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Reported physician-diagnosed prostate illness and subsequent falls among middle-aged and older Chinese men: a longitudinal population-based cohort study

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Abstract

Background

Falls are a major population-health concern in ageing societies. Prostate illness may identify men with broader health vulnerability, but diagnosis history, urinary symptom burden and treatment exposure are distinct constructs. We estimated the longitudinal association between self-reported physician-diagnosed prostate illness and subsequent falls in a population-based Chinese cohort.

Methods

We analysed five waves of the China Health and Retirement Longitudinal Study (2011–2020). The cohort included 5,036 men aged 45 years or older without reported prostate illness or falls at baseline, contributing 16,124 consecutive-wave intervals. Cumulative prostate illness history was updated at interval start, and any fall was assessed at the next interview. Binomial generalized estimating equations accounted for repeated observations. The primary model adjusted for age, baseline sociodemographic and health characteristics, province and interval period. Twenty-dataset multiple imputation assessed sensitivity to missing covariates. First reported follow-up hip fracture was an exploratory outcome.

Results

Falls were reported in 2,087 intervals. Fall-positive intervals accounted for 18.3% of exposed intervals and 12.5% of unexposed intervals. The period-adjusted odds ratio was 1.385 (95% confidence interval 1.162–1.650). The fully adjusted complete-case estimate was 1.108 (0.905–1.358; P = 0.320), and the multiple-imputation estimate was 1.196 (0.998–1.434; P = 0.053). The fully adjusted hip-fracture estimate was 1.679 (0.920–3.064), based on 128 events.

Conclusions

Reported prostate illness was followed by higher unadjusted fall occurrence, but the adjusted association was modest and imprecise. Population-health surveillance should not treat diagnosis history as a proxy for urinary symptoms or medication exposure. More specific measures of symptoms, treatment, function and care access are needed to identify actionable fall-prevention targets.

Clinical trial registration

Clinical trial number: not applicable. This study is a secondary observational analysis of CHARLS survey data and did not assign participants to an intervention.

Background

Falls are a major population-health problem because they can lead to injury, loss of independence, health-care use and long-term disability. Their determinants span medical, functional, behavioural and environmental domains, so prevention strategies require more than a single diagnostic label [1]. In ageing men, urinary and prostate-related health may be relevant to this wider prevention agenda because nocturia, urgency and treatment-related postural symptoms can affect mobility and daily activity.

Evidence linking prostate-related health with falls is heterogeneous because studies have assessed different exposure levels. A prospective cohort of men aged 65 years or older related graded lower urinary tract symptom (LUTS) severity to subsequent falls [2]. A population-based Korean study examined reported treatment for benign prostatic hyperplasia (BPH) [3], while medication studies assessed falls after initiation or use of specific alpha-antagonists [4, 5]. For population-health research, these findings should not be combined uncritically: diagnosis history, symptom severity and medication exposure represent different potential intervention targets.

A reported prostate diagnosis may also function as a marker of age, multimorbidity, health-care contact or unmeasured functional vulnerability. CHARLS analyses have described relationships between frailty trajectories and survey-defined BPH/LUTS, as well as the distribution of reported prostate illness in Chinese men [6, 7]. It is therefore important to estimate whether diagnosis history is associated with later fall reports after accounting for measured sociodemographic and health characteristics. Repeated survey waves allow this question to be examined with a clear temporal order at population level [8].

We investigated the association between interval-start reported prostate illness and any fall at the next interview among men initially free of reported prostate illness and recent falls. The primary analysis estimated a covariate-adjusted longitudinal association relevant to population surveillance and prevention planning. First reported follow-up hip fracture provided an exploratory outcome of public-health importance. The exposure was treated as diagnosis history, not as a proxy for a specific symptom or medication effect.

Methods

Study design and participants

This secondary cohort analysis used the 2011–2012 baseline and the 2013, 2015, 2018 and 2020 CHARLS follow-up waves. CHARLS is a population-based longitudinal survey of Chinese adults aged 45 years or older and their spouses [8]. Reporting was guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [9].

