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*Original research article*

# Risk Factors for Falls among Community-Dwelling Elderly People in Asia: A Systematic Review

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**ABSTRACT**

Risk factors for falls among community-dwelling elderly people have been well reported in Western countries more so than in Asian countries, which could lead to overlooking differences in risk factors for falls between the two regions. Therefore, this systematic review aims to determine common risk factors of falling among community-dwelling elderly people in Asia. The online databases searched were Cochrane, CINAHL and MEDLINE. We searched for cohort studies, longitudinal studies, or systematic review conducted among elderly people living in Asia. A total of 11 studies included in this review matched the inclusion criteria for data analysis. Incidence of falls conducted in Asia ranged from 15%-26% and increased incidence of falls was found to increase with age , especially among females. In addition, risk factors for falls were categorized as either intrinsic or extrinsic, which commonly reported risk factors of falls including demographic factors, medical and health conditions, physical performance, physical activity, cognitive performance, fear of falling and environmental hazards. Some fall risk factors including specific pain (back, knee region), and sleep quality also referred to fall risk factors in Asia. These factors should be considered as one of the fall risk factors for fall risk screening in community-dwelling elderly people in Asia.

**Keywords:** Risk factors; Falls; Community-dwelling; Older people; Asia

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## 1. Introduction

The population of the world aged 60 years or over totaled 962 million in 2017. The population of elderly people is predicted to double that by 2050, reaching nearly 2.1 billion people. In 2050, elderly people in Asia are expected to reach 24 % [1].

Approximately 30% of elderly people, residing in communities, fall each year [2]. A fall can impact both physical and mental health, such as causing bone fractures or a fear of falling. Additionally, falling was found to be related to mortality, hospitalization and health services expenses for elderly people [3]. Each year around the world, about 646,000 people die from falling, and over 80% of these deaths occur in low and middle income countries. Falls are defined as "inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, walls or other objects" [4].

Fall risk factors among community-dwelling elderly people have been well-reported; however, most related studies have been conducted in Western countries [5, 6]. Limited evidence is available regarding fall risk factors in Asia, while falls have become an important health issue for increasingly aging populations. Differences in cultures, residences, health care systems, health facilities, geography and environments, or even different definitions of falls and older people, between countries could possibly lead to differences in risk factors of falls in Asia compared to those in Western countries. Currently, systematic reviews of fall risk factors in Asia include a review by Romli et al. studying falling in Southeast Asia [7] , and a review by Kwan, Marcella Mun-San et al. studying falls among Chinese elderly people [8]. However, to the best of our knowledge, no studies at present have reviewed risk factors of falls among elderly people residing in communities in Asia. Therefore, this systematic review aimed to determine common risk factors of falling among older people residing in communities in Asia.

## 2. Materials and Methods

### 2.1 Search strategy

A literature review was conducted according to the research question, "What are risk factors of falling among the elderly residing in communities in Asia?". The search was created using PICO format, for which P (population) included the terms elderly, aged, aging, senior, older people, AND community or community dwelling, AND Asia, I (intervention). Further, C (comparison) and O (outcome) included the terms fall risk, fall risk factor, risk for fall, risk factor and risk assessment.

In this study, we searched research papers published from 1990 to 2020 (January 1, 1990 to July 25, 2020). The criteria were defined as English language, longitudinal study, cohort study or systematic reviews study design, elderly aged 60 and older residing in communities in Asia. We excluded studies involving participants with specific conditions such as stroke, cognitive impairment, Parkinson's disease and studies that referred to risk factors of falling from other causes such as car accidents. The searched online databases comprised Cochrane, CINAHL and Medline. The online search was performed by keywords, criteria and PICO format as described below.

Cochrane database: The search terms were: (elderly or older or aged or aging or senior or "older people" or community or "community dwelling") and ("fall risk" or "risk for fall" or "risk factor" or "risk assessment" or "fall risk factor") and ("fall" or "accidental fall") and ("Asia" or name of 48 countries in Asia).

CINAHL database: The search terms were: (elderly or aged or older or elder or geriatric) and ("fall risk" or "fall risk factor" or falling or fall) and (community) and ("Asia" or name of 48 countries in Asia).

MEDLINE database: The search terms were: (elderly or older or aged or aging or senior or "older people" or community or "community dwelling") and ("fall risk" or "risk for fall" or "risk factor" or "risk assessment" or "fall risk factor") and ("fall" or "accidental fall") and ("Asia" or name of 48 countries in Asia).

### 2.2 Selection criteria

All studies were assembled using the Endnote Program and duplicate data were deleted. A reviewer (PN) screened the titles, keywords and abstracts of all identified studies. Two reviewers (PN, PS) independently reviewed full text articles to include studies that matched all inclusion criteria, and the Kappa value was calculated for acceptable reliability (Kappa ≥0.5). In case of disagreements, discussions were held between the two reviewers until consensus was reached. Studies meeting these criteria were reviewed for further analysis.

### 2.3 Assessment of method quality

We used the Newcastle-Ottawa quality assessment scale form for cohort studies to evaluate the quality of the research, while the PRISMA checklist was used for quality assessment of systematic reviews. Quality assessment was performed independently by the two reviewers. The results of the quality assessment from the two reviewers were then compared. Any disagreement was resolved by discussion.

### 2.4 Data extraction and analysis

The data extracted from studies selected for the full review included authors, year of publication, country, study design, duration of following, participants, fall incidence and risk factors of falling.

