Risk factors for hospital admission after a fall: a prospective cohort study of community-dwelling older people

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Abstract

Background: Falls in later life that require admission to hospital have well-established consequences for future disability and health. The likelihood and severity of a fall will result from the presence of one or more risk factors. The aim of this study is to examine risk factors identified for their ability to prevent falls and to assess whether they are associated with hospital admission after a fall.

Methods: Analyses of data from the English Longitudinal Study of Ageing (ELSA), a prospective cohort study. In a sample of 3,783 men and women over 60 years old, a range of potential risk factors measured at wave 4 (demographic, social environment, physical and mental functioning) were examined as predictors of fall-related hospitalisations, identified using International Classification of Diseases, Tenth Revision (ICD-10) code from linked hospital records in the UK. Subdistribution hazard models were used to account for competing risk of death.

Results: Several risk factors identified by previous work were confirmed. Suffering from urinary incontinence (SHR=1.49; 95% CI: 1.14, 1.95) and osteoporosis (SHR=1.48; 95% CI: 1.05, 2.07) which are not commonly considered at an early stage of screening, were found to be associated with hospital admission after a fall. Both low and moderate levels of physical activity were also found to somewhat increase the risk of hospital admission after a fall.

Conclusions: Several predictors of having a fall, severe enough to require hospital admission, have been confirmed. In particular, urinary incontinence should be considered at an earlier point in the assessment of risk.

Key words: Falls; Risk Factors; Hospital Admission; Urinary incontinence

Introduction

Falls amongst older people are common, with around a third of people over age 65 and around half of people aged 80, experiencing at least one fall a year [1]. Falls in later life can have serious consequences, as injuries occur in around 20% of these falls [2] and approximately 5% of older people will require hospitalisation as a result [3]. Therefore, not all falls amongst older people will be severe enough to cause injury and not all falls that result in injury or harm will require hospital admission. However, those who are hospitalised after an unintentional fall are often more likely to have experienced a serious injury and will have an increased risk of future disability [4] or admission to a nursing home. [5] Although not all injurious falls will require admission to hospital, those that do impose a substantial burden on health and social care services. [6]

Current guidelines in the UK and the US (The National Institute for Health and Care Excellence (NICE), American Geriatrics Society/British Geriatrics Society) for the prevention of falls in older people recommend a two-stage assessment [7,8]. Research has identified that the strongest predictor of falls in later life are muscle weakness, history of falls, gait abnormality and balance deficit. [9-11] They advise that people over 65 are first screened for history of falls and difficulties with walking or balance (self-reported or evaluated by a healthcare professional) to identify those at greatest risk. It is then recommended that those identified high risk be offered a further multifactorial assessment which may include a range of other predictors, such as visual impairment, osteoporosis risk, cognitive impairment, urinary incontinence, assessment of home hazards, cardiovascular examination and medication review, perceived functional ability and fear relating to falling. [8,11,12] It is recommended that these assessments be carried out by professionals or organisations, which have health and social care as part of their remit and to refer older people to appropriate interventions, such as strength and balance exercise programmes.

However, many of these predictors have been identified from studies that use a definition of fall which encompasses a wide range of severity: from falls that do not lead to injury, to injurious falls where medical treatment is sought and to falls which result in hospitalisation. [7] Therefore the impact of these risk factors on falls of higher severity may not be understood. Participants in the English Longitudinal Study of Ageing (ELSA), a large population-based study, have been linked to hospital administrative data that offers a unique opportunity to examine hospital admission following a fall. Therefore, this study aims firstly to examine the association between being admitted to hospital after an unintentional fall, with the risk factors currently prioritised as screening tools (history of falls and difficulties with walking or balance). Secondly, we wish to identify additional risk factors (demographic, health behaviour, chronic illness, health-related) which remain predictive, independent of these screening factors. These additional risk factors were selected based on their availability in ELSA and were chosen to reflect established risk factors, according to current guidelines [7,12] and a recent review of the literature. [11] In addition, several risk factors which have been studied less frequently (living arrangements, wealth BMI, smoking status, physical activity) were explored.

Methods

Study Population

ELSA is an ongoing nationally representative sample of individuals aged 50 and older living in England. The study began in 2002-2003 (wave 1) with 11 391 individuals. Repeat assessments have been conducted every 2 years. The primary form of data collection in ELSA is a face to face computer assisted personal interview (CAPI) which takes place in the participant’s home. However, in 2004-05, 2008-09 and 2012-13 a nurse visit which included various physical performance assessments was also carried out [13]. For the purpose of this analysis the ‘baseline’ was taken as being 2008-09 (wave 4) since it included a refreshment sample, thus providing the greatest power for our analysis. ELSA was conducted in accordance with the Declaration of Helsinki and ethical approval and experimental protocols were granted by National Health Service (NHS) Research Ethics Committees under the National Research and Ethics Service. All participants provided informed consent.

Analytical sample

At wave 4 (2008-09), 8,643 members had a nurse visit. Of these, 7,654 participants consented to have their Hospital Episode Statistic (HES) data linked. Of these, 5,409 over 60 years of age were eligible for a walking speed test and responded to questions about fall status. Exclusions were made for participants who had missing data on key variables (n= 1,416) and 144 participants who had experienced a fall before their wave 4 interview, the average length of time that these falls occurred was 5 years before their interview date. A small number of participants resided in a nursing home (n=68) and this could alter their chance of being admitted to hospital after a fall, however, our sample did not include anyone who was currently living in a nursing home. These exclusions are depicted in Figure S1 (supplementary tables).