Eligible participants were men aged at least 45 years at baseline with known prostate illness and fall status who reported neither prostate illness nor a fall during the baseline recall period. Each participant had to contribute at least one eligible consecutive-wave interval with known prostate illness history at its

start and known any-fall status at its end. The observation intervals were 2011–2013, 2013–2015, 2015–2018 and 2018–2020. Participants could contribute more than one interval, including intervals after a follow-up fall. All eligible observations were used; the sample size was determined by data availability rather than an a priori power calculation.

Prostate illness history

Prostate illness was assessed using the CHARLS question about a physician-diagnosed prostate illness. The 2013 and 2015 item gives prostate hyperplasia as an example. We constructed a cumulative time-varying history at each interval start: once a positive diagnosis report was observed, subsequent intervals were classified as exposed. A negative history required negative reports in the relevant sequence; unresolved histories were not assigned to the unexposed group. The survey item identifies reported diagnosis history without a validated LUTS score, prostate measurement or medication-specific record. A consistent prostate-cancer exclusion was unavailable across waves; the exposure is therefore termed reported prostate illness.

Fall and hip-fracture outcomes

The primary outcome was any fall reported at the next interview for the period since the preceding interview. The baseline fall question used a two-year recall period. The analysis used the harmonized binary fall indicator rather than episode counts. The fall-count item recorded total falls in 2011–2015 and falls requiring medical treatment in 2018–2020, so it was not pooled into a cross-wave count, recurrent-fall or medically attended-fall outcome. Variable names and wording are documented in Additional file 1, Table S1.

The exploratory hip-fracture analysis excluded men with a positive or unknown baseline hip-fracture report and removed intervals after the first observed follow-up report. This outcome represents the first fracture reported during observed follow-up rather than a verified first lifetime fracture or a confirmed fall-related injury. Exact dates of falls and fractures within interview intervals were unavailable.

Covariates

The fully adjusted models included age at interval start and baseline rural residence, education, health insurance, ever smoking, ever drinking, self-rated health, depressive symptoms, sleep duration, body mass index (BMI), heart disease, stroke, diabetes, hypertension and chronic disease count. Depressive symptoms were represented by the 10-item Center for Epidemiologic Studies Depression Scale (CES-D-10). Baseline hip-fracture history was included in the any-fall model. Province and interval period were categorical terms. Apart from age, the covariates were baseline measurements. Covariate coding and missingness are detailed in Additional file 1.

Statistical analysis

Baseline characteristics are summarized as means with standard deviations or counts with percentages among participants with observed values. Outcome occurrence is reported as the number and percentage of intervals containing at least one reported event. The numerator for any fall is a fall-positive interval rather than the total number of falls. Exposure categories are time-varying, so a man may contribute intervals to both groups.

We fitted binomial generalized estimating equations (GEE) with a logit link, exchangeable working correlation and participant-clustered robust variance [10]. Odds ratios (ORs) and 95% confidence intervals (CIs) compare exposed with unexposed intervals. The period-adjusted model included prostate illness history and interval period; the primary complete-case model additionally included the covariates above. Each model used observations complete for its required variables. Comparisons across adjustment levels therefore involve both covariate adjustment and changes in analytic sample. Period terms account for differences between the four interview intervals. CHARLS survey weights were not applied; the estimates describe this restricted analytic cohort.

As a missing-data sensitivity analysis, chained-equation multiple imputation generated 20 participant-level baseline-covariate datasets using predictive mean matching, with baseline covariates, follow-up exposure and outcome summaries, and the number of observed intervals as predictors [11]. Exposure and follow-up outcomes were not imputed. The same fully adjusted GEE specification was fitted in each completed dataset, and log-OR estimates were combined using Rubin's rules [12]. The imputed hip-fracture sensitivity model also imputed the single unknown baseline fracture history, allowing its risk set to differ from the complete-case risk set. Details of implementation are supplied in Additional file 1 and Additional file 2.