## 3. Results

### 3.1 Search results

A total of 2,178 studies were chosen from 3 databases (1,686 studies from MEDLINE, 157 studies from Cochrane and 335 studies from CINAHL). One hundred and thirty-four studies were excluded due to duplication, and 1,799 studies were left for title screening. An additional 220 studies were excluded from abstract screening. Therefore, 25 studies underwent full-text screening by the two reviewers. In all, 14 studies were excluded;3 studies investigated people aged less than 60 years, 1 article was a letter, 1 article was not about fall risk factors, 1 article was not conducted in Asia, 1 article was not conducted among community-dwelling elderly people, and 7 studies were not longitudinal cohort, or systematic review study designs. Finally, 11 studies were included for data analyses (Fig. 1).

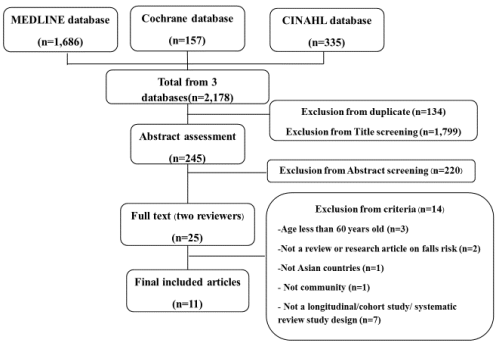


**Fig. 1.** Selection criteria flow chart for systematic reviews or cohort studies on fall risk factors among community-dwelling elderly people in Asia from 1990-July 2020.

### 3.2 Study population and study designs

Descriptions of study designs and study population of included studies are presented in Table 1. This study was conducted in 9 countries including Thailand (n=1), Iran (n=1), China (n=11), Japan (n=3), Sri Lanka (n=1), Taiwan (n=7), Hong Kong (n=6), Singapore (n=1), and Macao (n=1). The years of included studies ranged from 2011 to 2020. The participants totaled 174,788. Two studies were systematic reviews and 9 were cohort studies, with a range in follow-up time from 4 months to 73 months.

**Table 1.** Summary of included studies (n=11): distribution of characteristics of included studies.

| Author, Reference | Year | Country | Study design | Subject (n) | Fall incidence | Risk factors |
|---|---|---|---|---|---|---|
| Aranyavalai et al [9] | 2020 | Thailand | Cohort study (6-month F/U) | 255 Age:68.7±6.7 | - Fall incidence: 12.94% - Incidence density rate: 0.79 per 1000 person-days | Age Polypharmacy Urinary incontinence Physical activity (low) Physical performance (low functional mobility) |
| Takada et al. [10] | 2018 | Japan | Cohort study (12-month F/U) | 1,071 Age:71.1±4.4 | 19.6% | Sleep quality (poor) |
| Safarpour et al. [11] | 2018 | Iran | Cohort study (6-month F/U) | 732 Age:68.5±6.9 | 7.8% reported falls: 50% fell once 25% fell twice 25% fell ≥3 | Number of Comorbidities Cognitive impairment Depression |
| Wu and Ouyang [12] | 2017 | China | Longitudinal study (24-months F/U) | 8,683 Age:68.2±6.7 | 19.28% | Self-rated health Sex, Age Marital status Chronic diseases Disability items Limited ADL Physical function |
| Kitayuguchi et al. [13] | 2017 | Japan | Cohort study (36-month F/U) | 1,890 Age:68.3±5.9 | 13.6% fell once 4.8% multiple falls | Low back pain Knee Pain |
| Kojima et al. [14] | 2016 | Japan | Cohort study (72-month F/U) | 1,904 Age:70 | Male: 7.8% Female: 13.7% | Depression Visual impairment |
| Jiang et al. [15] | 2015 | China | Systematic review | 128,691 Age: ≥60 | - Fall-related injuries: 54.95 per 1000 -Incidence by age 60-69 yr: 25.95 per 1000 70-79 yr: 33.03 per 1000 ≥80 yr: 62.74 per 1000 | Sex |
| Hu et al. [16] | 2015 | China | Cohort study (12-month F/U) | 3,092 Age:75.0 ±9.4 | 7.6% indoor fall | Health status Physical function Environment |
| Ranaweera et al. [17] | 2013 | Sri Lanka | Cohort study (4-month F/U) | 1,200 Age:71.4±6.8 | 25.8% fell within previous year -Incidence rate of falls was 491 per 1000 person-years - Incidence rate in 60-69 years=360 per 1000 person-years 70-74 years= 458 per 1000 person-years ≥75 years= 691 per 1000 person-years | Age Chronic diseases Dizziness History of falls Poor mobility Disability Environment |
| Kwan et al. [18] | 2012 | Taiwan | Longitudinal study (24-month F/U) | 280 Age:74.9±6.4 | 33.1% | Self-rated health Depression Visual impairment Physical performance (reduced strength, poor balance) |
| Kwan et al. | 2011 | Taiwan | Systematic review | 26,990 | -Annual rate of | Age, sex |

| | | | | |
|---|---|---|---|---|
| [19] | Hong-Kong Singapore China Macao | Age: ≥60 | falls:15 to 26%<br>44%: fell indoor<br>22-76%: fell outdoor<br>59-97%: fell during daytime | Limited ADL<br>Multiple medications<br>Fear of falling<br>Used walking aid<br>Self-rated health<br>Marital status<br>Living alone<br>Gait abnormality<br>Chronic conditions<br>History of falls<br>Visual impairment<br>Depression |

### 3.3 Study quality

The results of the method quality assessment are presented in Table 2 (for cohort studies) and Table 3 (for systematic reviews). All of the included studies with cohort study designs were classified as good quality. For the included systematic reviews, the quality assessment score rated by the PRISMA checklist ranged from 18 to 23 points out of a possible total score of 27.

