BMJ Open

Risk factors for incident falls in Singaporean community-dwelling adult men and women: a prospective cohort study

Wan Fen Yip ,[1] Lixia Ge ,[1] Bee Hoon Heng,[1] Woan Shin Tan [1,2]

To cite: Yip WF, Ge L, Heng BH, *et al*. Risk factors for incident falls in Singaporean community-dwelling adult men and women: a prospective cohort study. *BMJ Open* 2023;**13**:e057931. doi:10.1136/bmjopen-2021-057931

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-057931).

Received 04 October 2021
Accepted 05 February 2023

[1]Health Services and Outcomes Research, National Healthcare Group, Singapore
[2]Geriatric Education and Research Institute, Singapore

Correspondence to
Dr Woan Shin Tan;
woan_shin_tan@nhg.com.sg

ABSTRACT

Objectives Our study aimed to identify the risk factors of incident falls between men and women.

Design Prospective cohort study.

Setting The study recruited participants from the Central region of Singapore. Baseline and follow-up data were collected via a face-to-face survey.

Participants Community-dwelling adults aged 40 years and above from the Population Health Index Survey.

Outcome measure Incident falls were defined as the experience of a fall between the baseline and 1-year follow-up but having no falls 1 year prior to baseline. Multiple logistic regressions were performed to determine the association of sociodemographic factors, medical history and lifestyle with incident falls. Sex subgroup analyses were conducted to examine sex-specific risk factors for incident falls.

Results 1056 participants were included in the analysis. At 1-year follow-up, 9.6% of the participants experienced an incident fall. Incidence of falls in women was 9.8% compared with 7.4% in men. In the multivariable analysis for the overall sample, older age (OR: 1.88, 95% CI: 1.10 to 2.86), being pre-frail (OR: 2.13, 95% CI: 1.12 to 4.00) and having depression or feeling depressed/anxious (OR: 2.35, 95% CI: 1.10 to 4.99) were associated with higher odds for incident falls. In subgroup analyses, older age was a risk factor for incident falls in men (OR: 2.68, 95% CI: 1.21 to 5.90) and pre-frail was a risk factor for incident falls in women (OR: 2.82, 95% CI: 1.28 to 6.20). There was no significant interaction effect between sex and age group (p value=0.341) and sex and frailty status (p value=0.181).

Conclusion Older age, presence of pre-frailty and having depression or feeling depressed/anxious were associated with higher odds of incident falls. In our subgroup analyses, older age was a risk factor for incident falls in men and being pre-frail was a risk factor for incident falls in women. These findings provide useful information for community health services in designing falls prevention programmes for community-dwelling adults in a multi-ethnic Asian population.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study had a prospective cohort study design with a large sample size (n=1053).
⇒ The study included the use of standardised questionnaire and validated tools to collect data on falls risk factors and covariates.
⇒ The study assessed a wide range of health outcomes allowing a comprehensive evaluation of risk factors associated with incident falls.
⇒ Fall information was acquired via questionnaire as self-reported falls; there might be recall bias.
⇒ This study did not further collect information on the aetiology of falls and fall-related consequences.

INTRODUCTION

Fall-related injuries are a major public health problems.[1] Specifically, falls are the second leading cause of death due to unintentional injuries.[1] Serious injuries resulting from falls include haematoma, joint dislocation, severe laceration, sprain, fractures and other disabling soft tissue injury.[2] Falls may also result in post fall syndrome that includes dependence, loss of autonomy, risk of recurrent fall, immobilisation and depression, leading to a further restriction in daily activities.[3] In particular, incident falls lead to an increased fear of falling, further limiting mobility beyond the physical injury and self-restriction of activities or exercises.[4] This self-imposition may further limit recovery, increase function deficits and expedite frailty progression.[4] The financial cost from fall-related injuries is also substantial.[5] In view of the implications of falls and given that falls are potentially preventable,[2] early detection of risk factors for incident falls is crucial.

Risk factors can be broadly categorised as modifiable (eg, frailty status, balance) or non-modifiable factors (eg, age, sex).[6 7] While risk factors of falls have been well studied, little research has been based on Asian population. Furthermore, sex differences in fall prevalence have been observed, where it tends to be higher in the female population.[8–10] Such sex differences may reflect differences in physiology, underlying health conditions and lifestyle. For example,

prevalence of alcohol drinking is typically higher for men,[11 12] but there is a stronger positive association of alcohol drinking and incidence of falls among older women (65 years and older).[13] This difference may be explained by lower alcohol metabolism among women which in turn impairs cognitive and physical functioning, resulting in an increased risk of falls.[13–15] As such, it will be crucial to examine if there are sex differences in risk factors for falls. Further understanding of risk factors for falls will improve design and implementation of falls prevention programmes.

