports of physician-diagnosed chronic conditions. To address potential underreporting, we drew on objectively measured blood pressure, fasting glucose, glycated hemoglobin, and lipid biomarkers to identify underreported cases of hypertension, diabetes, and dyslipidemia, and constructed an underreporting-corrected multimorbidity outcome. Generalized estimating equations were used to assess the association between education attainment and multimorbidity and to compare the education-by-age interaction across outcome definitions. Logistic regression was applied to identify factors associated with chronic disease underreporting.

Results

At baseline, the prevalence of self-reported multimorbidity was 45.40%, rising to 62.93% after correction for underreporting. Underreporting rates for hypertension, diabetes, and dyslipidemia were 16.25%, 7.01%, and 31.29%, respectively. When multimorbidity was based on self-reported diagnoses, the education-by-age interaction was not statistically significant ($P = 0.762$). By contrast, this interaction became statistically significant when using the underreporting-corrected multimorbidity measure ($P = 0.019$). Further analyses showed that older age was associated with higher odds of underreported hypertension and any chronic disease underreporting. Female sex was associated with higher odds of underreported dyslipidemia and any underreporting, whereas having a high school education or above was associated with lower odds of underreported dyslipidemia.

Conclusions

Reliance on self-reported information alone may substantially underestimate the burden of multimorbidity among older adults in China and obscure education-related health inequalities. Future research on healthy ageing and health equity should explicitly account for chronic disease

underreporting and its social patterning so as not to understate the impact of educational disadvantage on later-life health.

Contributions to the literature

Many studies of multimorbidity rely on self-reported diagnoses, which may miss conditions that have not been detected or reported.

By combining self-reports with objective health measurements, this study shows how missed disease can affect estimates of educational inequalities in multimorbidity.

It highlights chronic disease underreporting as a socially patterned source of bias in population health research, rather than only a data-quality issue.

This approach can help distinguish inequalities in disease burden from inequalities in disease detection, informing surveillance, screening, and equitable chronic disease management.

1 Background

Multimorbidity has become a major public health challenge in ageing societies. As populations age, the coexistence of multiple chronic conditions has become increasingly common, with important implications for healthcare delivery, clinical decision-making, and long-term care needs^[1]. It has been described as a defining challenge for health systems, as conventional disease-specific care models are ill-suited to patients with coexisting conditions^[2]. Cross-national evidence from 33 countries has shown that multimorbidity is unequally distributed across socioeconomic groups among middle-aged and older adults^[3]. Consistently, population-based studies from Scotland and England found that people living in more deprived areas developed multimorbidity at substantially younger ages, with multimorbidity occurring approximately 10–15 years earlier for multimorbidity overall and about seven years earlier for complex multimorbidity^[4, 5]. Given its associations with disability, mortality, reduced quality of life, healthcare use, and caregiving demands, understanding the educational patterning of multimorbidity in later life is central to healthy ageing and health equity^[6].

Education is widely recognized as a key social determinant of health. Unlike income and occupation, educational attainment is typically established early in life and can shape health over the long term through multiple pathways, including health literacy, risk perception, preventive behaviours, healthcare utilization, and chronic disease management^[7, 8]. Lower educational attainment may limit individuals' ability to obtain, understand, and use health information, and narrow opportunities for timely screening, diagnosis, and continuous disease management. These education-related differences are particularly consequential for chronic conditions such as hypertension, diabetes, and dyslipidemia, which are often asymptomatic and rely largely on health examinations or laboratory testing for detection. Among older

adults, education may therefore shape not only the occurrence and accumulation of chronic disease, but also whether diseases are detected, diagnosed, understood, remembered, and reported.

Important evidence gaps remain in research on educational inequality and multimorbidity. Most existing studies identify chronic conditions and multimorbidity from self-reported physician diagnoses. Yet self-reported information does not straightforwardly reflect underlying disease status. Research on health measurement in social surveys has long emphasized that self-reported morbidity may diverge from clinically assessed morbidity^[9]. Evidence from hypertension research further suggests that relying on subjective rather than objective health measures can alter the estimated socioeconomic gradient in health^[10]. In lower-income settings, self-reported morbidities may be especially sensitive to differences in healthcare access and disease awareness^[11]. For conditions like hypertension, diabetes, and dyslipidemia, reliance on self-reported information alone may therefore underestimate the true burden of multimorbidity, particularly when these conditions are asymptomatic or screening-dependent.

More importantly, chronic disease underreporting may itself be educationally patterned. Older adults with lower educational attainment may be less likely to undergo routine health examinations and more likely to struggle with understanding or recalling diagnostic information. Low health literacy has been linked to poorer health knowledge, worse health outcomes, and less effective use of health services^[12]. In China, biomarker-based evidence indicates that socioeconomic differences in older adults' health may not be fully captured by self-reported health information^[13]. If underreporting varies systematically across educational groups, self-reported multimorbidity may underestimate education-related differences in disease burden. Indeed, recent evidence has further suggested that tests of cumulative advantage and disadvantage in chronic disease trajectories may be biased when underreporting is ignored^[14]. Examining the educational patterning of underreporting is therefore essential to understanding how health inequalities come to be identified in later life.