Participant-clustered pooled logistic regression assessed sensitivity to model form. Tests were two-sided. Analyses used Python 3.12 with pandas, NumPy, SciPy and statsmodels. Analysis code and aggregate outputs are supplied in Additional file 2.

Use of AI-assisted tools

An AI assistant (OpenAI Codex) assisted with English-language editing, manuscript organization, code preparation and variable-harmonization checks. Statistical estimates were obtained from programmed regression models. The authors are responsible for independently reviewing the analysis, interpretation and submitted text.

Results

Participants and observed outcome occurrence

Of 17,671 baseline CHARLS participants, 8,304 were men aged at least 45 years. After excluding unknown prostate illness status, baseline reported prostate illness and baseline falls or unknown fall status, 5,759 men met baseline eligibility. The analytic cohort comprised 5,036 men with at least one eligible follow-up interval, contributing 16,124 intervals (Fig. 1). Mean baseline age was 59.2 years (standard deviation 9.2); 2,218 men (44.0%) were aged at least 60 years and 1,328 (26.4%) at least 65 years. Rural residents accounted for 62.6% of participants (Table 1).

There were 1,232 exposed intervals from 666 men and 14,892 unexposed intervals from 5,002 men; these participant counts overlap because exposure could change during follow-up. Falls were reported in 226 exposed intervals (18.3%) and 1,861 unexposed intervals (12.5%), for 2,087 fall-positive intervals overall (Table 2). The hip-fracture risk set contained 15,725 intervals from 4,979 men, with 146 first observed follow-up reports. Fracture-positive intervals accounted for 1.4% of exposed intervals and 0.9% of unexposed intervals.

Baseline BMI was missing for 785 men (15.6%), whereas each other listed baseline covariate was missing for fewer than 2% (Additional file 1, Table S2). The fully adjusted any-fall analysis included 13,505 intervals from 4,133 men and 1,709 fall-positive intervals.

Longitudinal associations

For any fall, the period-adjusted OR was 1.385 (95% CI 1.162–1.650). The fully adjusted complete-case OR was 1.108 (0.905–1.358; P=0.320) (Table 3; Fig. 2). The covariate-adjusted estimate was closer to the null, and its confidence interval included both no association and a modest increase in fall odds.

For first reported follow-up hip fracture, the period-adjusted OR was 1.711 (1.003–2.919). The fully adjusted OR was 1.679 (0.920–3.064; P=0.092), based on 128 events. The wider interval reflects substantially lower precision than for the any-fall outcome.

Sensitivity analyses

The multiple-imputation OR for any fall was 1.196 (95% CI 0.998–1.434; P=0.053), compared with 1.108 in the complete-case analysis. The imputed hip-fracture OR was 1.702 (0.985–2.940; P=0.056). These estimates describe sensitivity to missing-covariate handling rather than an independent replication (Table 3).

The fully adjusted pooled-logistic any-fall estimate was 1.146 (0.928–1.415). Full sensitivity results and descriptive interval-specific fall occurrence are reported in Additional file 1, Tables S3–S5.

Discussion

In this longitudinal cohort, men contributed a higher proportion of fall-positive intervals after reporting a prostate illness diagnosis. The association was modest and imprecise after adjustment for age and measured baseline health and sociodemographic characteristics. Hip-fracture estimates were less precise. The principal clinical distinction is between the unadjusted co-occurrence of a urological diagnosis with falls and the smaller conditional association observed within the adjusted model.

This distinction helps place the findings alongside symptom- and treatment-specific studies. Parsons and colleagues used graded LUTS severity in older men, whereas the Korean study assessed BPH treatment history [2, 3]. Studies of prostate-selective alpha-antagonists evaluated medication exposure or initiation, including an early period after a new prescription [4, 5]. The CHARLS diagnosis item identifies a broader group. A weaker diagnosis-level association can coexist with clinically relevant associations for nocturia, severe symptoms or particular treatment exposures; those constructs are not interchangeable.