**Table 2.** Quality assessment scores of Cohort studies (Newcastle Ottawa quality).

| Author, Reference | Selection (Total star) | Comparability (Total star) | Outcome (Total star) | Overall Quality Score | Quality |
|---|---|---|---|---|---|
| Aranyavalai et al. [9] | 4 | 1 | 3 | 8 | Good |
| Takada et al. [10] | 4 | 1 | 2 | 7 | Good |
| Safarpour et al. [11] | 4 | 1 | 3 | 8 | Good |
| Wu and Ouyang [12] | 4 | 1 | 2 | 7 | Good |
| Kitayuguchi et al. [13] | 4 | 1 | 2 | 7 | Good |
| Kojima et al. [14] | 4 | 2 | 2 | 8 | Good |
| Hu et al. [16] | 4 | 2 | 2 | 8 | Good |
| Ranaweera et al. [17] | 4 | 2 | 3 | 9 | Good |
| Kwan et al. [18] | 4 | 2 | 3 | 9 | Good |

**Table 3.** Quality assessment of systematic reviews (PRISMA).

| Author, Reference | Total (27) |
|---|---|
| Jiang et al. [15] | 23 |
| Kwan et al. [19] | 18 |

### 3.4 Fall epidemiology

In this review, fall incidences are summarized in Table 1.

#### *3.4.1 Incidence and person-time incidence by history of falls*

Different reports in terms of fall incidence, ranged from 19.6% within a 1-year follow-up, 7.8% to 12.96% within a 6-month follow-up [9, 11], and 12.8% within a 4 month follow-up in which 14.5% had more than one fall [17]. One systematic review [19] reported an annual rate of falls among elderly people at 15 to 26%. Another cohort study reported an incidence rate at 491 per 1000 person-years (95%CI 448-536) and found that falling once totaled 13.6% [13]. Incidents of falling once were also reported differently in other studies including 50% [11] and 59.3% [18]. Falling twice was reported at 25% [11] and 20.9% [18]. Incidence of triple or more falls was 19.7% [18] and 25% [11]. Several studies reported multiple falls (two or more times) which totaled 4.8% [13] and 4 to 5% [19]. Regarding location of falls, one study found that 22 to 76% of falls occurred outdoors while 44% occurred indoors. In addition, falls occurred in rural (88%) more than urban areas (69%) [19].

#### *3.4.2 Incidence by injury time*

Two studies reported on time of injury from falls, showing that falls occurred during daytime at 60% [16] and 59 to 97% [19].

#### *3.4.3 Incidence and person-time incidence by falls-related injury*

Three studies reported falls resulting in an injury (4.5%) [13] or health problem (48.6%) [17] including fractures (12.1%). Another study found that person-time incidence of fall-related injuries was 54.95 per 1000 [15].

#### *3.4.4 Incidence and person-time incidence by sex*

Three studies reported that women fell more than men. The fall rate among men was 7.8%, while for women it was 13.7% [14]. Another study reported person-time incidence among men was 462 per 1000 person-years (95%CI 420-504) [17], and 94.54 per 1000 for related injuries [15] among men, while for women it was 515 per 1000 person-years (95%CI 469-561) [17] and 91.72 to 144.93 per 1000 for related injuries [15].

#### *3.4.5 Incidence by age*

Two studies investigated age associated with falls at various ranges of age. Jiang et al. (2015) divided age of incidence of fall-related injury as detailed below. For the age range of 60 to 69 years, it was 25.95 per 1000 (95% CI, 12.81-39.09), 70 to 79 years was 33.03 per 1000 (95% CI, 11.12-54.93), and for those 80 years or older it was 62.74 per 1000 (95% CI, 20.09-105.39) [15]. The study by Ranaweera et al. (2017) reported incidence of falls for the age range of 60 to 69 years was 360 per 1000 (95% CI 328 to 392), 70 to 74 years was 458 per 1000 (95% CI 417-499), and 75 years or older was 691 per 1000 (95% CI 629-753) [17].

### 3.5 Fall risk factors

All the included studies in this review examined risk factors of falls in different ways including odds ratio, relative risk, hazard ratio, IRR, and regression coefficients. Risk factors reported in the included studies are summarized and presented in Table 4. Falls risk factors have been divided in 2 main categories: intrinsic and extrinsic [20].

#### *3.5.1 Intrinsic risk factors*

##### *3.5.1.1 Demographic factors*

**Age:** Three cohort studies and 1 systematic review of 11 included studies reported 'age' as a risk factor of falls and found that increased age increases the risk of falls [9, 12, 17, 19].

**Sex:** Two studies of 9 reported that females tended to be at greater risk of falling compared to males [12, 19].

**Marital status:** One cohort study of 9 included studies reported that people who had married tended to fall 1.11 times more, compared with individuals with single status [12]. On the other hand, Kwan et al. [19] reported that unmarried elderly, including both single and widowed, experienced falls at a rate of 1.2 to 2.8 times higher than married elderly people.

**Living alone:** Only one systematic review in this review reported living alone as a risk of falls where an individual living alone had 1.2 to 3.1 times more risk of falling [19].

##### *3.5.1.2 History of falls*

A cohort study by Ranaweera et al. reported that having a history of falls in the previous year, could increase risk of falling 4.19 times [17]. Another study reported having falls in the previous 12 to 18 months would increase chance of an additional fall by 13.1 times [19].

##### *3.5.1.3 Medical/health conditions*

**Comorbidities:** Five studies [11, 12, 16, 17, 19] in this review investigated comorbidities as fall risk factors. The

studies differently reported comorbidities including number of medical conditions [11, 16, 17], classification (2 or 4 diseases) or report of individual diseases [12, 19] such as hypertension, dyslipidemia, diabetes mellitus, and cancer or malignant tumor etc. Results of odds ratios or relative risk of comorbidities as a risk factor of falls from the included studies are summarized in Table 4.