Outcome measure: Hospital admission after a fall

Hospital admission after a fall were ascertained using electronic health records and linked to study members. Administrative data collated on a monthly basis and supplied by all English hospitals in the National Health Service (NHS), data are collected by the care provider while the patient receives treatment. For each participant, a record of every episode of admission to hospital is available, with admission date, primary and secondary diagnoses. However, those who received medical treatment in a different setting such as outpatient care or a GP surgery will not be captured by these data. Diagnoses were coded according to the International Classification of Disease 10th version (ICD-10). Falls correspond to the ICD-10 codes *W00 to W19*. These codes are used as secondary diagnoses to provide additional information about a primary cause of admission, especially when the primary diagnosis is due to external causes. These codes have been previously used to assess fall-related admissions in the UK[14-16]. Participants were followed-up for hospital in-patient admissions from the year and month immediately after the interview date at wave 4 (2008 or 2009) up to 31st January 2018, the last date of record linkage. Mortality up to April 2018 was ascertained from linked mortality register data. By the end of follow-up 658 deaths occurred. The majority of fall-related admissions in this sample were due to a primary diagnosis of injury (78%) and of those, the majority of injuries were fractures (43%). Sensitivity analysis was carried out restricting the outcome to those who were admitted due to a fall-related injury: primary diagnosis of injury (International Classification of Diseases (ICD)-10-AM codes S00 to T75).

Risk factors

Self-reported previous falls (12 months):

It is recommended that older people are regularly asked by health and social care professionals about previous falls and that this acts as a screening tool to identify older people who will require a more comprehensive risk assessment [11,12]. We wished to capture this self-reported assessment as a predictor of hospital admission after a fall. We used a self-reported assessment of falls drawn from survey data so that we could capture previous falls that needed medical treatment, but might not have been serious to require admission to hospital. We captured this information using a question that asked participants who were aged 60 or over if they had *'fallen down in the last year for any reason'.* Those who in a follow up enquiry confirmed they had *'injured themselves seriously enough to need medical treatment'* were classified as having reported a 'severe previous fall'.

Physical performance assessments:

Short Physical Performance Battery (balance tests, chair rises, gait speed) The Short Physical Performance Battery (SPPB) is a group of measures that examine lower limb mobility, it is comprised of walking/gait speed, time to complete five chair rises, and balance tests. This battery has been extensively validated and has found to be predictive at the pre-clinical stage of later disability [17]. It has also been found to be predictive of falls in older people living in the community [11]. The balance tests evaluate the respondent's ability to hold for 10 seconds three separate stands side-by-side, semi-tandem and full tandem. All participants for whom it was judged safe to do and who had successfully held the previous position were asked to complete the test and were timed by the nurse. A walking speed test was performed among participants aged 60 and over [18]. The test involved measuring the time taken to walk a distance of 8 feet, and the walking speed of respondents (m/s) was computed. Respondents were asked to stand up from a firm chair without using their arms. If they succeeded in doing a single rise, they were asked to stand up and sit down as quickly as they could for five rises and the time taken was noted. A total SPPB score was calculated which combines the results of the gait speed, chair stand and balance tests (0-12). Poor performance was defined as a score of 8 or lower [17] . *Grip strength:* Grip strength is included in cohort studies as a measure of upper body strength and it was tested using a gripometer in all respondents for whom it was safe, for example, those without swelling, pain or recent injury. Three values were recorded for each hand, using a Smedley dynamometer in a standing position, starting with the non-dominant hand and alternating between hands and the maximum value for the dominant hand was used in the analysis. [19,20]

Demographics:

Age, sex, were taken into account throughout the analyses. *Household wealth* was assessed via the face-to-face interview, which collected information on the financial circumstances of respondents using 45 questions regarding household income and 31 questions regarding household wealth. An aggregate measure of total non-pension household wealth was derived from these components by economists at The Institute for Fiscal Studies (IFS) including financial assets, physical assets and housing wealth but not pension wealth.[21] *Living alone* is defined as whether the participant lived in a solo household or resided with other people.

Physical health/functioning:

Visual impairment: Participants were asked to rate their eyesight (with glasses if used) using five categories as excellent, very good, fair, poor or registered or legally blind. We grouped these responses into two categories: excellent/very good versus fair/poor or blind. *Urinary incontinence*: Participants were asked whether in the last 12 months they had lost any amount of urine beyond their control. *Activities of daily living and instrumental activities of daily living:* Respondents were asked to report whether they had any difficulty with the following activities of daily living (ADLs): dressing, walking across a room, bathing or showering, eating, getting out of bed, using the toilet. Similarly, they reported difficulties with instrumental ADLs (IADLs): using a map, preparing a hot meal, shopping for groceries, making phone calls, taking medications, doing work around the house, managing money. The number of difficulties with ADLs and IADLs were used as binary predictors (1 or more or no difficulties). *Body Mass Index (BMI)* was derived from weight and height measured during a home visit by a nurse (kg/m2) and three categories created: Underweight/Normal (<18-24.9), Overweight (25.0-29.9) and Obese (30+). It was not possible to explore separately the Underweight category of BMI due to the small sample size (n= 28, 0.7% of the full sample).

Mental health/functioning:

Depressive symptoms: Depressive symptoms were assessed using the eight-item version of the Centre for Epidemiologic Study Depression scale (CESD-8) administered in the face-to-face interview [22]. Enquiries were made about the degree to which the respondent had experienced depressive symptoms such as restless sleep and being unhappy over the prior month. We used a binary variable to define a high level of depressive symptoms as those reporting 4 or more [23]. *Cognitive impairment:* This was measured using an index that combined the scores on the two memory tests (immediate and delayed memory), ranging from 0 to 20. Higher scores indicate better memory [24].