China provides a valuable setting for examining this research question. Older Chinese adults have lived through rapid social transformation, and educational opportunities varied substantially across birth cohorts, so that individuals with low educational attainment still make up a large proportion of the oldest age groups. At the same time, China bears a heavy burden of chronic disease and cardiometabolic risk factors in later life^[15]. Globally, large pooled analyses reveal persistent gaps in the detection, treatment, and control of hypertension, diabetes, and non-optimal cholesterol^[16–18]. In China, nationally representative survey data showed that the awareness and control rates of hypertension among adults were 46.9% and 15.3%, respectively^[19]. The diagnosis awareness of diabetes was 36.7%^[20], and the awareness and control rates of dyslipidemia were 31.0% and 8.9%, respectively^[21]. These gaps suggest that a substantial proportion of cardiometabolic conditions may remain undiagnosed or unreported in population surveys. Whether lower educational attainment carries a higher risk of chronic disease underreporting among older Chinese adults is therefore central to understanding education-related differences in disease recognition and later-life health inequality.

Against this background, this study used five waves of the China Health and Retirement Longitudinal Study from 2011 to 2020^[22]. By integrating self-reported diagnoses, objective physical measurements, laboratory biomarkers, and medication information, we constructed both self-reported multimorbidity and underreporting-corrected multimorbidity outcomes. The study had three objectives: first, to compare the burden of multimorbidity under self-reported and corrected outcome definitions; second, to examine whether the association between educational attainment and multimorbidity differs across these outcome definitions, including its age-related patterning; and third, to assess whether underreporting of hypertension, diabetes, and dyslipidemia is patterned by educational attainment. By incorporating chronic disease underreporting into the analytical framework of educational inequality, this study offers empirical evidence for more accurately identifying education-related health inequalities in multimorbidity among older adults in China.

2 Methods

2.1 Data source and study population

This study drew on five waves of the China Health and Retirement Longitudinal Study (CHARLS), conducted in 2011, 2013, 2015, 2018, and 2020. CHARLS is a nationally representative longitudinal survey of middle-aged and older adults in China that collects information on sociodemographic characteristics, health status, self-reported chronic conditions, physical measurements, biomarkers, and healthcare utilization^[22]. The 2011 wave served as the study baseline.

Of the 17,708 participants who completed the 2011 baseline survey, 10,148 were excluded for being younger than 60 years or had missing age information. Among the remaining 7,560 participants aged 60 years or older, 654 were excluded because they had no follow-up interview in 2013, 2015, 2018, or 2020 and/or missing data on key baseline variables (sex, urban–rural residence, educational attainment, and baseline multimorbidity status). The final analytic sample comprised 6,906 older adults, contributing 29,584 person-wave observations (Figure 1).

2.2 Measures

2.2.1 Educational attainment

Educational attainment was defined by the highest level of education reported during face-to-face interviews. Reflecting its distribution in the study population, we grouped educational attainment into three groups: less than primary school, primary or middle school, and high school or above. The less-than-primary-school group served as the reference category in all analyses.

2.2.2 Multimorbidity outcomes

We constructed two longitudinal multimorbidity outcomes. The first was self-reported multimorbidity, defined based on self-reported physician diagnoses of 14 chronic conditions: hypertension, dyslipidemia,

diabetes, cancer, chronic lung disease, liver disease, heart disease, stroke, kidney disease, digestive disease, psychiatric or emotional problems, memory-related disease, arthritis, and asthma. At each survey wave, participants with two or more coexisting chronic conditions were classified as having self-reported multimorbidity^[4].

The second outcome was underreporting-corrected multimorbidity. Based on the self-reported chronic conditions described above, we further reclassified hypertension, diabetes, and dyslipidemia using available objective measurements, laboratory biomarkers, and relevant medication use. The remaining chronic conditions continued to be defined by self-reported physician diagnoses. Participants with two or more chronic conditions in the same survey wave after this correction were classified as having underreporting-corrected multimorbidity. This correction was intended to reduce potential measurement bias arising from reliance on self-reported chronic disease information^[13, 14].

Corrected hypertension was defined as self-reported hypertension, systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or current use of antihypertensive medication^[23]. Corrected diabetes was defined as self-reported diabetes, fasting plasma glucose ≥ 126 mg/dL, glycated hemoglobin $\geq 6.5\%$, or current use of glucose-lowering medication^[24]. Corrected dyslipidemia was defined as self-reported dyslipidemia, current use of lipid-lowering medication, triglycerides ≥ 150 mg/dL, total cholesterol ≥ 240 mg/dL, low-density lipoprotein cholesterol ≥ 160 mg/dL, or reduced high-density lipoprotein cholesterol, defined as < 40 mg/dL in men and < 50 mg/dL in women^[25].

2.2.3 Chronic disease underreporting

For hypertension, diabetes, and dyslipidemia, underreporting was defined as the absence of a self-reported physician diagnosis in a participant who nonetheless met the corrected criteria for the condition based on objective measurements, laboratory biomarkers, or medication use. We constructed separate indicators for underreported hypertension, underreported diabetes, and underreported dyslipidemia. Participants with underreporting of at least one of these three conditions were classified as having any chronic disease underreporting. Because identification of underreporting required objective measurement, biomarker, or medication data, the sample size for these analyses was smaller than the full baseline analytic sample.

2.2.4 Covariates

Covariates in the main longitudinal analyses comprised baseline age, sex, urban–rural residence, birth cohort, and survey wave. Baseline age was defined as age in 2011 and centered before model estimation. Where reported, birth cohort was based on year of birth; when this was missing, year of birth was imputed by subtracting baseline age from 2011.

Baseline total household income was additionally included in sensitivity analyses to assess whether the association between educational attainment and multimorbidity, including its age-related patterning, was robust to further adjustment for household economic resources. Missing baseline total household

income was handled using multiple imputation by chained equations (MICE). The imputed household income variable was log-transformed before being included in the sensitivity models.