**Low back pain and Knee pain:** One cohort study in this review investigated low back pain and knee pain during 1- and 3-year follow-up surveys reporting that participants who had chronic low back pain and knee pain with moderate or severe pain intensity had a greater risk of falls [13].

**Activities of daily living:** Two studies of 9 [12, 19] reported that declined activity level or difficult activities of daily living could result in a high risk of falling.

**Self-rated health:** Only 1 cohort study [12] of 9 reported that elderly people having self-rated health at very good or good level was associated with a decreased risk of falling by up to 0.76 times (95% CI 0.64-0.90). Two studies [18, 19] reported that elderly people who had self-rated their health as poor, including limited activities of daily living or pain, had a higher risk of falling.

**Depression:** Three cohort studies and 1 systematic review [11, 14, 18, 19] reported that depressive symptoms could increase risk of falling, especially, depression [11]. However, one study [14] reported that associations between falls and depressive symptoms were found among women 1.7 times (95%CI 1.09-2.62), but not among men.

**Visual impairment:** Four studies of 9 reviews and cohort studies [11, 14, 18, 19] reported that visual impairment increased the risk of falls. In addition, depth perception, cataract, or glaucoma could increase risk of falls [18, 19]. However, the cohort study by Kojima et al. in 2016 [14] reported that visual impairment was significantly associated with falls among females at 2.34 times (95% CI 1.45-3.71), but not among males. The study also reported that elderly people with depressive symptoms combined with visual impairment had an increased risk of falling by 3.5 times, but this relationship was found among females only.

**Disability items:** Two cohort studies of 9 [12, 17] investigated the association between disabilities and falling, and found that having a disability increased risk of falls by 1.18 to 2.74 times.

**Dizziness:** Only 1 cohort study by Ranaweera et al. [17] reported that dizziness had a relationship with falling (OR 1.56, 95% CI 1.04-2.34).

**Urinary incontinence:** A cohort study by Aranyavalai et al. in 2020 [9] reported that urinary incontinence was related to fall incidence in within a 6 month follow-up period (HR 2.87, 95% CI 1.45-5.68).

**Sleep quality:** A cohort study by Takada et al. in 2018 [10] found that poor sleep quality, assessed by the Pittsburgh Sleep Quality Index (PSQI), correlated with fall occurrences in the following year (OR 1.50 for each three-point increase of PSQI score, 95% CI 1.20-1.89).

#### *3.5.1.4 Physical performance*

**Physical function:** Only 1 cohort study by Wu et al. [12] reported that impaired physical function led to an increased risk of falling (OR 1.09, 95%CI 1.06-1.13). One study [16] investigating balance in physical function, divided into distinct levels defined as moderate, severe, and major, found that impaired balance resulted in increased risk of falls. One study by Kwan et al. [18] reported that increased sway resulted in an increased risk of falls (IRR 1.43, 95% CI 1.18-1.73).

**Mobility:** Two cohort studies [9, 17] measuring mobility using the Timed Up and Go Test found that low functional mobility would increase risk of falls to HR=6.43,

OR=2.45 times. Another study [19] reported that gait abnormality or instability resulted in 1.4 to 2.6 times higher risk of falls.

**Reduced strength:** Only 1 of 9 reviews and cohort studies included in this review reported that reduced lower limb strength resulted in an increased risk of falling [18].

#### *3.5.1.5 Physical activity*

A cohort study by Aranyavalai et al. [9] reported that fall incidence during a 6 month follow-up period was related to behavioral risk factors including walking less than 5,000 steps/day (HR 3.6, 95% CI 1.76-7.31), having a PASE score of less than 100 (HR 3.53, 95% CI 1.24-10.04), and moderate to vigorous intensity physical activity of less than 60 min/week (HR 3.66, 95% CI 1.12-12.01).

#### *3.5.1.6 Cognitive performance*

A cohort study [11] investigated associations between cognitive impairment and falls and found that a higher severity of cognitive impairment could result in higher risk of falls.

#### *3.5.1.7 Fear of falling*

A systematic review by Kwan et al. [19] including 21 research studies reported that 6 studies investigated correlation between fear of falling and fall occurrences. Five of those reported that elderly people who had a fear of falling had an increased risk of falls by a factor of 1.9 to 3.1.

### *3.5.2 Extrinsic risk factors*

#### *3.5.2.1 Multiple medication use*

A cohort study by Aranyavalai et al. [9] and a systematic review by Kwan et al. [19] reported that multiple medication use and antihypertensive medication could increase risk of falls. Multiple medication use was defined as either use of 2 or more drugs as a fall risk factor [21-23], or use of 3 or more drugs as a fall risk factor [24].

#### *3.5.2.2 Assistive device*

Only 1 systematic review [19] of 9 reported a relationship between the use of an assistive device and fall occurrence. The review found that 6 studies investigated the correlation between assistive device use and falls occurrences; five of those reported that elderly people using an assistive device had a higher risk of falling by a factor of 1.6 to 2.8,and 1 study reported a lower risk of falls among elderly people using an assistive device at 0.6 times those not using an assistive device.