Chronic health conditions:

Respondents were asked whether a physician had ever told them that they suffered from any of the following conditions: coronary heart disease (CHD), diabetes, stroke, arthritis and osteoporosis or Parkinson's disease.

Health behaviours:

Physical activity: Participants were asked how often (more than once a week, once a week, one to three times a month and hardly ever/never) they took part in vigorous, moderate- and low-intensity physical activity. This questionnaire has been described in further detail elsewhere [25]. We computed a 5-level score from inactive to active: (1) hardly ever/never does vigorous or moderate activity, (2) No vigorous & once a week/one to three times a month (moderate) (3) No vigorous, but high moderate (4) Medium amount of moderate/vigorous (5)

Regular vigorous. *Frequency of alcohol intake* in the last 12 months was ascertained in the self-completion questionnaire, responses were recoded into a binary variable defined as having an alcoholic drink daily (5/7 days week) or less than daily (<5 days a week). *Smoking status* was recorded as current smoker, ex-smoker or non-smoker.

Statistical method

Subdistribution hazard ratios (SHR) with accompanying 95% confidence intervals were by competing risk regression models; using a version of the sub distribution hazard model. This sub distribution hazard model allows the effect of covariates on the primary event (hospital admission after a fall) to be modelled after accounting for competing events that might occur during the follow-up instead of the event of interest, in this case, mortality [26]. In additional sensitivity analysis, hazard ratios with accompanying 95% confidence intervals were estimated using Cox proportional hazards regression models. All effect estimates were adjusted for a series of covariates. Interactions terms between each risk factor and sex were also examined. Survival time was measured from the date of the wave four interview to first recorded hospital admission with secondary diagnoses of a fall, date of death or end of follow-up (31st March 2018).

To examine the association between quantitative covariates and the outcome we used restricted cubic spline regressions with Harrell knots [27]. Restricted cubic splines offer a mechanism to model non-linear relationships in regression models, by transformation of a continuous predictor.

Results

Our analytical sample comprised 3,783 individuals (1,992 women) of whom 315 had experienced admission to hospital after a fall (8%) during a median of 9 years of follow-up.

Of these 315 events, 236 (75%) had sustained an injury as their principal diagnosis. Participants' baseline characteristics (Table 1) show some differences between participants who were admitted to hospital for a fall related injury and those who were not. Those participants, who had a hospital admission after a fall, were more likely to be older, female, living alone and to be in the lowest wealth quintile than those who did not fall. Moreover, around 50% of those who fell scored lower than eight on the SPPB test (0-12) compared to 20% of those who did not experience a fall. They were also more likely to report having had a severe fall that required medical attention in the past year, to report a chronic disease (CHD, Diabetes, Stroke, Arthritis, Osteoporosis, Parkinson 's disease), vision impairment, urinary incontinence and difficulty with both ADLs and IADLs. There were no substantial differences in mean BMI, alcohol use or smoking status, although participants who had a hospital admission after a fall were more likely to report low levels of physical activity.

Age was a consistent independent predictor of admission to hospital after a fall in all models, and this association was found to be linear (likelihood-ratio test: linear versus quadratic; p =0.63), therefore age was included as a linear term in further models. After adjustment for age and sex, all objective assessments of mobility examined (balance tests, gait speed, chair rises, handgrip) were significantly associated with hospital admission after a fall (Table 2). However, after adjustment for other physical performance assessments (model 2) only the two most difficult balance tests (semi-tandem, tandem) remained associated, with the tandem balance test showing the strongest association (Subdistribution hazard ratios (SHR=1.57; 95% CI: 1.18, 2.09). Completing a single chair rise was associated with a higher risk of hospital admission after a fall, although after adjustment for the other physical performance assessments (model 2), significance at conventional levels was not apparent. Nevertheless, a significant interaction with sex (p=0.040) suggested that not being able to complete a single chair raise remained a consistent predictor for men (SHR 2.46; 95% CI: 1.47, 4.13) but less so for women (SHR 1.48; 95% CI: 0.98, 2.22). However, in sensitivity analysis where we examined only those who were admitted after an injury, this association attenuated. Slower gait speed was found to be a significant linear predictor (Table 2 and Figure 1). Poor overall performance on the SPPB test (cut-point ≤8) was consistently associated across all three models with increased risk of a hospital admission after a fall (Model 2: SHR= 1.57; 95% CI: 1.19, 2.08). This measure was also found to be associated with hospital admission for a fall related injury (Model 2: SHR 1.49; 95% CI: 1.09, 2.05). A significant interaction with sex (p=0.038), suggested that this binary measure of SPPB performance was a stronger predictor of the outcome for men (SHR= 2.34; 95% CI: 1.53, 3.59) than women (SHR= 1.51; 95% CI: 1.08, 2.11). The association between handgrip strength and the outcome was initially found to be linear (Figure 1), however, after adjustment for chronic health conditions, BMI and health behaviours, significance at conventional levels was not apparent. In Table 2, we show an association between reporting any previous fall in the last 12 months and admission to hospital for a fall related injury (Model 1), although adjustment for covariates had an attenuating effect (Model 2 & Model 3). However, when the effect for the self-reported history of severe falls was examined, that remained consistent upon adjustment for a range of covariates (Model 2: SHR= 1.88; 95% CI: 1.34, 2.64). Self-reported history of severe falls was also found to be associated with hospital admission for a fall related injury (Model 2: SHR= 1.66; 95% CI: 1.10, 2.51).