Hence, the aim of our study was to identify the risk factors of incident falls between sex.

METHODS

Study design, setting and population

The Population Health Index (PHI) survey is a longitudinal survey to examine the health of community-dwelling adult population in the Central region of Singapore. Details of the study have been described previously.[16] In brief, the PHI survey used a standardised survey questionnaire to collect information on demographic and socioeconomic characteristics, physical and mental health status, functional and nutritional status, cognition status and medication usage.[16] A sampling frame of residential dwelling units was constructed by matching postal codes in the National Database on Dwellings in Singapore with the list of postal codes for the central region.[16] Within each planning area, a sample of dwelling units was selected proportionately from defined dwelling type groups. One eligible household member (Singaporean or permanent residents aged 21 years and above, staying in the household for >6 months) was randomly selected using the Kish grid.[17]

Between November 2015 and November 2016, trained interviewers carried out baseline face-to-face survey.[16] A total of 1942 individuals participated in the baseline survey, of which, 1526 participants completed 1-year follow-up survey between November 2016 and December 2017 (retention rate: 78.6%). For this study, we included only participants aged 40 years and above at baseline (N=1451). We excluded participants with missing baseline information on polypharmacy, vision and hearing impairment, alcohol intake, depression status, self-reported pain, loneliness status, and frailty status, and information on falls at 1-year follow-up (N=315). We further excluded participants who have experienced a fall prior to the baseline examination (n=83). The final analytical sample comprised of 1053 participants. Baseline characteristics of those who were included and excluded from the data analysis are shown in online supplemental table S1. The study was approved by the research ethics committee of the National Healthcare Group. Written informed consent was obtained from each participant before enrolment and the conduct of the study adhered to the Declaration of Helsinki.

Patient and public involvement

Participants and the public were not involved in the planning and execution of this study. However, they were informed of the need of the study and follow-up which was informed at the face-to-face survey.

Risk factors

Risk factors included participants' sociodemographic characteristics (age, sex, ethnic group), polypharmacy, sensory function, alcohol intake, depression status, self-reported pain, loneliness status and frailty status at baseline. These risk factors were included as they have been reported in literature to increase an individual's risk of falling.[7 18–21]

Age categories (40–60 years old and >60 years old), sex, ethnicity (Chinese; non-Chinese: Malay, Indian, others). polypharmacy, hearing or vision loss, alcohol intake and depression status, self-reported pain and loneliness status were included as dichotomised variables. Middle age was defined as 40–60 years old and older age was defined as >60 years old.[20] Vision/hearing impairment was defined as self-reported difficulties with vision (even with glasses) or difficulties with hearing/the use of a hearing aid.[7] Polypharmacy was defined as an intake of four or more types of prescription medications.[7 21] Information on alcohol intake was obtained by asking 'how often do you have a drink containing alcohol'. This question had five options: 1=never, 2=monthly or less, 3=two to four times a month, 4=two to three times a week, 5=four or more times a week. Evidence on the association between alcohol consumption and incident falls in an Asian population is limited. Further, alcohol threshold adopted varied across studies. In our study, alcohol intake was defined as an intake of alcoholic drink two or more times a week (score≥4). Self-reported depression was defined as a previous doctor's diagnosis. Feeling depressed/anxious was assessed using the EQ-5D-5L anxiety/depression dimension.[22] The anxiety/depression dimension had five levels; 1=not anxious or depressed, 2=slightly anxious or depressed, 3=moderately anxious or depressed, 4=severely anxious or depressed, 5=extremely anxious or depressed. Feeling depressed/anxious was defined as present if an individual reported any anxiety or depression (score≥2).[23] Self-reported pain was defined as the presence of pain experienced. Self-reported pain was assessed using the EQ-5D-5L pain/discomfort dimension. The pain/discomfort dimension had five levels; 1=no pain/discomfort, 2=slight pain/discomfort, 3=moderate pain/discomfort, 4=severe pain/discomfort, 5=extreme pain/discomfort. Self-reported pain was defined as present if an individual reported that they experience any pain/discomfort (score≥2). Evidence on the association between loneliness (measured using University of California Los Angeles (UCLA) loneliness scale) and incident falls in an Asian population is limited. Further, there was no literature to guide the definition of loneliness (measured using UCLA loneliness scale). In our study, presence of loneliness was assessed using the three-item UCLA loneliness scale.[24]