In analyses of factors associated with chronic disease underreporting, we added variables reflecting health behaviours, healthcare contact, and functional status. These included current smoking, current drinking, physical inactivity, overweight or obesity, having a regular doctor, usually seeking care at a hospital, health insurance coverage, cognitive score, self-rated memory, and activities of daily living. These variables were used to explore whether behavioural risks, healthcare access, and health recognition capacity were associated with the social patterning of chronic disease underreporting.

2.3 Statistical analysis

Categorical variables were summarized as frequencies and percentages, and continuous variables as means and standard deviations. Baseline characteristics were compared across educational groups.

Using the five-wave longitudinal data, generalized estimating equation models were applied to examine the association between educational attainment and multimorbidity, with self-reported multimorbidity and underreporting-corrected multimorbidity fitted as separate outcomes^[26]. An interaction term between educational attainment and centered baseline age was included to assess whether educational differences in multimorbidity varied by age. Models were adjusted for baseline age, sex, urban–rural residence, birth cohort, and survey wave. An exchangeable working correlation structure was specified, and robust standard errors were used.

Rather than separately identifying the independent effects of age, period, and cohort which are confounded by generational composition and historical change, we included birth cohort and survey wave as covariates and interpreted the education-by-age interaction as age-related heterogeneity in educational differences after this adjustment.

In the baseline sample, logistic regression models were used to examine factors associated with underreported hypertension, underreported diabetes, underreported dyslipidemia, and any chronic disease underreporting. As a sensitivity analysis, the main longitudinal GEE models were refitted with additional adjustment for baseline total household income. Missing income values were handled using multiple imputation by chained equations (MICE), and the imputed total household income variable was log-transformed before model inclusion. Results were considered robust if the direction of the main associations and the statistical conclusions did not materially change.

2.4 Ethics approval

The China Health and Retirement Longitudinal Study (CHARLS) was approved by the Institutional Review Board of Peking University. The approval number for the main household survey, including anthropometric measurements, was IRB00001052-11015, and the approval number for biomarker collection was IRB00001052-11014. Written informed consent was obtained from all participants. The

present study was a secondary analysis of de-identified CHARLS data and involved no direct contact with participants.

3 Results

3.1 Sample characteristics

The analysis included 6,906 older adults aged ≥ 60 years at the 2011 baseline who had completed at least one subsequent follow-up wave. At baseline, males accounted for 49.75% of the sample, and 76.51% of the participants resided in rural areas. Regarding educational attainment, 58.67% had an incomplete primary school education, 34.54% had completed primary or middle school, and 6.79% had attained a high school education or above. The predominant baseline age group was 60–69 years (64.35%), while those aged 70–79 years and ≥ 80 years accounted for 28.79% and 6.86%, respectively. At baseline, the prevalence of self-reported multimorbidity was 45.40%, whereas the corrected prevalence was 62.93% (Table 1).

Table 1
Baseline characteristics of the study participants stratified by educational attainment.

Variable	Total	Incomplete primary school	Primary/Middle school	High school and above	P value
Age (years), Mean (SD)	68.00 (6.67)	68.92 (7.26)	66.42 (5.38)	68.06 (5.87)	< 0.001
Sex					< 0.001
Male	3,436 (49.75)	1,483 (36.60)	1,613 (67.63)	340 (72.49)	
Female	3,470 (50.25)	2,569 (63.40)	772 (32.37)	129 (27.51)	
Residence					< 0.001
Urban	1,622 (23.49)	452 (11.15)	774 (32.45)	396 (84.43)	
Rural	5,284 (76.51)	3,600 (88.85)	1,611 (67.55)	73 (15.57)	
Birth cohort					< 0.001
1929	299 (4.33)	250 (6.17)	35 (1.47)	14 (2.99)	
1930–1939	1,585 (22.95)	1,113 (27.47)	370 (15.51)	102 (21.75)	
1940–1949	3,860 (55.89)	2,024 (49.95)	1,543 (64.70)	293 (62.47)	
1950–1955	1,112 (16.83)	665 (16.41)	437 (18.32)	60 (12.79)	
Self-reported multimorbidity					< 0.001
0–1 chronic condition	3,771 (54.60)	2,294 (56.61)	1,241 (52.03)	236 (50.32)	
≥chronic conditions	3,135 (45.40)	1,758 (43.39)	1,144 (47.97)	233 (49.68)	
Corrected multimorbidity					0.503
0–1 chronic condition	2,560 (37.07)	1,520 (37.51)	862 (36.14)	178 (37.95)	

Variable	Total	Incomplete primary school	Primary/Middle school	High school and above	<i>P</i> value
≥ 2 chronic conditions	4,346 (62.93)	2,532 (62.49)	1,523 (63.86)	291 (62.05)	

3.2 Comparison of self-reported and corrected outcomes

In the Generalized Estimating Equation (GEE) models, when self-reported multimorbidity was defined as the outcome, the interaction between educational attainment and age was not statistically significant ($P = 0.762$)(Table 2). Conversely, when corrected multimorbidity was used as the outcome, the education-by-age interaction term reached statistical significance ($P = 0.019$)(Table 2). Specifically, the odds ratios (ORs) for the interaction of age with the primary/middle school group and the high school and above group were 1.011 (95% CI:1.000–1.023, $P = 0.049$) and 1.025(95% CI: 1.004–1.046, $P = 0.021$), respectively. To further visually illustrate the age-related trajectories of multimorbidity among older adults across different educational levels, interaction plots of predicted probabilities were generated based on both the self-reported and corrected outcomes (Fig. 2).