Figure 2 shows the association between demographic, physical and mental functioning factors with a hospital admission after a fall. In a model including age and sex, those in the lowest quintile of wealth have an increased risk of a hospital admission after a fall (SHR= 1.59; 95% CI: 1.10, 2.23) (Table S1). Several risk factors remained independent predictors of admission to hospital after a fall, when physical performance assessments and reporting a severe fall were taken into account. These are (Table S1: model 3) urinary incontinence (SHR=1.49; 95% CI: 1.14, 1.95), reporting one impaired ADL (SHR=1.32; 95% CI: 0.95, 1.83) and one impaired IADL (SHR=1.51; 95% CI: 1.09, 2.08). Urinary incontinence and reporting one impaired IADL were also found to be associated with hospital admission for a fall related injury, although the association was attenuated for those reporting one impaired ADL. No significant differences in the association between these predictors and the outcome by sex were observed.

In figure 3 associations with chronic conditions, BMI and health behaviours are shown. Most of the chronic conditions examined (CHD, diabetes, arthritis and osteoporosis) were found to be significant predictors in a model adjusted for age and sex, although losing statistical significance after adjustment for physical performance assessments and fall history except for osteoporosis (SHR=1.48; CI: 1.05, 2.07) and Parkinson's Disease (SHR=4.86; CI: 2.29, 2.07). However, the small number of cases of Parkinson's disease resulted in very wide confidence intervals for these estimates. These predictors also appeared to be associated with hospital admission for a fall related injury, although again the effect attenuates in these results. There were a significant association with physical activity (Table S2: model 1) so that lower levels of physical activity were associated with higher risks of hospitalisation, but BMI, smoking and alcohol use did not display any clear association. This pattern was confirmed by sensitivity analysis examining hospital admission for a fall related injury. No significant differences in the association between these predictors and the outcome by sex were observed.

Discussion

Main results

In this prospective cohort study, we examined a range of risk factors to identify those that could be used to screen older people at risk of admission to hospital after a fall. We found that being unable to complete the most difficult balance test (tandem), having a slow walking speed and reporting a severe fall in the previous 12 months were the strongest predictors, once potential confounders had been taken into account in the model. We also found that gait speed and grip strength (a measure of upper body strength) exhibited a linear association with risk of a hospital admission after a fall.

Several other predictors - urinary incontinence, reporting a problem with an IADL, reporting a diagnosis of osteoporosis or undertaking lower levels of physical activity - were predictive of an admission to hospital after a fall.

Strengths and limitations of the study

Our study has several methodological strengths. Firstly, we used a large nationally representative prospective cohort study, collecting a wide range of potential predictors, including objective measures of mobility, assessed by trained nurses. It was also possible to use a longitudinal research design to examine our research questions. We used an objective outcome, drawn from administrative health records, which allowed us to examine those who had been admitted to a hospital in the UK with an injury that was related to having experienced a fall. This minimised any potential recall bias associated with self-reported fall data and allowed us to examine only falls that had been severe enough to warrant hospital admission.[7] However, this approach is not without limitations, firstly as this outcome might also be measuring the different potential care pathways to hospital admission that exist when an older person experiences a fall in the UK, for example, older people living in nursing homes might be less likely to be admitted to hospital after a fall. Furthermore, those who received medical treatment in a different setting were not captured. Secondly, there are limitations to using ICD-10 codes to assess a hospital admission after a fall, especially those that identify external causes and are used to report a secondary diagnosis related to hospital admission. Although these codes have previously been used in the UK to identify hospital admissions related to falls, we cannot rule out that there might be regional variation in the documentation or clinician variation in the coding of diagnoses which could lead to measurement error and underreporting. Furthermore, a number of participants did not authorise the use of linkage to hospital records and so these missing cases might contribute to underreporting. Finally, although we were able to cover a wide range of risk factors, especially physical health and social factors, were could not cover several potentially important risk factors such as polypharmacy, environmental hazards and syncope.

Comparison with other studies

Research in this area has emphasised how falls amongst older people in the community are associated with a wide range of risk factors[3,7,11,28-30] with those most predictive of falling being gait and balance problems and a history of falls. Our present findings confirm the importance of these risk factors for admission to hospital after a fall. However, not all studies differentiate between falls events according to their severity[11] or document differences in how risk factors are associated with falls or their sub-categories e.g. such as injurious falls or admission to hospital after a fall.[10,11] We find that self-report of a severe fall, which required medical treatment, was the clearest predictor of admission to hospital. Additionally, we show that there is a linear association between slower walking speed and risk of admission to hospital after a fall, suggesting no adaptive mechanism to reduce fall risk. [31] We find that the SPPB score was a strong predictor of the risk of hospital admission following a fall, this measure has also been found to be associated with falls occurring after discharge from hospital.[32] The SPPB measure was found not to be associated with injurious falls (ascertained through interviews), however, the chair stand component was found to be an independent predictor of injurious falls. [33] The chair stand component alone has also been found by previous studies to be associated with subsequent falls.[34] We also find that this component was associated with hospital admission after a fall, although we find that the full battery of tests is more consistent as a predictor. The full battery of tests could be used to identify older people at risk of hospital admission after a fall.[11] However, further research would be needed to confirm this in different settings and to explore the sensitivity of different cut-off scores. We also find that reporting one or more ADLs and IADLs were associated with a risk of a hospital admission after a fall and in sensitivity analysis, were found to be associated with hospital admission for a fall related injury. Reporting one or more impaired IADL have been previously found to be an important predictor of injurious falls and this is confirmed here. [35] Assessment of ADLs and IADLs could compliment objective assessments of physical impairment and also be offered in local community settings; these scores have also been found to be strongly associated with a fear of falling.[36]