A loneliness score of 6–9 was classified as 'lonely'.[25] Frailty status was determined at baseline using the Clinical Frailty Scale (CFS).[26 27] Each participant was rated a CFS score (CFS 1–9) by a nurse based on a protocol mapped with the descriptors of the CFS.[26 27] CFS score was dependent on the presence of chronic conditions, severity of dementia, performance in activities of daily living and high-order instrumental activities of daily living (shopping, housekeeping, transportation, handing medication and finances), frequency of taking part in active recreation or regular fitness programme and presence of active bothersome symptoms.[27] It was categorised as: non-frail (CFS 1–3), pre-frail (CFS 4) and frail (CFS 5–9).

Outcome variable

Information on falls was collected at 1-year follow-up through a question 'Did you have a fall in the past 1 year?' A dichotomised variable (yes—fell; no—did not fall) was used in the analyses. An incident fall was defined as the experience of a fall between the baseline and 1-year follow-up but having no falls 1 year prior to baseline.

Statistical analysis

We compared baseline characteristics of those who did not fall and incident fallers using independent sample X^2 test or Fisher's exact test for categorical variables, respectively. Fisher's exact test was employed where sample size in the cell is small.[28]

Multiple logistic regression was performed to determine the associations between sociodemographic factors, medical history and lifestyle with incident falls. To examine if the risk factors for incident falls differed between men and women group, sex subgroup analyses were conducted. Risk factors (age group and frailty status) that were significantly associated with incident falls in the sex subgroup analyses were included in the interaction analyses. Interaction between (1) sex and age group and (2) sex and frailty status was evaluated by including a cross-product interaction term as an independent variable (ie, (1) sex*age group; (2) sex*frailty status). Adjusted OR were estimated from multivariable models and reported with corresponding 95% CIs.

To account for missing data, sensitivity analysis using multiple imputation was conducted. Each missing value for the following variables—frailty status, polypharmacy, feeling depressed/anxious loneliness status, were imputed using chained equations based on available data (table 1).[29] Multinomial regression was used to impute frailty category, while logistic regression was used to impute other variables (polypharmacy, feeling depressed/anxious loneliness status). Ten different datasets were generated, and coefficients were being pooled. All statistical analyses were performed using Stata V.13.0 (StataCorp LP).

Table 1 Comparison of baseline characteristics of those who did not fall and incident fallers

	Did not fall (n=961)	Incident fallers (n=92)	
	n (%)	n (%)	P value*
Age group			
40–60 years old	521 (54.2)	34 (37.0)	**0.002**
>60 years old	440 (45.8)	58 (63.0)	
Sex, women	523 (54.4)	57 (62.0)	0.165
Ethnic group			
Chinese	770 (80.1)	77 (83.7)	0.409
Non-Chinese	191 (19.9)	15 (16.3)	
Polypharmacy, yes	123 (12.8)	19 (20.7)	**0.035**
Vision/hearing impairment, yes	54 (5.6)	7 (7.6)	0.435
Alcohol intake, yes	79 (8.2)	5 (5.4)	0.346†
Self-reported depression or feeling depressed/anxious yes	52 (5.4)	12 (13.0)	**0.003**
Self-reported pain, yes	223 (23.2)	29 (31.5)	0.074
Loneliness, yes	53 (5.5)	6 (6.5)	0.688
Diabetes, yes	157 (16.3)	25 (27.2)	**0.028**
Frailty category			
Non-frail (CFS 1–3)	857 (89.2)	70 (76.1)	**0.001**†
Pre-frail (CFS 4)	73 (7.6)	17 (18.5)	
Frail (CFS≥5)	31 (3.2)	5 (5.4)	

*P value for differences between those who did not fall and incident fallers, by χ^2 test or †Fisher's exact test as appropriate.
CFS, Clinical Frailty Scale.

RESULTS

Table 1 compares the baseline characteristics between those who did not fall and those who experienced incident falls during 1-year follow-up. In this sample of community-dwelling older adults, 92 individuals (9.6%) (men: 35, 7.4%; women: 57, 9.8%, p value=0.481) experienced incident falls during the 1-year follow-up period. Compared with those who did not fall, participants who reported a fall at follow-up were older, taking four or more types of medication (polypharmacy), depressed, diabetic and pre-frail or frail at baseline.