#### *3.5.2.3 Home environmental hazards*

Two cohort studies studied associations between home living environment and falls. One of the studies assessed the home living environment by using a scale regarding unsafe items in a corridor, bedroom, living room, kitchen, lavatory, and balcony. Only a corridor score classified as bad (score > 2) was associated with falls at the hazard ratio 2.732 (95% CI 1.613-4.626) [16]. Another cohort study assessed house risk level using a hazard environment checklist including obstacles, poor lighting, and slippery surfaces in different areas of the house and garden. The study found that when elderly people lived in a house with a high risk level**,** they had a higher risk of falls compared to older people living in a house with low risk level by a factor of 1.71 (95% CI 1.13-2.60) [17].

**Table 4.** Risk factors of falling.

| Risk factors | Odds ratio (95% CI) | Relative risk (95% CI) | Regression coefficients | Author, Reference |
|---|---|---|---|---|
| **Intrinsic risk factors** | | | | |
| **1. Demographic factors** | | | | |
| **Age (years)** | | | | |
| 66-70 | 1.13(0.99,1.29) | - | 0.123 | Wu and Ouyang [12] |
| ≥75 | 1.85(1.23-2.77) | - | - | Ranaweera et al [17] |

| | | | | |
|---|---|---|---|---|
| Increasing age | 1.1-2.2 | 1.1-2.0 | - | Kwan et al. [19] |
| | | **Hazard ratio** | | |
| | - | 3.54(1.37-9.11) | - | Aranyavalai et al. [9] |
| **Sex** (Female) | 1.43(1.28,1.60) | - | 0.359 | Wu and Ouyang [12] |
| | 1.5-2.9 | - | - | Kwan et al. [19] |
| **Marital status** | 1.11(0.97,1.27) | - | 0.105 | Wu and Ouyang [12] |
| | 1.2-2.8 | - | - | Kwan et al. [19] |
| **Living alone** | 1.2-3.1 | 2.1 | - | Kwan et al. [19] |
| **2. History of falls** | | | | |
| - Previous year | 4.19(2.76-6.35) | - | - | Ranaweera et al. [17] |
| - Past 12 to 18 months | 13.1 | 1.7-10.2 | - | Kwan et al. [19] |
| **3.Medical/health conditions** | | | | |
| **Comorbidities** | | | | |
| ≥3 | - | 2.03(1.20-3.42) | - | Safarpour et al. [11] |
| **Chronic diseases*** | 1.08(1.05,1.12) | - | 0.081 | Wu and Ouyang [12] |
| Chronic conditions | 1.2-2.8 | - | - | Kwan et al. [19] |
| -Diabetes mellitus | 1.3-1.6 | 1.8 | - | Kwan et al. [19] |
| -Hypotension | 1.2-1.8 | - | - | Kwan et al. [19] |
| -Hypertension | 1.5-1.8 | - | - | Kwan et al. [19] |
| **Number of diseases** | | **Hazard ratio** | | |
| 2 | - | 0.974 (0.677-1.400) | -0.027 | Hu et al. [16] |
| 3 | - | 1.699 (1.171-2.465) | 0.530 | Hu et al. [16] |
| 4 or more | - | 1.198 (0.786-1.825) | 0.180 | Hu et al. [16] |
| **Chronic diseases >2** | 1.50(1.01-2.22) | - | - | Ranaweera et al. [17] |
| **Low back pain** | | | | |
| **(1-year F/U)** | | | | |
| Chronicity | 2.46(1.08-5.63)‡ | - | - | Kitayuguchi et al. [13] |
| **(3-year F/U)** | | | | |
| Chronicity | 2.11(1.07-4.14)‡ | - | - | Kitayuguchi et al. [13] |
| Intensity(Moderate/severe) | 2.17(1.08-4.36)‡ | - | - | Kitayuguchi et al. [13] |
| **Knee Pain** | | | | |
| **-1-year F/U** | | | | |
| Chronicity | 2.39(1.29-4.44)‡ | - | - | Kitayuguchi et al. [13] |
| **-3-year F/U** | | | | |
| Chronicity (≥3 months) | 1.81(1.09-3.02)‡ | - | - | Kitayuguchi et al. [13] |
| Intensity(Moderate/severe) | 1.67(0.97-2.87)‡ | - | - | Kitayuguchi et al. [13] |
| **ADL**** | 1.14(1.08,1.20) | - | 0.131 | Wu and Ouyang [12] |
| | 1.6-3.9 | 1.2 | - | Kwan et al. [19] |
| **Self-rate health** | | | | |
| -Very good/good | 0.76(0.64,0.90) | - | -0.268 | Wu and Ouyang [12] |
| **Self-rate health** | | **IRR[j](95% CI)** | | |
| -Limit in stair climbing | - | 1.83(1.18-2.84) | - | Kwan et al. [18] |
| -Moderate-extreme pain | - | 2.06(1.33-3.17) | - | Kwan et al. [18] |
| -Self-perceived poor health | 1.0-2.9 | 1.8 | - | Kwan et al. [19] |
| **Depression** | 1.4-4.6 | 1.6 | - | Kwan et al. [19] |
| | 1.70(1.09-2.62)[t] | - | - | Kojima et al. [14] |
| | | **IRR[j](95%CI)** | | |
| | - | 1.82(1.12-2.94) | - | Kwan et al. [18] |
| -Mild impairment | - | 1.33(0.64-2.72) | - | Safarpour et al. [11] |
| -Intermediate impairment | - | 2.98(1.48-6.00) | - | Safarpour et al. [11] |
| -Severe impairment | - | 4.06(1.94-8.48) | - | Safarpour et al. [11] |
| **Visual impairment** | | | | |
| (only women but not men) | 2.34(1.45-3.71)[t] | - | - | Kojima et al. [14] |
| **Visual impairment** | | **Hazard ratio** | | |
| -Moderate | - | 1.168(1.052-1.600) | 0.155 | Hu et al. [16] |
| -Severe | - | 1.714(1.160-2.533) | 0.539 | Hu et al. [16] |
| **Visual impairment** | | **IRR[j] (95%CI)** | | |
| -Depth perception | 1.3-1.6 | 1.25(1.02-1.53) | - | Kwan et al. [18] |
| -Eye problem (e.g. cataract or glaucoma) | - | 1.6-2.4 | - | Kwan et al. [19] |
| **Combination** (Depression and visual impairment) | 3.50(1.65-7.13)[t] | - | - | Kojima et al. [14] |