Prostate illness diagnosis occurs alongside other characteristics relevant to falling, including age, multimorbidity and contact with healthcare. CHARLS evidence relating frailty to subsequent survey-defined BPH/LUTS reinforces the overlap between urological health and broader public-health vulnerability [6]. The difference between the period-adjusted and fully adjusted estimates is consistent with the importance of this broader health profile. Because the models also differ in sample composition, the present comparison does not isolate which covariates account for that difference.

For population-health surveillance and prevention, the next step is more specific exposure characterization: nocturia and urgency burden, timing and class of medication, orthostatic symptoms, functional vulnerability and access to care. These measures could distinguish symptom-related mobility risk from treatment-related postural effects and identify potentially actionable groups. Diagnosis history alone does not provide that distinction, and this analysis did not evaluate a prediction model or a screening intervention.

Strengths and limitations

The study uses a large population-based longitudinal survey, repeated exposure assessments, temporally ordered follow-up outcomes and participant-clustered models. It retains a consistent binary fall endpoint across five survey waves and makes cross-wave outcome definitions, missingness and analytic choices explicit. These features support a population-level estimate while avoiding claims that the diagnosis item is a clinical risk score.

Several features constrain interpretation. The self-reported prostate illness item is heterogeneous and may include conditions other than BPH; symptom severity, prostate size and medication timing were not characterized. Self-reported outcomes and interval-based recall introduce measurement error, with no verified event dates. The cohort excludes baseline reported prostate illness and recent falls and requires an observed follow-up interval, creating scope for selection and attrition bias. Most covariates were measured only at baseline, and functional status, orthostatic symptoms and healthcare-use patterns

were not included in the adjustment set. The analysis did not use survey weights or explicitly model household or community clustering, so estimates should not be extrapolated as national prevalence or incidence measures. Finally, missing-data sensitivity estimates depend on the imputation assumptions, and the low number of fractures leaves substantial uncertainty about that exploratory association.

Conclusions

In this population-based cohort, self-reported physician-diagnosed prostate illness was followed by higher unadjusted fall occurrence, but the adjusted association was modest and imprecise. Diagnosis history should not be used as a substitute for urinary symptom, medication, functional or care-access measures in population-health surveillance. Future studies should combine these domains to identify specific and actionable fall-prevention targets for middle-aged and older men.

Abbreviations

BMI, body mass index; BPH, benign prostatic hyperplasia; CES-D-10, 10-item Center for Epidemiologic Studies Depression Scale; CHARLS, China Health and Retirement Longitudinal Study; CI, confidence interval; GEE, generalized estimating equations; LUTS, lower urinary tract symptoms; OR, odds ratio; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.

Declarations

Ethics approval and consent to participate

Human ethics approval for the original CHARLS survey was granted by the Institutional Review Board at Peking University (IRB00001052-11015). Written informed consent was obtained from participants for the original survey [13]. This secondary analysis used de-identified survey data and involved no new participant recruitment or intervention. No additional ethics approval was sought for this secondary analysis.

Consent for publication

Not applicable.

Clinical trial registration

Clinical trial number: not applicable. This study is a secondary observational analysis of CHARLS survey data and did not assign participants to an intervention.

Ethics approval and consent to participate

The original CHARLS survey was approved by the Institutional Review Board of Peking University (IRB00001052-11015) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants. This study was a secondary analysis of de-identified CHARLS data, with no new participant recruitment or intervention. No additional ethics approval was sought for this secondary analysis.