Table 2

Generalized estimating equation model results for self-reported and corrected multimorbidity.

Variable	Self-reported multimorbidity		Corrected multimorbidity	
	OR (95% CI)	<i>P</i> value	OR (95% CI)	<i>P</i> value
Educational attainment				
Incomplete primary school	1.00 (Ref)	—	1.00 (Ref)	—
Primary/Middle school	1.194 (1.078–1.321)	< 0.001	1.185 (1.073–1.308)	< 0.001
High school and above	1.123 (0.922–1.367)	0.248	1.063 (0.877–1.288)	0.533
Age (mean-centered, continuous)	1.001 (0.985–1.018)	0.863	1.002 (0.986–1.019)	0.769
Education × Age interaction				
Primary/Middle school × Age	1.004 (0.992–1.015)	0.515	1.011 (1.000–1.023)	0.049
High school and above × Age	1.005 (0.984–1.027)	0.65	1.025 (1.004–1.046)	0.021
Overall education × age interaction	—	0.762	—	0.019
Birth cohort				
1929	1.00 (Ref)	—	1.00 (Ref)	—
1930–1939	1.231 (0.935–1.619)	0.138	1.383 (1.068–1.791)	0.014
1940–1949	1.194 (0.816–1.746)	0.362	1.324 (0.921–1.903)	0.129
1950–1955	1.167 (0.735–1.853)	0.513	1.300 (0.834–2.024)	0.246
Sex				
Male	1.00 (Ref)	—	1.00 (Ref)	—
Female	1.354 (1.237–1.482)	< 0.001	1.405 (1.288–1.533)	< 0.001
Residence				
Urban	1.00 (Ref)	—	1.00 (Ref)	—
Rural	0.686 (0.610–0.771)	< 0.001	0.728 (0.650–0.816)	< 0.001

Variable	Self-reported multimorbidity		Corrected multimorbidity	
	OR (95% CI)	<i>P</i> value	OR (95% CI)	<i>P</i> value
Educational attainment				
Survey wave				
2011	1.00 (Ref)	—	1.00 (Ref)	—
2013	1.258 (1.208–1.310)	< 0.001	0.758 (0.719–0.798)	< 0.001
2015	2.140 (1.980–2.313)	< 0.001	1.767 (1.628–1.919)	< 0.001
2018	2.615 (2.303–2.969)	< 0.001	1.211 (1.069–1.372)	0.003
2020	2.956 (2.521–3.465)	< 0.001	1.354 (1.159–1.581)	< 0.001

3.3 Factors associated with underreporting

Baseline analysis revealed that the underreporting rates for hypertension, diabetes, and dyslipidemia were 16.25%, 7.01%, and 31.29%, respectively. Furthermore, 44.70% of the respondents underreported at least one chronic condition.

Logistic regression analysis indicated that the underreporting of chronic conditions was significantly associated with educational attainment, demographic characteristics, and healthcare utilization factors. In the fully adjusted models, the underreporting of hypertension was significantly associated with older age and rural residence, whereas having a regular physician was associated with a lower risk of underreporting. The factors associated with the underreporting of diabetes were relatively less pronounced, with only a self-rated memory of "fair" significantly linked to a higher risk of underreporting. Regarding dyslipidemia, females exhibited a higher risk of underreporting, whereas attaining a high school education or above and usually seeking care at a hospital were associated with a reduced risk. For the underreporting of any chronic condition, both increasing age and female sex were associated with an elevated risk, while usually seeking care at a hospital was linked to a lower risk. These results are visualized in the forest plot in Fig. 3.

3.4 Sensitivity analysis

For the sensitivity analysis, multiple imputation by chained equations (MICE) was employed to address missing baseline total household income. The imputed and log-transformed total household income was subsequently incorporated into the models, and interaction plots of predicted probabilities were generated (Fig. 4). The results demonstrated that the education-by-age interaction term remained

statistically non-significant in the self-reported multimorbidity model ($P = 0.8882$), and significant in the corrected multimorbidity model ($P = 0.0495$).

4 Discussion

This study examined the association between educational attainment and multimorbidity among older adults in China, focusing on whether chronic disease underreporting affects the identification of education-related differences. Three main findings emerged. First, reliance on self-reported chronic disease information substantially underestimated multimorbidity burden. At baseline, the prevalence of multimorbidity was 45.40% based on self-reported diagnoses, but increased to 62.93% after incorporating objective measurements, laboratory biomarkers, and medication information for hypertension, diabetes, and dyslipidemia. Second, the education-by-age interaction was not statistically significant when multimorbidity was defined using self-reported diagnoses, but became statistically significant after correction for underreporting. This suggests that chronic disease underreporting may obscure age-related educational patterning in multimorbidity. Third, underreporting differed across disease types and social groups. Dyslipidemia showed the highest level of underreporting, and underreporting was associated with educational attainment, age, sex, and healthcare contact. The main findings remained stable after additional adjustment for household income.

Our findings are consistent with prior evidence that multimorbidity is socially patterned. Population-based studies from Scotland and England have shown that people in more deprived areas develop multimorbidity and complex multimorbidity at younger ages^[4, 5]. More recent longitudinal and cross-national evidence also suggests that socioeconomic disadvantage is associated with greater accumulation of chronic conditions and unequal distributions of physical, psychological, and cognitive multimorbidity^[3, 27]. The current study extends this literature by showing that education-related differences in multimorbidity may also be shaped by unequal recognition and reporting of chronic disease.