We also find that low levels of physical activity are a risk factor for serious falls requiring admission to hospital. This confirms previous work that suggests low levels of physical activity are associated with a risk of falls. [37,38] Previous work in ELSA using retrospective recall of falls showed that low levels of activity was related a greater risk of reporting both injurious and non-injurious falls. [39] However, increasing physical activity may not reduce fall risk, since a decline in physical activity may result from reduced balance, gait problems and a fear of falling. Additionally, we find that groups who engaged in moderate levels of physical activity were more likely to be at risk of hospital admission following a fall. This might suggest the association between physical activity and risk of a severe fall is non-linear and moderate levels of physical activity although beneficial for mobility, might also increase exposure for falls. Several chronic conditions were consistent risk factors for falls, with the strongest association found for those older people reporting osteoporosis. Osteoporosis is often underdiagnosed amongst older people and so diagnosis is likely to be the result of having previously sustained a fall-related fracture. Admission to hospital following a fall could be related to the severity of the associated injury. Osteoporosis is related to bone health and combined with a fall are more likely to result in a fracture amongst older people.[40] In addition, we find Parkinson's disease to be a strong predictor of admission to hospital following a fall, which confirms previous evidence in this area that older adults with PD are more likely to experience a fall and have higher rates of hospital admission following a fall than those without PD[41]. We also find that urinary incontinence remained a strong predictor of hospital admission after a fall, when co-morbidities, physical performance assessments and reporting a severe fall in the previous year were taken into account. A potential mechanism is that those with urinary incontinence may rush to get to the toilet, increasing their chance of falling, even if their balance and gait are steady under normal circumstances. [42] Moreover, if urinary incontinence is being treated with medication it is also possible that this plays a role here, although we were not able to examine this in detail. However, it is important to note the findings of a recent study, which emphasised how risk factors for falls might be clustered together and so combining different risk factors, especially those that suggest physical and cognitive impairment might allow for improved prevention of falls in the community. Although identifying these clusters will require further examination of falls of all severity. [38]

In conclusion, we examined a range of risk factors associated with a hospital admission after a fall. We corroborate evidence that the factors used to screen older people as being at high risk of experiencing a fall in the community (history of falls, gait and balance) are significant predictors. However, we also find that struggling with self-care or urinary incontinence should be considered at an earlier point in the assessment of risk.

Disclosure Statement

The authors have no conflicts of interest to declare.

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Table 1: Baseline characteristics of sample according to fall status. Values are numbers (percentages) unless stated otherwise

	Total (N= 3,783)	No fall (3,468)	Hospital admission after a fall (N= 315)	P value (test for trend)
Age, years: mean (sd)	69.6 (7.6)	69.1 (7.2)	74.4 (9.2)	<0.0001
Women	1,992 (52.7)	1,793 (51.7)	199 (63.2)	<0.0001
Living alone	948 (25.1)	825 (23.8)	123 (39.1)	<0.0001
Wealth (lowest quintile)	511 (13.5)	440 (12.7)	71 (22.5)	<0.0001
Balance (Side-by-side stand)	88 (2.3)	68 (2.0)	20 (6.4)	<0.0001
Balance (Tandem)	715 (18.9)	584 (16.8)	131 (41.6)	<0.0001
Chair rises (single)	307 (8.1)	244 (7.0)	63 (20.0)	<0.0001
Gait, (m/s): mean(sd)	0.86 (0.33)	0.87 (0.33)	0.67 (0.32)	<0.0001
Short Physical Performance Battery (≤8)	1,244 (32.9)	1,057 (30.5)	187 (59.4)	<0.0001
Handgrip, (kg): mean (sd)	30.1 (11.0)	30.6 (11.0)	25.2 (10.0)	<0.0001
Self-reported previous fall (12 mths)	929 (24.6)	822 (23.7)	107 (34.0)	<0.0001
Self-reported severe fall (12 mths)	213 (5.6)	171 (4.9)	42 (13.3)	<0.0001
Vision impairment (Fair/Poor/Blind)	417 (11.0)	359 (10.4)	58 (18.4)	<0.0001
Urinary incontinence	574 (15.2)	489 (14.1)	85 (27.0)	<0.0001
Difficulty with ADLs (1+)	598 (15.8)	501 (14.5)	97 (30.8)	<0.0001
Difficulty with IADLs (1+)	697 (18.4)	572 (16.5)	125 (39.7)	<0.0001
Depression (caseness)	439 (11.6)	377 (10.9)	62 (19.7)	<0.0001
Cognition (verbal fluency): mean (sd)	20.7 (6.5)	20.9 (6.4)	18.6 (6.7)	<0.0001