Table 2 shows the association of risk factors with incident falls. In the multivariable analysis, older individuals (OR: 1.88, 95% CI: 1.10 to 2.86, p value=0.019), presence of pre-frailty (OR: 2.13, 95% CI: 1.12 to 4.00, p value=0.02) and having depression or feeling depressed/anxious (OR: 2.35, 95% CI: 1.10 to 4.99, p value=0.027) were significantly associated with higher likelihood of incident falls. Results from the sensitivity analysis using multiple imputation demonstrated similar associations to our main analysis (online supplemental table 2). Separate analysis was also conducted to examine the association between socioeconomic status with incident falls.

Table 2 Association of risk factors with incident falls

Risk factors	OR (95% CI)*	P value
Age group		
Age (40–60 years old)	Reference	
Age (>60 years old)	**1.88 (1.10 to 2.86)**	**0.019**
Men	Reference	
Women	1.29 (0.81 to 2.06)	0.280
Ethnic group†		
Chinese	Reference	
Non-Chinese	0.71 (0.38 to 1.29)	0.259
Polypharmacy, no	Reference	
Polypharmacy, yes	1.02 (0.55 to 1.91)	0.950
Vision/hearing impairment, no	Reference	
Vision/hearing impairment, yes	0.82 (0.34 to 1.97)	0.656
Alcohol intake, no	Reference	
Alcohol intake, yes	0.82 (0.31 to 2.14)	0.675
Self-reported pain, no	Reference	
Self-reported pain, yes	1.16 (0.70 to 1.92)	0.562
Loneliness, no	Reference	
Loneliness, yes	0.77 (0.30 to 1.95)	0.575
Diabetes, no	Reference	
Diabetes, yes	1.70 (1.00 to 2.89)	0.05
Frailty category		
Non-frail (CFS 1–3)	Reference	
Pre-frail (CFS 4)	**2.13 (1.12 to 4.00)**	**0.02**
Frail (CFS≥5)	0.99 (0.33 to 2.94)	0.982
Self-reported depression or feeling depressed/anxious, no	Reference	
Self-reported depression or feeling depressed/anxious, yes	**2.35 (1.10 to 4.99)**	**0.027**

*Variables included in model: age, sex, ethnic group, polypharmacy, vision and hearing impairment, alcohol intake, self-reported depression or feeling depressed/anxious, self-reported pain, loneliness status, diabetes status and frailty status.
†Results from additional analysis separating each ethnicity in the model are described in online supplemental table 4.
CFS, Clinical Frailty Scale.

In this analysis, no significant association between socioeconomic status and incident falls was observed (online supplemental table 3).

Table 3 compares the baseline characteristics between men and women incident fallers.

Table 4 shows the association of risk factors with incident falls by sex. Among men, only older age group (OR: 2.68, 95% CI: 1.21 to 5.90, p value=0.015) was found to be associated with incident falls. Among women, only presence of pre-frailty (OR: 2.82, 95% CI: 1.28 to 6.20, p value=0.01) was significantly associated with incident falls. Results from the sensitivity analysis using multiple imputation demonstrated similar associations to our main analysis (online supplemental tables 5 and 6). However, we did not observe a significant interaction effect between sex and age group (p value=0.341) and sex and frailty status (p value=0.181).

Table 3 Comparison of baseline characteristics between men and women incident fallers

	Men (n=35)	Women (n=57)	P value*
	n (%)	n (%)	
Age group			
40–60 years old	10 (28.6)	24 (42.1)	0.192
>60 years old	25 (71.4)	33 (57.9)	
Ethnic group			
Chinese	32 (91.4)	45 (79.0)	0.116†
Non-Chinese	3 (8.6)	12 (21.1)	
Polypharmacy, yes	6 (17.1)	13 (22.8)	0.515
Vision/hearing impairment, yes	3 (8.6)	4 (7.0)	0.785†
Alcohol intake, yes	3 (8.6)	2 (3.5)	0.298†
Self-reported depression or feeling depressed/anxious, yes	3 (8.6)	9 (15.8)	0.318†
Self-reported pain, yes	7 (20.0)	22 (38.6)	0.062
Loneliness, yes	2 (5.7)	4 (7.0)	0.806†
Diabetes, yes	9 (25.7)	16 (28.1)	0.805
Frailty category			
Non-frail (CFS 1–3)	30 (85.7)	40 (70.2)	0.235†
Pre-frail (CFS 4)	4 (11.4)	13 (22.8)	
Frail (CFS≥5)	1 (2.9)	4 (7.0)	

*P value for differences between those who did not fall and incident fallers, by X^2 test or †Fisher's exact test as appropriate.
CFS, Clinical Frailty Scale.