The difference between self-reported and underreporting-corrected multimorbidity in this study was notable. This finding is in line with research showing that self-reported morbidity may differ from objective or biomarker-based indicators, and that such differences can influence estimates of socioeconomic gradients in health^[9–11]. In our study, underreporting affected hypertension, diabetes, and dyslipidemia, in 16.25%, 7.01%, and 31.29% of cases, respectively. Among participants with sufficient information for classification, 44.70% had at least one underreported condition. Dyslipidemia showed the highest level of underreporting, which is plausible because it is usually asymptomatic and depends largely on laboratory testing for identification. This pattern is also consistent with national evidence from China indicating suboptimal awareness and control of cardiometabolic conditions: the awareness and control rates were 46.9% and 15.3% for hypertension, the diagnosis awareness of diabetes was 36.7%, and the awareness and control rates were 31.0% and 8.9% for dyslipidemia^[19–21]. These findings suggest that studies based only on self-reported diagnoses may miss a meaningful share of chronic disease burden, especially for screening-dependent conditions.

Our results further suggest that chronic disease underreporting is not randomly distributed. Older adults with lower educational attainment may have fewer opportunities for routine examinations, lower health literacy, and more limited ability to understand or recall diagnostic information. In descriptive analyses, the absolute increase from self-reported to corrected multimorbidity was larger among participants with less than primary education than among those with high school education or above. Among the lowest educational group, multimorbidity increased from 43.39% to 62.49% after correction; among those with high school education or above, it increased from 49.68% to 62.05%. The regression results pointed in the same direction. Compared with participants with less than primary education, those with high school education or above had a lower risk of underreported dyslipidemia (OR = 0.643, 95% CI: 0.477–0.867). Healthcare contact was also associated with lower underreporting: having a regular doctor was associated with lower hypertension underreporting (OR = 0.794, 95% CI: 0.659–0.957), while usually seeking care at a hospital was associated with lower dyslipidemia underreporting (OR = 0.759, 95% CI: 0.624–0.924) and lower risk of any underreporting (OR = 0.744, 95% CI: 0.615–0.901). These findings are consistent with evidence from China that biomarkers can reveal health inequalities among older adults that are not fully captured by self-reported measures^[13]. They also align with recent evidence showing that underreporting can bias tests of cumulative advantage and disadvantage in chronic disease trajectories^[14].

This measurement perspective may help explain why previous studies have reached different conclusions about whether educational differences in health widen, remain stable, or narrow in later life. When multimorbidity is measured using self-reported diagnoses, education-related differences may be affected by unequal disease awareness and reporting. In this study, the education-by-age interaction was not statistically significant when multimorbidity was defined using self-reported information. After incorporating objective measurements, laboratory biomarkers, and medication information, however, the interaction became statistically significant. This pattern suggests that underreporting may mask age-related heterogeneity in education-related differences in multimorbidity. Accordingly, chronic disease underreporting should not be viewed only as a minor data-quality problem; it may also affect substantive conclusions about later-life health inequalities. This issue is particularly relevant for multimorbidity research, because different definitions and measurement strategies can lead to different estimates of prevalence, social gradients, and policy priorities.

More broadly, lower socioeconomic status has been associated with the development of mental and physical health conditions and with premature mortality[28,29]. From a public health perspective, these findings call for caution in using self-reported chronic disease information to monitor multimorbidity and health inequalities among older adults. Self-reported diagnoses remain valuable in large population surveys because they are feasible and inexpensive. However, for conditions that are asymptomatic, screening-dependent, or unequally diagnosed, self-reported information alone may be insufficient. Where possible, studies of multimorbidity should integrate physical measurements, laboratory biomarkers, and medication information to improve disease classification. In practice, reducing education-related inequalities in disease recognition requires more than improving individual awareness. It also requires

routine screening, health education, primary care follow-up, and continuity of care for older adults with lower educational attainment. Improving disease detection among disadvantaged groups may help identify hidden morbidity and provide a more accurate basis for chronic disease management and health equity policies.

This study has several strengths. First, it used five waves of nationally representative longitudinal data from CHARLS, allowing us to examine multimorbidity and educational differences among older adults in China over an extended period. Second, instead of relying solely on self-reported physician diagnoses, this study incorporated objective measurements, laboratory biomarkers, and medication information to construct underreporting-corrected multimorbidity outcomes. This approach helped reduce measurement bias arising from self-reported chronic disease information. Third, this study explicitly examined chronic disease underreporting and its social patterning, providing evidence that educational differences in disease recognition may influence estimates of multimorbidity and later-life health inequalities. This contribution is relevant to recent calls for more precise assessment of multimorbidity and its social determinants in ageing populations^[30].

Several limitations should also be acknowledged. First, correction for underreporting was conducted only for hypertension, diabetes, and dyslipidemia, because these conditions had available objective measurements, biomarkers, and medication information in CHARLS. Other chronic conditions were still defined based on self-reported physician diagnoses. Therefore, the overall burden of underreported chronic disease and corrected multimorbidity may still be underestimated. Second, biomarker and medication information was not equally available for all participants and all survey waves, which may have reduced the sample size for underreporting analyses and introduced potential selection bias. Third, mortality and loss to follow-up are unavoidable in longitudinal studies of older adults. If attrition differs by education, health status, or disease awareness, estimates of age-related educational patterning may be affected. Finally, this was an observational study. Although we adjusted for key sociodemographic factors and conducted sensitivity analyses with household income, residual confounding cannot be completely ruled out.