| | | | | |
|---|---|---|---|---|
| **Disability items**** | 1.18(1.09,1.27) | - | 0.162 | Wu and Ouyang [12] |
| | 2.74(1.77-4.22) | - | - | Ranaweera et al. [17] |
| **Dizziness** | 1.56(1.04-2.34) | - | - | Ranaweera et al. [17] |
| | | **Hazard ratio** | | |
| **Urinary incontinence** | - | 2.87(1.45-5.68) | - | Aranyavalai et al. [9] |
| **Sleep quality (poor)** | 1.50(1.20-1.89) | - | - | Takada et al. [10] |
| **4. Physical performance** | | | | |
| **Physical functioning***** | 1.09(1.06,1.13) | - | 0.091 | Wu and Ouyang [12] |
| -Balance ability | | **Hazard ratio** | | |
| Moderate | - | 2.289(1.53-3.42) | 0.828 | Hu et al. [16] |
| Severe | - | 2.650(1.48-4.75) | 0.975 | Hu et al. [16] |
| Major | - | 6.758(4.08-11.20) | 1.911 | Hu et al. [16] |
| **Poor balance** | | **IRR[j](95%CI)** | | |
| -Sway-floor with eyes open | - | 1.40(1.14-1.71) | - | Kwan et al. [18] |
| -Sway-foam with eyes open | - | 1.29(1.05-1.60) | - | Kwan et al. [18] |
| **Mobility** | | **Hazard ratio** | | |
| - Poor mobility | 2.45(1.43-4.13) | - | - | Ranaweera et al. [17] |
| | - | 6.34(2.65-15.57) | - | Aranyavalai et al. [9] |
| - Gait abnormality | 1.4-2.6 | - | - | Kwan et al. [19] |
| **Reduced Strength** | | **IRR[j](95% CI)** | | |
| -Knee extension Strength | - | 0.72(0.57-0.91) | - | Kwan et al. [18] |
| -Knee flexion Strength | - | 0.74(0.59-0.94) | - | Kwan et al. [18] |
| -combined Strength | - | 0.72(0.57-0.90) | - | Kwan et al. [18] |
| **5. Physical activity** | | **Hazard ratio** | | Aranyavalai et al. [9] |
| -Walking <5,00 steps/day | - | 3.6(1.76-7.31) | - | |
| -PASE score <100 | - | 3.53(1.24-10.04) | - | |
| -Physical activity <60 min/week **(**Moderate to vigorous intensity**)** | - | 3.66(1.12-12.01) | - | |
| **6.Cognitive performance** | | | | |
| -Mild | - | 1.13(0.59-2.14) | - | Safarpour et al. [11] |
| -Intermediate & severe | - | 1.97(1.05-3.47) | - | Safarpour et al. [11] |
| **7. Fear of falling** | 0.9;1.9-3.1 | - | - | Kwan et al. [19] |
| **Extrinsic risk factors** | | | | |
| **1. Multiple medication use** | | | | |
| -Antihypertensive medications | 1.1-2.6 | 2.1 | - | Kwan et al. [19] |
| | 1.4-2.9 | 1.8-2.5 | - | Kwan et al. [19] |
| | | **Hazard ratio** | | |
| - Polypharmacy | - | 4.32(2.12-8.79) | - | Aranyavalai et al. [9] |
| **2. Assistive device** | 0.6;1.6-2.8 | - | - | Kwan et al. [19] |
| **3. Home environmental hazards** | | | | |
| **Home-living environment** | | **Hazard ratio** | | |
| -Score of corridor | - | 2.732(1.613-4.626) | 1.005 | Hu et al. [16] |
| **House risk level** | | | | |
| -High level | 1.71(1.13-2.60) | - | - | Ranaweera et al. [17] |

**Note:***Chronic diseases included (1) hypertension, (2) dyslipidemia, (3) diabetes or high blood sugar, (4) cancer or malignant tumor, (5)chronic lung diseases,(6) liver disease, (7) heart disease, (8) stroke, (9) kidney disease, (10) stomach or other digestive diseases, (11) emotional, nervous, or psychiatric problems, (12) memory-related disease, (13) arthritis or rheumatism and (14) asthma.

**ADL was assessed by the question "do you have any difficulty with dressing, bathing or showering, eating such as cutting up your food, getting in or out of bed, using the toilet, including getting up and down, controlling urination and defecation".

***Physical functioning included running or jogging about 1 km, walking 1 km, walking 100 m, getting up from a chair after sitting for a long time, climbing several flights of stairs without rest, stooping, kneeling or crouching, reaching or extending your arms above the shoulders, lifting or carrying over 5 kg such as a heavy bag of groceries and picking up a small coin from a table.

****Disability items included (1) physical disabilities, (2) brain damage/mental retardation, (3) vision problem, (4) hearing problem and (5) speech impediment.

**Key for adjustment of confounding factors:**

[‡]Adjusted for sex, age, body mass index, community, years of education, self-rated health, depressive symptoms, smoking habit, chronic disease history, physical activity, medication use and consultation with physicians.