DISCUSSION/CONCLUSION

In this community-dwelling population, we observed that older age, presence of pre-frailty and self-reported depression or feeling depressed/anxious were associated with incident falls. In our subgroup analyses, we observed sex-specific risk factors. In men, only older age was associated with higher likelihood of incident falls. In women, only presence of pre-frailty was significantly associated with incident falls. These findings provide useful information for community health services in designing falls prevention programmes for community-dwelling adults in a multi-ethnic Asian population.

The incidence of falls observed in our study was comparable to two recent studies conducted in Singapore (incident of falls: 14%,[18] age standardised rate for falls: 13.8%[30]). In our pooled analysis, we observed older age, presence of pre-frailty and the presence of depression or feeling depressed/anxious to be associated with incident falls. While the association between older age and

Table 4 Association of risk factors with incident falls by sex

Sex	Risk factors	OR (95% CI) *	P value
Men (n=473)			
	Age (40–60 years old)	*Reference*	
	Age (>60 years old)	**2.68 (1.21 to 5.90)**	**0.015**
	Ethnic group		
	Chinese	Reference	
	Non-Chinese	0.34 (0.10 to 1.20)	0.093
	Polypharmacy, no	Reference	
	Polypharmacy, yes	0.78 (0.27 to 2.21)	0.639
	Vision/hearing impairment, no	Reference	
	Vision/hearing impairment, yes	0.75 (0.19 to 3.03)	0.686
	Alcohol intake, no	Reference	
	Alcohol intake, yes	0.59 (0.17 to 2.04)	0.408
	Self-reported pain, no	Reference	
	Self-reported pain, yes	1.09 (0.43 to 2.78)	0.861
	Loneliness, no	Reference	
	Loneliness, yes	0.78 (0.15 to 4.10)	0.773
	Diabetes, no	Reference	
	Diabetes, yes	1.53 (0.65 to 3.60)	0.334
	Frailty category		
	Non-frail (CFS 1–3)	Reference	
	Pre-frail (CFS 4)	1.26 (0.38 to 4.16)	0.699
	Frail (CFS≥5)	0.61 (0.07 to 5.42)	0.656
	Self-reported depression or feeling depressed/anxious, no	Reference	
	Self-reported depression or feeling depressed/anxious yes	2.65 (0.60 to 11.65)	0.198
Women (n=580)			
	Age (40–60 years old)	Reference	
	Age (>60 years old)	1.43 (0.77 to 2.69)	0.261
	Ethnic group		
	Chinese	Reference	
	Non-Chinese	1.02 (0.49 to 2.11)	0.959
	Polypharmacy, no	Reference	
	Polypharmacy, yes	1.29 (0.58 to 2.86)	0.526
	Vision/hearing impairment, no	Reference	
	Vision/hearing impairment, yes	0.95 (0.30 to 3.05)	0.931
	Alcohol intake, no	Reference	
	Alcohol intake, yes	1.79 (0.38 to 8.57)	0.465
	Self-reported pain, no	Reference	
	Self-reported pain, yes	1.13 (0.60 to 2.13)	0.705
	Loneliness, no	Reference	
	Loneliness, yes	0.77 (0.24 to 2.46)	0.660
	Diabetes, no	Reference	
	Diabetes, yes	1.82 (0.91 to 3.61)	0.088
	Frailty category		
	Non-frail (CFS 1–3)	Reference	
	Pre-frail (CFS 4)	**2.82 (1.28 to 6.20)**	**0.010**
	Frail (CFS≥5)	1.34 (0.35 to 5.03)	0.669
	Self-reported depression or feeling depressed/anxious, no	Reference	
	Self-reported depression or feeling depressed/anxious yes	2.90 (0.84 to 5.24)	0.115

*Variables included in model: for age, ethnic group polypharmacy, vision and hearing impairment, alcohol intake, self-reported depression or feeling depressed/anxious, self-reported pain, loneliness status, diabetes status and frailty status.
CFS, Clinical Frailty Scale.

incident falls has been well reported,[1 7] the link between depression and falls is less clear. It has been suggested that the association between the use of antidepressant medication could be a causal factor.[31] However, we did not have information on drug type, hence, unable to explore this in our study. Other studies proposed that physical decline caused by depression could have led to an increase in the risk of falls.[31–33] Further studies are needed to elucidate the relationship between depression and incident falls.