5 Conclusions

This study found that reliance on self-reported chronic disease information alone substantially underestimated the multimorbidity burden among older adults in China. After incorporating objective measurements, laboratory biomarkers, and medication information, the age-related patterning of education-related differences in multimorbidity became more clearly identifiable. Chronic disease underreporting was associated with educational attainment and healthcare contact, indicating that it is not merely a data-quality issue but also reflects social differences in disease detection, diagnosis, and awareness.

These findings highlight the need to consider measurement bias when using self-reported chronic disease data to study ageing and health inequality. Future population-based studies should, where

possible, integrate self-reported diagnoses with objective measurements, biomarkers, and medication information to improve the classification of multimorbidity. Public health efforts should also strengthen routine screening, health education, primary care follow-up, and continuity of care for older adults with lower educational attainment, so that hidden chronic disease burden can be better identified and managed.

Declarations

Ethics approval and consent to participate

The China Health and Retirement Longitudinal Study (CHARLS) was approved by the Biomedical Ethics Review Committee of Peking University. The approval number for the main household survey, including anthropometric measurements, was IRB00001052-11015, and the approval number for biomarker collection was IRB00001052-11014. Written informed consent was obtained from all participants prior to participation. The present study was a secondary analysis of publicly available, de-identified CHARLS data and involved no direct contact with participants. All methods and study procedures were carried out in accordance with the Declaration of Helsinki and relevant institutional and national ethical guidelines and regulations.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analyzed during the current study are available from the China Health and Retirement Longitudinal Study (CHARLS) through the official CHARLS data portal upon registration and approval. The authors do not have permission to redistribute the original individual-level CHARLS data.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

XF: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing – original draft.

LF: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing – original draft.

ZS: Methodology, Validation, Writing – review and editing.

CST: Methodology, Validation, Writing – review and editing.

JZ: Data curation, Validation, Writing – review and editing.

JQ: Data curation, Validation, Writing – review and editing.

XS: Investigation, Validation, Writing – review and editing.

HZ: Investigation, Validation, Writing – review and editing.

TL: Data curation, Validation, Writing – review and editing.

YM: Literature review, Validation, Writing – review and editing.

YZ: Clinical interpretation, Validation, Writing – review and editing.

BY: Conceptualization, Supervision, Project administration, Methodology, Writing – review and editing.

All authors read and approved the final manuscript.

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Figures

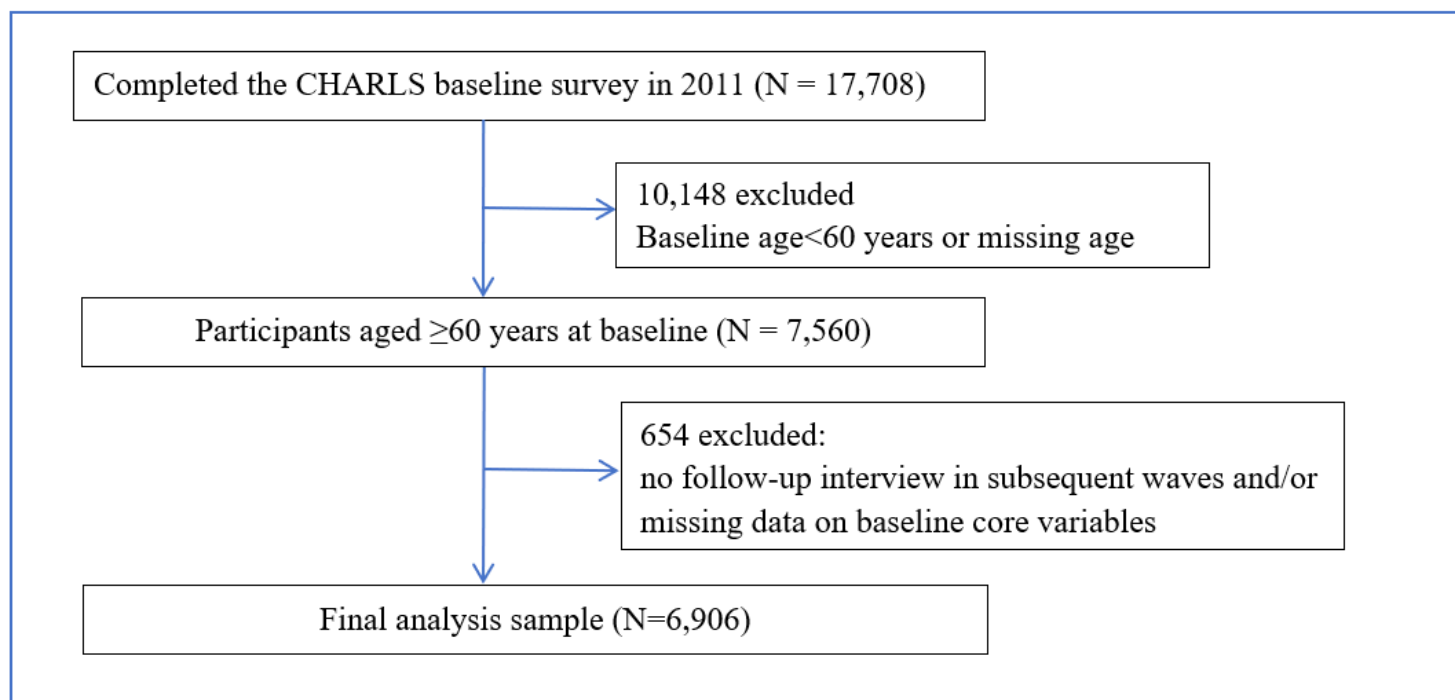


Figure 1

Study profile and flowchart of participant selection from the CHARLS 2011–2020 cohort