Coronary heart disease (CHD)	458 (12.1)	394 (11.4)	64 (20.3)	<0.0001
Diabetes	406 (10.8)	362 (10.4)	47 (14.9)	0.014
Stroke	163 (4.3)	139 (4.00)	24 (7.6)	0.003
Arthritis	1,489 (39.4)	1,323 (38.2)	166 (52.7)	<0.0001
Osteoporosis	274 (7.2)	231 (6.7)	43 (13.7)	<0.0001
Parkinson's Disease	23 (0.6)	14 (0.4)	9 (2.9)	<0.0001
BMI, kg/m^2: mean (sd)	28.2 (5.1)	28.3 (5.0)	27.8 (5.3)	0.15
Alcohol use (Daily (5/7 days week)	925 (24.5)	859 (24.8)	66 (21.0)	0.32
Smoking (Current smoker)	386 (10.2)	353 (10.2)	33 (10.5)	0.79
Physical activity (Sedentary)	168 (4.4)	141 (4.1)	27 (8.6)	<0.0001

Table 2: Association between objective mobility assessments, self-reported previous falls and hospital admission for a fall related injury

	Competing risk					
315/3,783	Model 1	P value (test for trend)	Model 2	P value (test for trend)	Model 3	P value (test for trend)
	SHR (CI 95%)		SHR (CI 95%)		SHR (CI 95%)	
Balance (side by side)						
Completed (10 seconds)	1.00 (ref)		1.00		1.00	
Not completed	1.93 (1.15, 3.24)	0.013	1.44 (0.85, 2.42)	0.18	1.67 (1.02, 2.79)	0.05
Balance (semi-tandem)						
Completed (10 seconds)	1.00 (ref)		1.00		1.00	
Not completed	2.03 (1.45, 2.84)	<0.001	1.49 (1.04, 2.13)	0.028	1.71 (1.19, 2.45)	0.004
Balance (tandem)						
Completed (10 seconds)	1.00 (ref)		1.00		1.00	
Not completed	2.05 (1.55, 2.60)	<0.001	1.57 (1.18, 2.09)	0.002	1.77 (1.35, 2.33)	<0.001
Chair rises (single)						
Completed	1.00 (ref)		1.00		1.00	
Not completed	1.99 (1.46, 2.71)	<0.001	1.37 (0.98, 1.93)	0.065	1.70 (1.22, 2.35)	0.002
Gait speed: (tertiles):						
1 (High)	1.00 (ref)	(<0.001)	1.00	(<0.001)	1.00	(<0.001)
2	1.83 (1.32, 2.53)	<0.001	1.71 (1.23, 2.38)	0.001	1.68 (1.20, 2.34)	0.002

3 (Low)	2.94 (2.09, 4.13)	<0.001	2.12 (1.46, 3.10)	<0.001	2.36 (1.62, 3.43)	<0.001
Short Physical Performance						
Battery :	1.00 (ref)		1.00		1.00	
>8	2.12 (1.64 - 2.74)	<0.0001	1.57 (1.19, 2.08)	0.001	1.75 (1.34, 2.29)	<0.001
≤8						
Handgrip tertiles:						
1 (High)	1.00 (ref)	(0.017)	1.00	(0.12)	1.00	(0.10)
2	1.40 (0.95, 2.07)	0.086	1.36 (0.92, 2.00)	0.124	1.28 (0.87, 1.89)	0.21
3 (Low)	1.87 (1.20, 2.90)	0.005	1.61 (1.02, 2.53)	0.039	1.47 (0.93, 2.32)	0.10
Previous fall (12 months):						
No	1.0 (ref)		1.0		1.0	
Yes	1.42 (1.12, 1.80)	<0.001	1.16 (0.91, 1.48)	0.22	1.27 (1.00, 1.62)	0.05
Previous severe fall (12 months):						
No	1.00 (ref)		1.0		1.0	
Yes	2.35 (1.70, 3.26)	<0.001	1.88 (1.34, 2.64)	<0.001	2.21 (1.59, 3.09)	<0.001

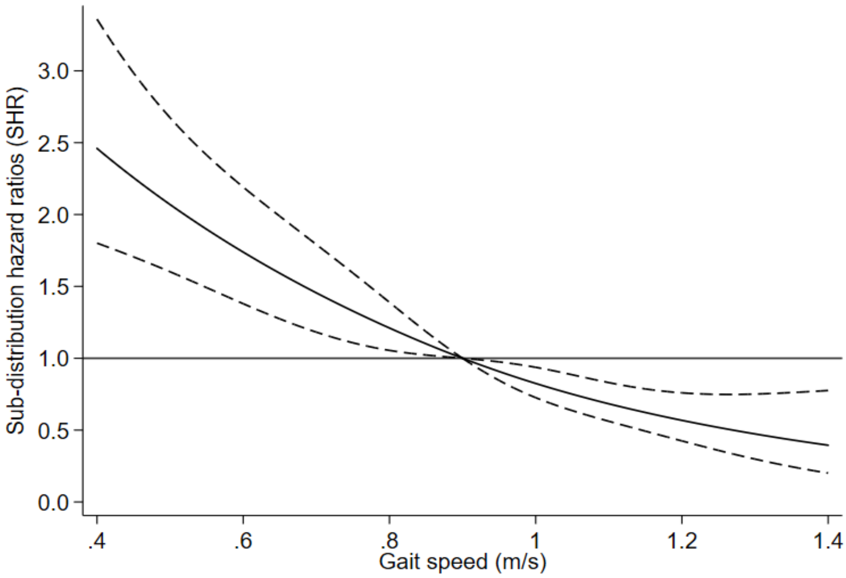
Model 1: age, sex; Model 2: Model 1 + living alone, wealth, Fair/poor eyesight, urinary incontinence, ADLS, IADLS, and CESD-D; Model 3: Model 1 + chronic conditions (CHD, diabetes, Stroke, Arthritis, Osteoporosis, Parkinson's Disease), BMI (normal, overweight, obese), Smoking status (never, previous, current), Alcohol drinking risk (5/7 days week versus less)