Availability of data and materials

The data analysed in this study are available from the official CHARLS data platform subject to its registration and data-use requirements [14]. The survey waves used were the 2011–2012 baseline and the 2013, 2015, 2018 and 2020 follow-ups. Analysis code, variable mappings and aggregate output tables are included in Additional file 2. Participant-level CHARLS data are not redistributed in the supplementary files.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Baseline characteristics of the analytic cohort

Characteristic	Value
Participants	5,036
Age, years, mean (SD)	59.2 (9.2)
Age 45–59 years	2,818 (56.0)
Age 60–64 years	890 (17.7)
Age at least 65 years	1,328 (26.4)
Rural residence	3,153 (62.6)
Ever smoking	3,708 (73.6)
Ever drinking	3,276 (65.1)
Health insurance	4,726 (94.3)
CES-D-10 score, mean (SD)	6.9 (5.5)
Sleep duration, hours, mean (SD)	6.6 (1.8)
BMI, kg/m², mean (SD)	23.0 (3.6)
Heart disease	466 (9.3)
Stroke	121 (2.4)
Diabetes	249 (5.0)
Hypertension	1,150 (22.9)
Chronic disease count, mean (SD)	1.2 (1.3)
Baseline reported hip fracture	54 (1.1)

Values are n (%) unless otherwise specified. Percentages use non-missing denominators. All covariate missingness is reported in Additional file 1. BMI, body mass index; CES-D-10, 10-item Center for Epidemiologic Studies Depression Scale; SD, standard deviation.

Table 2 Reported outcome occurrence by interval-start prostate illness history

Outcome	Reported prostate illness	Positive / eligible intervals	Positive intervals (%)
Any fall	No	1,861 / 14,892	12.5
Any fall	Yes	226 / 1,232	18.3
First follow-up hip fracture	No	129 / 14,546	0.9
First follow-up hip fracture	Yes	17 / 1,179	1.4

These are unadjusted interval proportions, not individual episode counts or incidence rates. A man may contribute both exposed and unexposed intervals. The hip-fracture risk set excludes positive or unknown baseline fracture reports and intervals after the first observed follow-up fracture. Interview interval lengths differ across waves.

Table 3 Associations between reported prostate illness and subsequent outcomes

Outcome	Analysis	OR (95% CI)	P value	Intervals	Men	Positive intervals
Any fall	Period-adjusted GEE	1.385 (1.162-1.650)	<0.001	16,124	5,036	2,087
Any fall	Adjusted CC GEE	1.108 (0.905-1.358)	0.320	13,505	4,133	1,709
Any fall	Adjusted MI GEE	1.196 (0.998-1.434)	0.053	16,124	5,036	2,087
First follow-up hip fracture	Period-adjusted GEE	1.711 (1.003-2.919)	0.049	15,725	4,979	146
First follow-up hip fracture	Adjusted CC GEE	1.679 (0.920-3.064)	0.092	13,159	4,087	128
First follow-up hip fracture	Adjusted MI GEE	1.702 (0.985-2.940)	0.056	15,729	4,980	146

CC, complete case; CI, confidence interval; GEE, generalized estimating equations; MI, multiple imputation; OR, odds ratio. Period-adjusted models include interval period. Adjusted models also include age at interval start, baseline covariates and province, with baseline hip-fracture history in the any-fall model. Model denominators differ according to missingness. In the imputed hip-fracture analysis, the single missing baseline fracture status was imputed and the risk set was recalculated; reported denominators are rounded averages across 20 imputations. ORs and CIs use three decimal places to avoid rounding a confidence limit across the null.