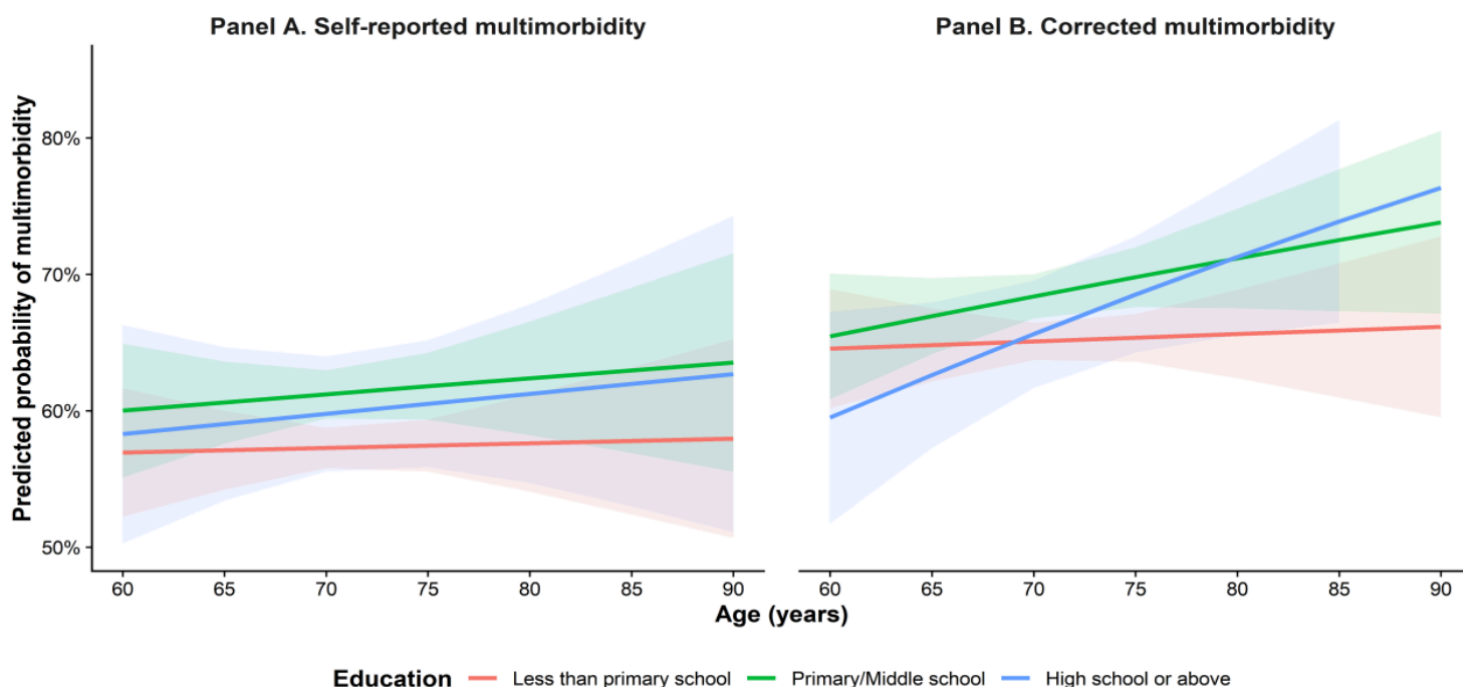


Figure 2

Interaction plots of predicted probabilities of self-reported and corrected multimorbidity among older adults across different educational levels