SHR= Sub-hazard distribution ratios

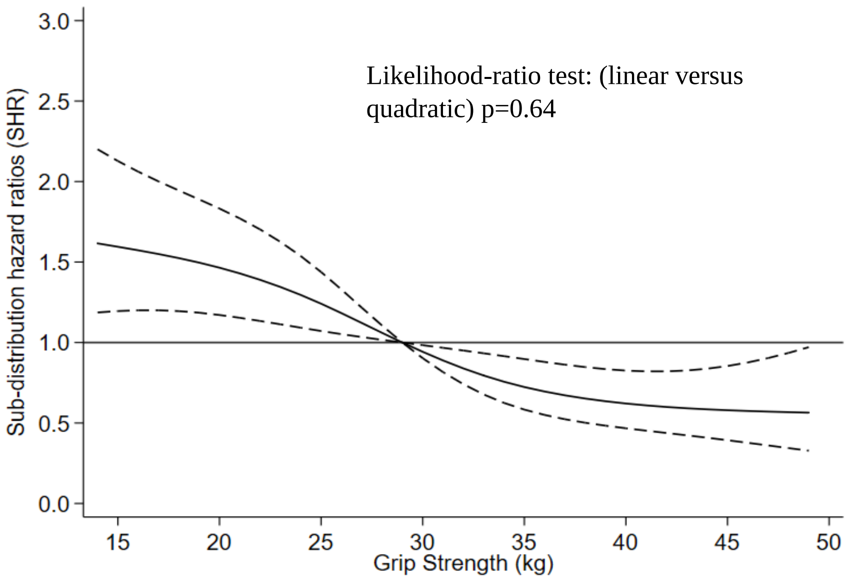
Figure 1. Association of gait speed (Panel A) and grip strength (Panel B) with hospital admission after a fall