Figures

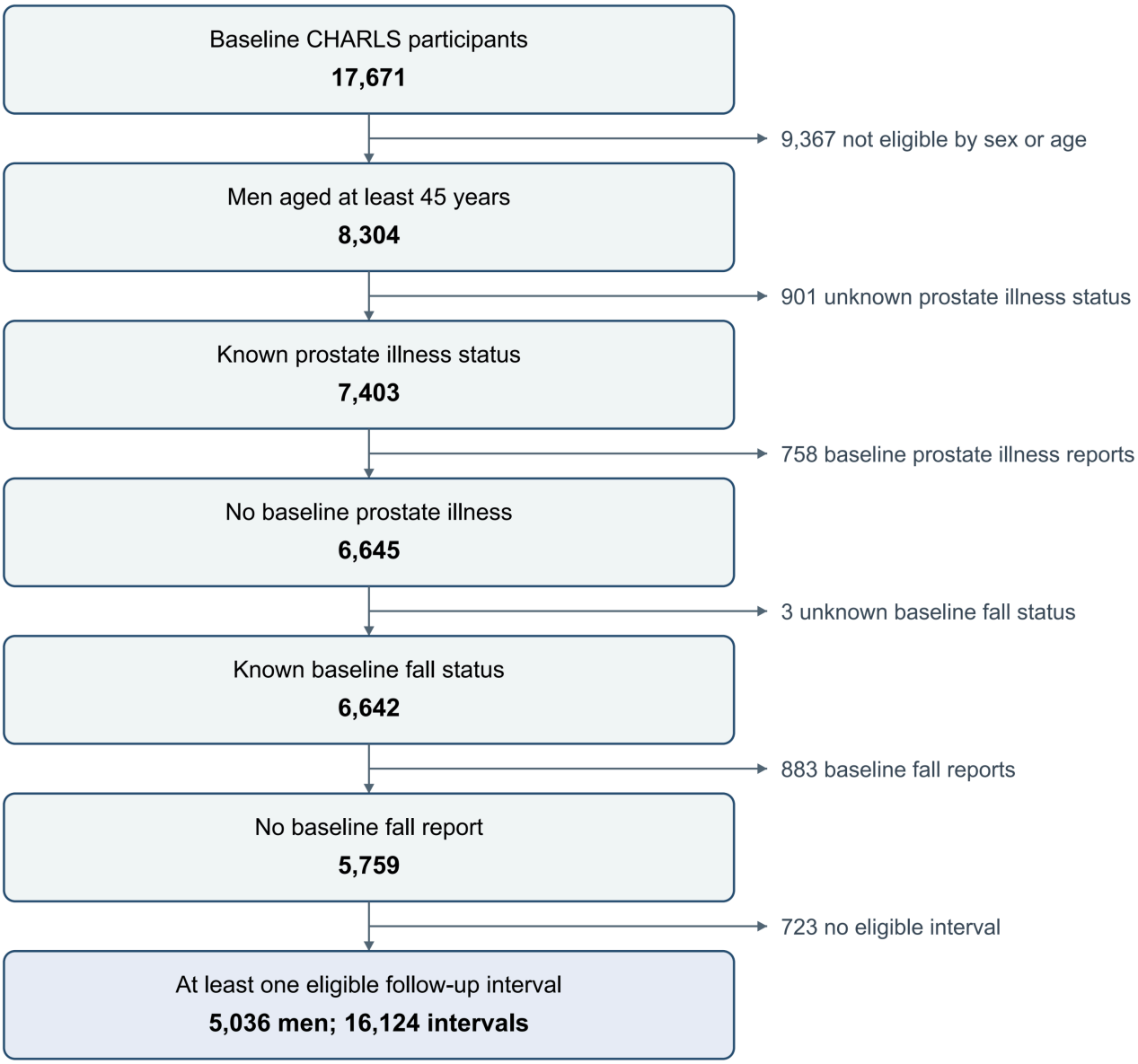


Figure 1

Participant selection and eligible follow-up intervals

Selection of the CHARLS cohort from the baseline survey to the longitudinal analytic sample. Baseline falls refer to the two-year recall period. Eligible consecutive-wave intervals require known interval-start prostate illness history and known next-interview any-fall status.