[t]Adjusted for enrolment year, hypertension, diabetes mellitus, body mass index, exercise habit, hypnotic use, walking speed and Tokyo Metropolitan Institute of Gerontology index of competence.

IRR[j] adjusted for the length of the follow-up.

# 4. Discussion

## 4.1 Fall epidemiology

### *4.1.1 Incidence and person-time incidence by history of fall*

In this present review, fall incidence reported in reviews or cohort studies conducted in Asia ranged from 15 to 26%, slightly lower than those reported in studies conducted in Western countries (28% to 35%) [25]. Possible explanations could be cultural differences, residences, environments, and health facilities. In addition, understanding of falls and methods of collecting data differed such as self-reports which may have been affected by recall bias that could also contribute to the difference of fall incidence rates reported in Asian and Western countries. A study by Garcia et al. found that history of falls by self-reporting exhibited moderate agreement and should be carefully considered in making conclusions [26]. In addition, this review included middle-income countries classified by the world bank group [27]. Consequently, elderly people, who experience falling may worry about expenses related to their falls [28, 29]. In Asia, access to health care differs from countries with high income households that can afford healthcare more so than low income households. Moreover, out-of-pocket costs relating to healthcare vary widely among Asian countries, for instance, the cost of inpatient and outpatient care, medicines, fees, etc. [30]. However, in Western countries, such as Britain, most healthcare services are not charged at service points. Examples of covered areas are preventive medicine, primary care, and hospital services [31]. In the US, healthcare includes multiple systems which are intended to cover all citizens [32]. Notably, health care systems can potentially affect the elderly's decision to seek healthcare services.

### *4.1.2 Incidence by injury time*

In this review, fall occurrences were reported more frequently during daytime than night time, similar to related studies of falls in Asia by Hua et al. [33] and Fong et al. [34]. This corresponds with related studies investigating falls conducted in Western countries [25, 35-37]. Asmost elderly people perform their activities of daily living or other activities more frequently during the daytime, it stands to reason that most falls occur during daytime.

### *4.1.3 Incidence and person-time incidence by fall-related injuries*

In the current review, falls could lead to injury and health problems, including bone fracture. The incidence of fall-related injuries in this study corresponded to the related systematic review of Peng et al. conducted among elderly Chinese [38]. However, the incidence of fall-related injuries in this review was lower than that of a related study conducted in the US [29]. The difference in findings could have resulted from the different number of participants, and fall-related injuries might have been defined differently. The study conducted in the US categorized fall-related injuries in fatal fall injuries and nonfatal fall injuries while the studies included in Peng's review and this review defined fall-related injuries generally, without classification.

### *4.1.4 Incidence and person-time incidence by sex*

The results of fall incidence by sex in this review were consistent with several related studies [39-41] supporting the idea that females were more likely to fall than males. This might be due to greater reduced muscle mass and muscle strength among females compared with males, in whom muscle mass loss and muscle strength totaled about 15% compared to the 30% found in females. Muscle mass loss and strength loss in females occurs rapidly 5 to 10 years after menopause [42]. Reduced

muscle strength has been identified as a risk factor of falls [20].

#### *4.1.5 Incidence by age*

Similar to related studies in Western countries (the US and UK) [3, 39], the current review also found increased age exhibits a linear association with the incidence of falls. This could be explained by the many risk factors of falls including changes in gait control, increased inactivity, chronic conditions, and multiple medication use [5].

### 4.2 Risk factors

#### *4.2.1 Intrinsic risk factors*

##### *4.2.1.1 Demographic factors*

**Age and sex:** This review found that increased age and being female were risk factors of falls. The related systematic review by Ambrose et al. [5] and Deandrea et al. [6] provided similar findings. Physiologic and pathologic changes associated with increased age could provide reasons for general populations of elderly people having higher fall risk worldwide.

**Marital status**: The included studies by Kwan et al. [19] reported that unmarried, including single and widowed, status could increase risk of falls. Another study provided a similar result to ours, finding that living alone increased fall risk [41]. On the other hand, only 1 study [12] in this review found that marriage status tended to increase risk of falling. Therefore, from our review, the relationship between marital status and falls remains controversial.

**Living alone:** This review showed that elderly people living alone had 1.2-3.1 times the risk of falls as those not living alone. This result was consistent with a study by Elliott et al. [37] and Sophonratanapokin et al. [43], reporting the percentage of falls was higher among elderly people living alone compared to that of those living with others. One possible reason could be the fact that older people living alone might have less social support than those living with others or family members. This social support could lead to higher confidence when performing various activities [44].

##### *4.2.1.2 History of falls*

This review found that a history of falls was associated with the risk of falls similar to a review by Ambrose et al. in 2013 reporting that a history of falls among the elderly could lead to a fear of falling. From the review, 40% of those with a fear of falling, resulting from a history of falls, reported effects to their daily physical activities, causing physical decline which could potentially create more problems including social isolation and depression [5]. These factors could lead to an elevated risk of falls among elderly people.

##### *4.2.1.3 Medical/health conditions*

**Comorbidities**: The results of this current review showed that having a comorbidity was one of the risk factors of falls, as several related studies reported including a systematic review of Deandrea et al. [6], several studies from Asia [43, 45, 46], and Western countries [41, 47]. The common ailments that could be found together with falls included depression, cognitive impairment, delirium, stroke, Parkinson's disease, cerebellar diseases, vestibular dysfunction, hypertension, etc.