The association between pre-frailty and incident falls has been unclear.[34 35] In our study, we observed that pre-frailty status was associated with an increased likelihood of incident falls. Pre-frail individuals, who may appear independent and healthy, exhibit early signs of frailty, such as decreased functional reserve capacity in maintaining position, balance and coordination.[36] Pre-frail individuals often do not realise or recognise these symptoms to be risk factors for falls.[37] As such, these individuals may continue with their day-to-day activities without taking precaution.[37] Our findings echoed results from another study that reported older adults who had little difficulty in performing physical tasks was significantly associated with an increased likelihood of incident falls compared with those who did not have any difficulty. However, the study did not observe a significant association between individuals who had significant difficulty in performing physical tasks with increased likelihood of incident falls compared with those who did not have any difficulty.[38] Collectively, findings from these studies indicated that independent individuals who exhibit early signs of frailty might not recognise their own physical limitations, hence, are at risk of incident falls. Polypharmacy, vision and hearing impairment are known risk factors of falls.[7 21 30] However,

we did not observe a significant association between polypharmacy, vision and hearing impairment and incident falls in pooled analysis as well as in subanalyses. A possible reason could be because our study population had comparatively low prevalence of vision and hearing impairment, and polypharmacy.

In our subgroup analyses for men and women population, we observed a significant association between older age and incident falls in men. A possible explanation that older age was observed to be associated with incident falls in men but not in women in our population could be because older men were more likely to engage in social activities (eg, going out for meals, playing sports, going for walk) compared with women.[39] Hence, this observed association between older age and higher odds of falls in men may be attributed to the greater social activities. We hypothesise that higher levels of social activities may have increased the risk of falls, possibly due to extrinsic factors (eg, unfamiliar environment, slippery floor). However, in our study, we did not collect information on fall location, cause of fall and level of social participation. As such, we are unable to test our hypothesis in this study. Interpretation of our results from the subgroup analysis will also need to keep in mind the non-significant interaction effect between sex and age group. Further studies with a larger sample size will be needed to (1) validate our findings and (2) examine if more frequent engagement in social activities may increase the risk of falls.

The association between presence of pre-frailty and incident falls was observed only in women. In a study conducted in Singapore, the authors reported lower appendicular skeletal muscle and lower hand grip strength in pre-frail women compared with pre-frail men.[40] Lower appendicular skeletal muscle is a proxy measurement of lean tissue mass loss[41] and lower grip strength is a proxy measurement of muscle strength.[42] Together, lower appendicular skeletal muscle and lower grip strength translate to lower extremity physical function and walking ability increasing an individual's risk of falls.[43–46] As such, it is possible that pre-frail women had lower appendicular skeletal muscle and grip strength compared with pre-frail men of similar body mass index, potentially increasing their risk of falls. Interpretation of our results from the subgroup analysis will also need to keep in mind the non-significant interaction effect between frailty status and sex in our interaction analysis. Further studies with larger sample size and information on lower appendicular skeletal muscle and grip strength will be needed to confirm our findings.

Based on our findings, we highlight that fall prevention strategies are important to both sexes; this information on the sex difference on underlying cause of falls may be taken into consideration in the development and implementation of targeted fall prevention strategies.

The strengths of this study include the use of standardised questionnaire and validated tools to collect data on fall risk factors and covariates, thus allowing us to conduct a comprehensive evaluation of risk factors associated with incident falls. However, this study also has a few limitations. First, as fall information was acquired via questionnaire as self-reported falls, there might be recall bias, which may result in under-reporting or over-reporting of falls. Second, we only collected data on falls but did not further collect information on the aetiology of falls and fall-related consequences. Third, we did not collect the number of falls experienced by each individual within the 1-year follow-up. Fourth, the low prevalence of risk factors (eg, alcohol intake, loneliness status, frailty status) may have limited our ability to detect statistically significant associations with incident falls. Fifth, the identification of fall risk factors was limited to the information that was collected from our survey.

CONCLUSION

In conclusion, in this community-dwelling population, older age, presence of pre-frailty and presence of depression were associated with incident falls. Specifically, we observed that older men and pre-frail women had a higher likelihood of incidents falls. Findings from our study can help community screening programmes further streamline their screening process and focus on specific population for their fall preventive programmes.