Panel A

Likelihood-ratio test: (linear versus quadratic) p=0.50

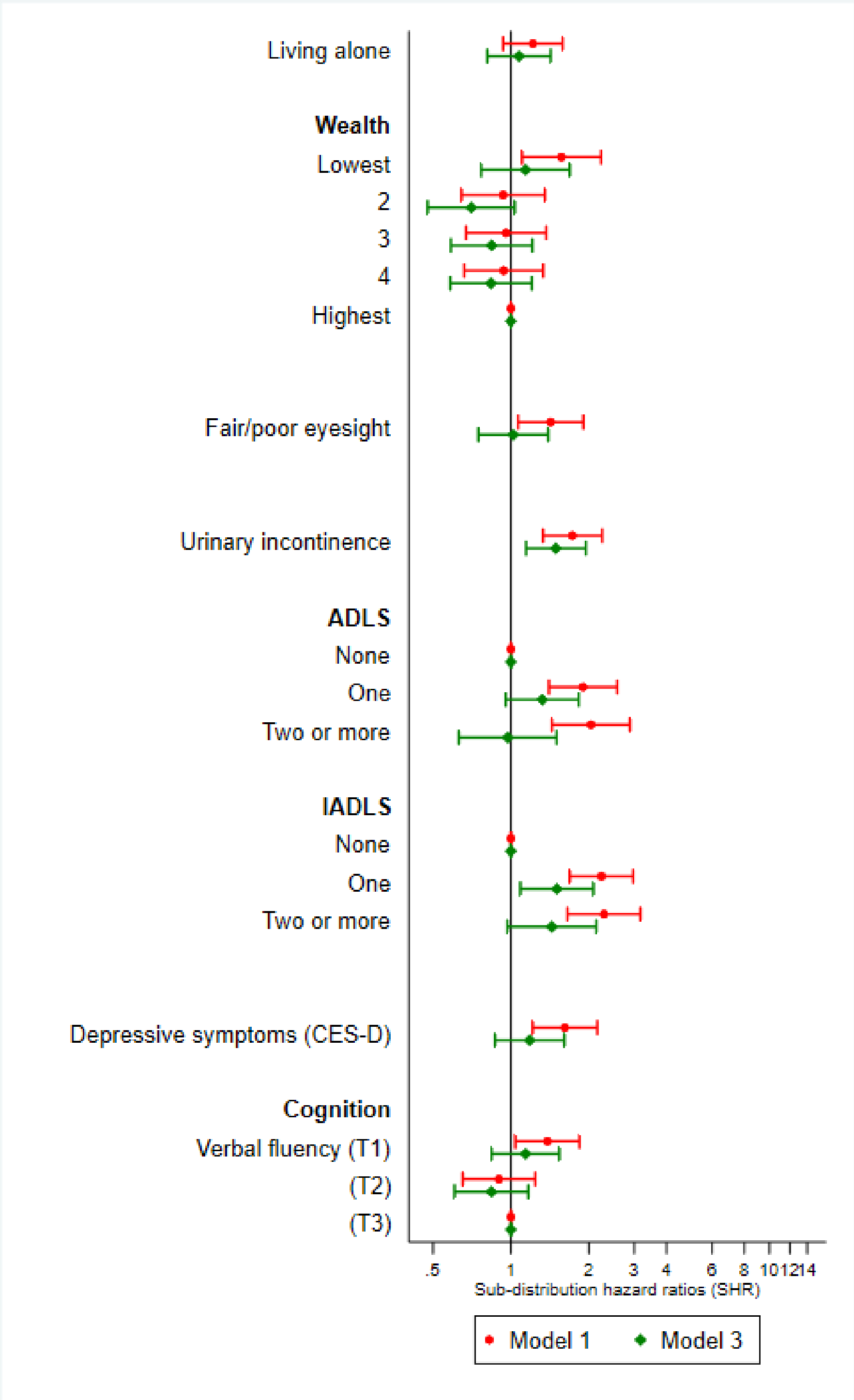


Panel B



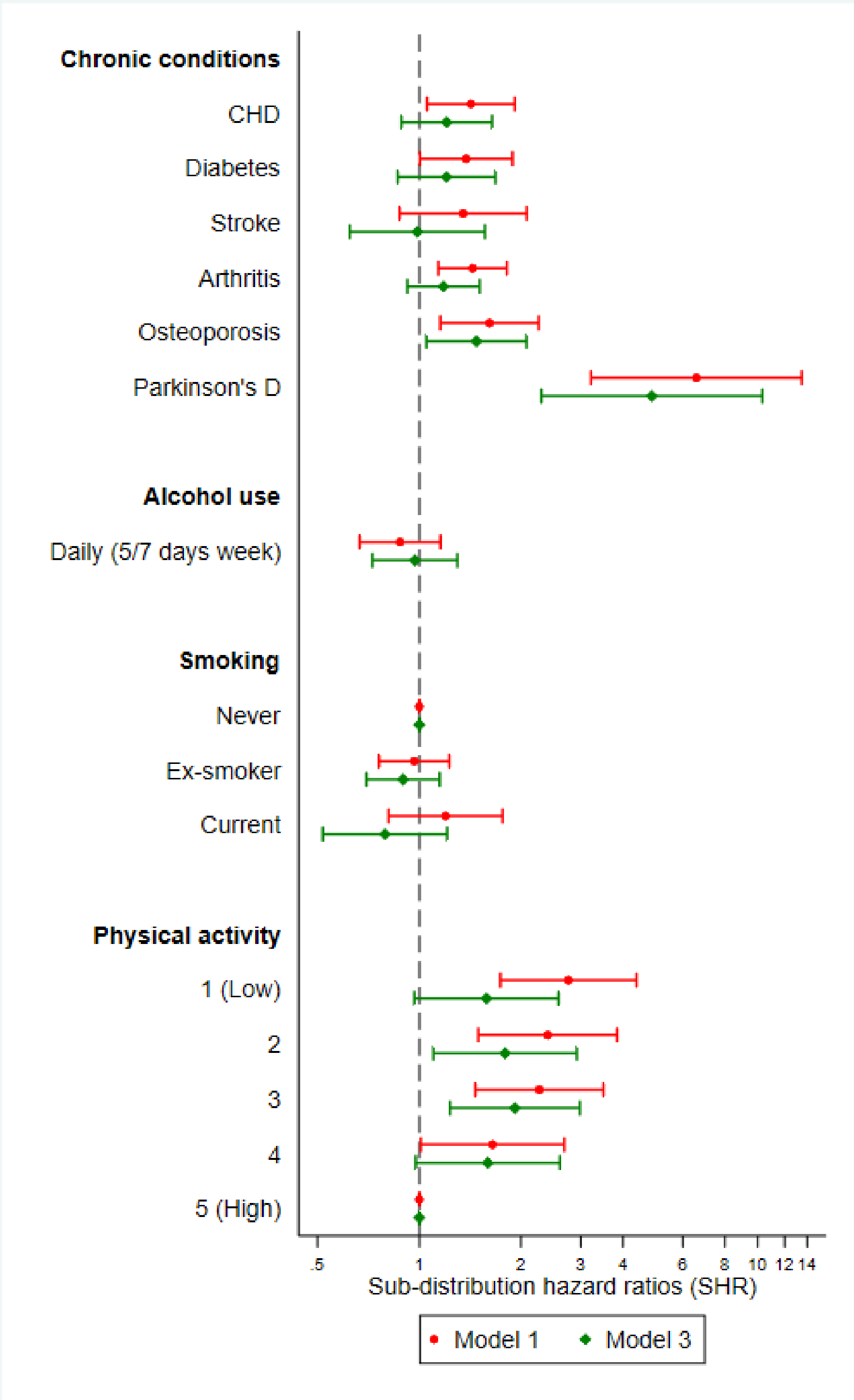
Panel A. Graph shows age, sex and BMI adjusted sHRs with 95% CI for the relation of gait speed, to the occurrence of admission to hospital after a fall. Gait speed was modelled by right-restricted cubic splines with four knots (0.45, 0.80, 1, and 1.35) in a cox regression model. Reference value is 0.9 (m/s). **Panel B.** Graph shows age, sex and BMI adjusted sHRs with 95% CI for the relation of grip strength (kg), to the occurrence of admission to hospital after a fall. Grip strength was modelled by right-restricted cubic splines with four knots (14, 25, 34, and 49) in a competing risk regression model. The reference value is 29kg.

Figure 2. Association between demographic, physical, and mental functioning with hospital admission after a fall.



Sub-distribution hazard ratios (SHRs) with 95% CIs shown for Model 1 (age and sex adjusted), Model 3 mutually adjusted for all other risk factors, + SPPB (binary), reporting a previous severe fall. *T1=Tertile 1/ T2=Tertile 2/T3=Tertile 3

Figure 3. Association between chronic health conditions, BMI and health behaviours) with hospital admission after a fall.



Sub-distribution hazard ratios (SHRs) with 95% CIs shown for Model 1 (age and sex adjusted), Model 3 (mutually adjusted for all other risk factors + SPPB (<8/8+) and having had a previous severe fall.