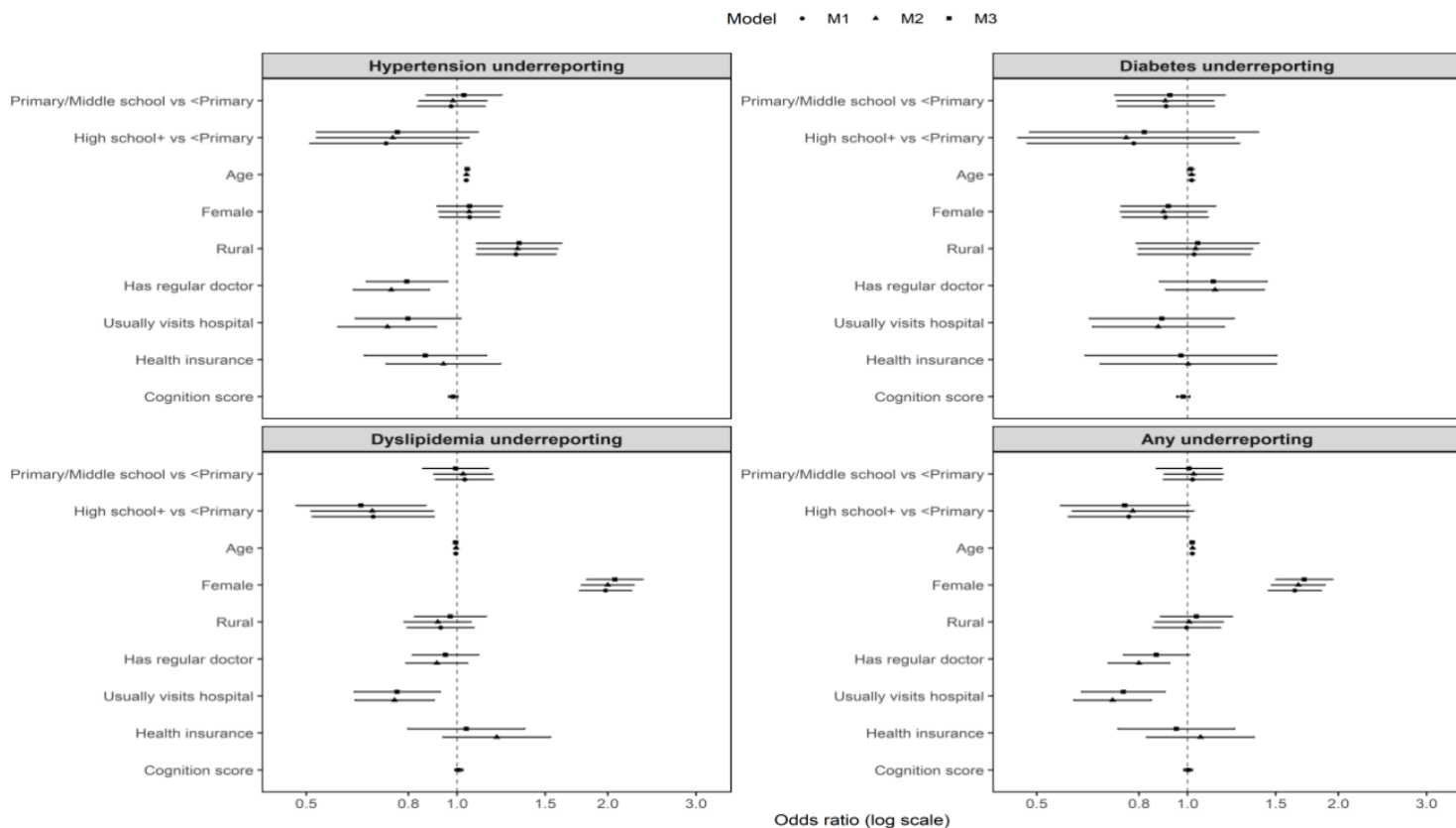


Figure 3

Forest plot of factors associated with the underreporting of common chronic conditions.

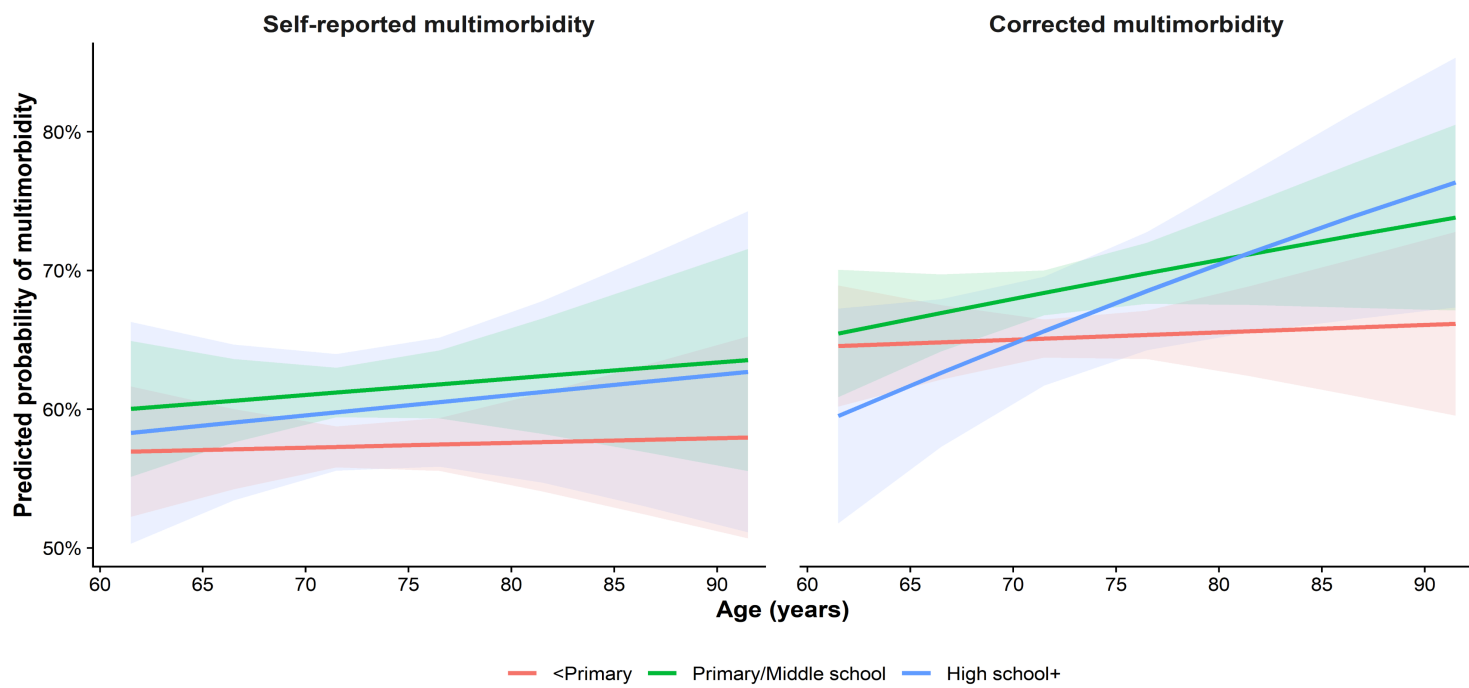


Figure 4

Interaction plot of self-reported versus corrected predicted probabilities of multiple chronic diseases among elderly individuals with different education levels after incorporating household total income into the model