Contributors WFY conceptualised, performed data analysis, interpreted the findings and wrote the manuscript; LG recruited and conducted the study and revised the manuscript; BHH reviewed the study methodology and revised the manuscript; WST contributed to the conceptualisation and design of the work, interpreted the findings and revised the manuscript. WFY and WST are responsible for the overall content as guarantor. All authors reviewed and approved the final version of the manuscript for publication.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Consent obtained directly from patient(s).

Ethics approval The study was approved by the ethics review committee of the National Healthcare Group Domain Specific Review Board (Reference Number: 2015/00269).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

ORCID iDs

Wan Fen Yip http://orcid.org/0000-0002-8443-517X

Lixia Ge http://orcid.org/0000-0001-8080-7020
Woan Shin Tan http://orcid.org/0000-0003-1055-0412

REFERENCES

1 Who Health Organization. WHO global report on falls prevention in older age. 2008. Available: https://http://www.who.int/publications/i/item/97892415635362022
2 James SL, Lucchesi LR, Bisignano C, *et al*. The global burden of falls: global, regional and national estimates of morbidity and mortality from the global burden of disease study 2017. *Inj Prev* 2020;26:i3–11.
3 Al-Aama T. Falls in the elderly: spectrum and prevention. *Can Fam Physician* 2011;57:771–6.
4 Fuller GF. n.d. Falls in the elderly. (0002-838X (print)).
5 Stevens JA, Corso PS, Finkelstein EA, *et al*. The costs of fatal and non-fatal falls among older adults. *Inj Prev* 2006;12:290–5.
6 Europe. What are the main risk factors for falls amongst older people and what are the most effective interventions to prevent these falls? 2004. Available: https://http://www.euro.who.int/__data/assets/pdf_file/0018/74700/E82552.pdf
7 Board HP. Fall prevention among older adults living in the community. 2015. Available: https://http://www.hpb.gov.sg/docs/default-source/pdf/cpg_falls_preventionb274.pdf2020
8 Chan KM, Pang WS, Ee CH, *et al*. Epidemiology of falls among the elderly community dwellers in singapore. *Singapore Med J* 1997;38:427–31.
9 Ngamsangiam P, Suttanon P. Risk factors for falls among community-dwelling elderly people in asia: a systematic review. *Sci Tech Asia* 2020;25:105–26.
10 Wu H, Ouyang P. Fall prevalence, time trend and its related risk factors among elderly people in china. *Arch Gerontol Geriatr* 2017;73:294–9.
11 Wang Q, Zhang Y, Wu C. Alcohol consumption and associated factors among middle-aged and older adults: results from china health and retirement longitudinal study. *BMC Public Health* 2022;22:322.
12 Lim W-Y, Subramaniam M, Abdin E, *et al*. Lifetime and twelve-month prevalence of heavy-drinking in singapore: results from a representative cross-sectional study. *BMC Public Health* 2013;13:992.
13 Chang Vc Fau - Do MT, DoMT. n.d. Risk factors for falls among seniors: implications of gender. (1476-6256 (electronic)).
14 Nolen-Hoeksema S. Gender differences in risk factors and consequences for alcohol use and problems. *Clin Psychol Rev* 2004;24:981–1010.
15 Guo Y, Hu H, Liu Y, *et al*. n.d. Gender differences in the relationship between alcohol consumption and insomnia in the Northern Chinese population. *PLoS ONE*;13:e0207392.
16 Ge L, Yap CW, Ong R, *et al*. Social isolation, loneliness and their relationships with depressive symptoms: a population-based study. *PLoS One* 2017;12:e0182145.
17 Kish L. A procedure for objective respondent selection within the household. *J Am Stat Associat* 1949;44:380–7.
18 Chen TY, Tan PJ, Chan A. Ethnicity predicts falls among community-dwelling older adults in singapore. *Geriatr Gerontol Int* 2018;18:72–9.
19 Zeytinoglu M, Wroblewski KE, Vokes TJ, *et al*. Association of loneliness with falls: A study of older US adults using the national social life, health, and aging project. *Gerontol Geriatr Med* 2021;7:2333721421989217.
20 Who Health Organization. Falls. 2021. Available: https://http://www.who.int/news-room/fact-sheets/detail/falls2022