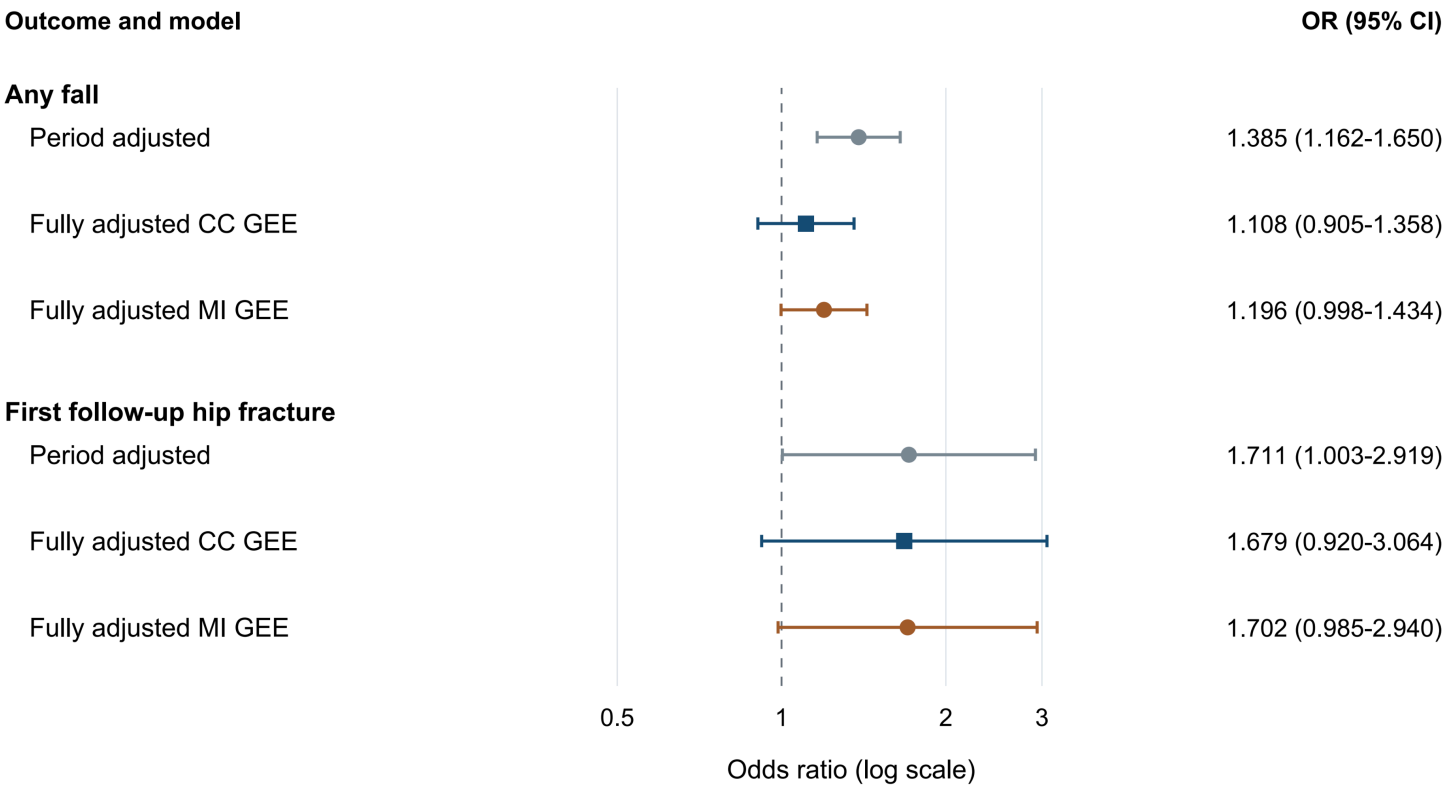


Figure 2

Longitudinal associations and missing-data sensitivity estimates

Odds ratios and 95% confidence intervals are shown on a log scale; the dashed line marks OR=1. Fully adjusted complete-case GEE is primary; multiple imputation uses 20 baseline-covariate datasets as sensitivity. Hip-fracture models use first observed follow-up reports. CC, complete case; MI, multiple imputation.

Supplementary Files

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- Supplementary.docx