21 Hammond T, Wilson A. Polypharmacy and falls in the elderly: a literature review. *Nurs Midwifery Stud* 2013;2:171–5.
22 Herdman M, Gudex C, Lloyd A, *et al*. Development and preliminary testing of the new five-level version of EQ-5D EQ-5D-5L). quality of life research: an international journal of quality of life aspects of treatment, care and rehabilitation. 2011;20:1727–36.
23 Short H, Al Sayah F, Ohinmaa A, *et al*. The performance of the EQ-5D-3L in screening for anxiety and depressive symptoms in hospital and community settings. *Health Qual Life Outcom* 2021;19:96.
24 Hughes ME, Waite LJ, Hawkley LC, *et al*. A short scale for measuring loneliness in large surveys: results from two population-based studies. *Res Aging* 2004;26:655–72.
25 Steptoe A, Shankar A, Demakakos P, *et al*. Social isolation, loneliness, and all-cause mortality in older men and women. proceedings of the national academy of sciences of the united states of america. 2013;110:5797–801.
26 Rockwood K, Theou O. Using the clinical frailty scale in allocating scarce health care resources. *CGJ* 2020;23:210–5.
27 Ge L-O, Yap CW, Heng BH. n.d. Prevalence of frailty and its association with depressive symptoms among older adults in singapore. (1364-6915 (electronic)).
28 Kim HY. Statistical notes for clinical researchers: chi-squared test and fisher's exact test. *Restorat Dentis Endodont* 2017;42:152–5.
29 Jakobsen JC, Gluud C, Wetterslev J, *et al*. When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. *BMC Med Res Methodol* 2017;17.
30 Dai W, Tham Y-C, Chee M-L, *et al*. Falls and recurrent falls among adults in A multi-ethnic asian population: the singapore epidemiology of eye diseases study. *Sci Rep* 2018;8:7575.
31 Iaboni A, Flint AJ. The complex interplay of depression and falls in older adults: a clinical review. *Am J Geriat Psychiat* 2013;21:484–92.
32 Bruce ML, Seeman TE, Merrill SS, *et al*. The impact of depressive symptomatology on physical disability: macarthur studies of successful aging. *Am J Public Health* 1994;84:1796–9.
33 Whooley MA, Kip KE, Cauley JA, *et al*. Depression, falls, and risk of fracture in older women. *Arch Intern Med* 1999;159:484–90.
34 Kojima G. Frailty as A predictor of future falls among community-dwelling older people: A systematic review and meta-analysis. *J Am Med Dir Assoc* 2015;16:1027–33.
35 Cheng MH, Chang SF. Frailty as a risk factor for falls among community dwelling people: evidence from a meta-analysis. *J Nurs Scholarsh* 2017;49:529–36.
36 Chen CY, Gan P, How CH. n.d. Approach to frailty in the elderly in primary care and the community. (0037-5675 (print)).
37 Soriano TA, DeCherrie LV, Thomas DC. Falls in the community-dwelling older adult: a review for primary-care providers. *Clin Interv Aging* 2007;2:545–54.
38 Yip W, Ge L, Heng BH. n.d. Association between patient-reported functional measures and incident falls. *Sci Rep*;11.
39 Ang S. Social participation and mortality among older adults in singapore: does ethnicity explain gender differences? *J Gerontol B Psychol Sci Soc Sci* 2018;73:1470–9.
40 Merchant RA, Soong JTY, Morley JE. Gender differences in body composition in pre-frail older adults with diabetes mellitus. *Front Endocrinol (Lausanne)* 2022;13:795594.
41 Ackermans L, Rabou J, Basrai M. Screening, diagnosis and monitoring of sarcopenia: when to use which tool? *Clin Nutr ESPEN* 2022;48:36–44.
42 Bohannon RW. Grip strength: an indispensable biomarker for older adults. *Clin Interv Aging* 2019;14:1681–91.
43 Pijnappels M, van der Burg Pj Fau - Reeves ND, Reeves Nd Fau - van Dien JH. n.d. Identification of elderly fallers by muscle strength measures. (1439-6319 (print)).
44 Yeung SSY, Reijnierse EM, Pham VK, *et al*. Sarcopenia and its association with falls and fractures in older adults: a systematic review and meta-analysis. *J Cachexia Sarcopenia Muscle* 2019;10:485–500.
45 Lin Y-H, Chen H-C, Hsu N-W, *et al*. Using hand grip strength to detect slow walking speed in older adults: the yilan study. *BMC Geriatr* 2021;21:428.
46 Delinocente MLB, de Carvalho DHT, Máximo R de O. Accuracy of different handgrip values to identify mobility limitation in older adults. *Arch Gerontol Geriatr* 2021;94:104347.