**Low back pain and knee pain:** This review found that the effect of pain could amplify the risk of falls. This finding was similar to that of a related cohort study of falls among Japanese by Muraki et al. in 2013 [48]. In addition, the result of this review paralleled that of the cohort study by Woo et al. in 2009 in Hong Kong [49] indicating that pain was relevant to falls and could contribute to functional limitations and psychological impairments. The current findings also corresponded to several studies from Western countries [50, 51]. Pain associated with muscle weakness and functional limitations such as difficulty

standing or walking short distances led to less confidence while performing activities which could increase the risk of falling [52-54]. Pain assessment in both Asia and Europe uses a variety of factors in terms of severity or location of pain. The assessment could be done either by question or Brief Pain Inventory, so the reported details of pain assessment may lack similarity.

**Activity of daily living/disability items:** This review showed that declined activity level or difficulty performing activities increased the risk of falls among elderly people. This corresponded with a related prospective study conducted in 12 European countries [55]. A relationship was found between activity level and the risk of falls looking at the decreasing level of physical activityof the elderly worldwide. Studies conducted in 2016 showed that the prevalence of physical inactivity was 27.5% (95% uncertainty interval 25.0 to 32.2), with higher levels among females and older people. In addition, the study showed that in 2001 and 2016, the prevalence of physical inactivity in western countries exhibited a higher percentile than that of Asian countries [56]. This suggests that using technology for living enhances the performance of sedentary activities [57]. On the contrary, physical activity relates to physical performance; if physical activity decreases over a long period, it could decrease physical performance including balance, strength and mobility, and consequently increase the risk of falls [58-60].

**Self-rated health**: This review found that self-rated health at reported at the poor level could increase the risk of falls similar to related studies from Western countries (Brazil,US) [61, 62] which found a relationship between poor level self-rated health and a higher risk of falls. In addition, poor self-rated health was also found to be related toother fall risk factors including medical conditions, depression, and fear of falling [63]. In other words, elderly people, presenting chronic health conditions or depression, will have a lower level of self-perception than normal people, affecting the capacity to perform activities in daily life. It also caused lower confidence in performing such activities and consequently increased risk of falls [64, 65].

**Depression:** This review found that depressive symptoms could increase the risk of falls corresponding to related cohort studies conducted in Western countries [41, 55] and the systematic review by Kvelde et al., which showed that a higher level of depressive symptoms could increase falls [66]. This could be explained by the idea that as people age, chronic conditions, sensory impairments, and activity limitations could lead to falls. The common chronic conditions mentioned including cardiovascular disease and diabetes related to anxiety and depression [67].

**Visual impairment:** This review showed that visual impairments could increase the risk of falls. This was similar to findings from a study by Ecosse et al. conducted in Singapore [68] and a study by Crews et al. conducted in the US [69]. Furthermore, visual impairment was shown to be related to decreased postural stability [70].

**Dizziness:** Dizziness is a symptom frequently found in elderly people. This review also found that dizziness was associated with falling, as did a related review [5] and cohort study [55]. The research of Gomez et al. in 2011 reported that dizziness was associated with other factors related to risk of falls such as chronic conditions, visual impairment, multiple medication use, poor self-perceived health, cognitive impairment, and depression [71].

**Urinary incontinence:** This review found that urinary incontinence increased the risk of falls corresponding wtih a related systematic review by Deandrea et al. (Western countries) [6] and a prospective study by Brown et al. (US) [72]. One

possible reason could be that individuals with urinary incontinence are prone to rush to the toilet [73] and have anxiety about not being able to go to the toilet in time [72]. Additionally, being concentrated on controlling one's bladder could serve as a distracting factor influencing balance control and motor performance e.g., walking [74].

**Sleep quality:** Our review supported the notion that poor sleep quality could increase fall risk. This corresponded to a related study by Brassington et al. [75], conducted in northern California revealing that sleep problems were associated with number of falls experienced. Additionally, related systematic reviews [76], mostly conducted in the US and Australia, reported that sleep problems such as short sleep duration, daytime sleepiness, and napping could increase the risk of falls. This could be because poor sleep might influence cognitive performance (slower response times, cognitive dysfunction) [77], daytime sleepiness, and balance [78] which could consequently lead to falls [75, 79].

#### *4.2.1.4 Physical performance*

**Physical function, mobility:** The results of this review indicate that physical function impairment and poor mobility, including impaired balance, gait abnormality, or instability constituted risk factors of falls similar to the results of a related systematic review [5] and the research of Degani et al., conducted in the US; they found that elderly people exhibited increased body sway due to compensation by the body from age-related changes such as degenerated sensory, neutral, and motor functions [80].

**Reduced strength:** This review supports the idea that reduced strength could increase risk of falls, similar to the findings of a related review [81]. This could be explained by the fact that muscle strength is important in performing physical activities, e.g., gait control, getting out of chairs, and walking up stairs [82].

#### *4.2.1.5 Physical activity*

This review found that low physical activity levels such as walking fewer than 5,000 steps/day and moderate to vigorous intensity of physical activity at less than 60 minutes/week could increase fall incidence among elderly people. These results were consistent with related cohort studies [83, 84] conducted in Western countries, reporting that elderly people with a low activity level (walking less than 60 minutes daily [83], low step count and more sedentary behavior [84]) would increase the risk of falls. In addition, a related review found that a low physical activity level indicated a high risk of recurrent falls among elderly people [85].

#### *4.2.1.6 Cognitive performance*

This review found that an increased severity of cognitive impairment could result in higher risk of falls, similar to the findings of a related cohort study conducted in 12 Western countries [55], revealing that elderly people with cognitive impairment have impaired gait and postural control [86, 87].

#### *4.2.1.7 Fear of falling*

The results of this review showed that fear of falling was one of the factors for fall risk as was reported in related systematic reviews conducted in both Asian and Western countries [6]. Prevalence rates concerning fear of falling appear to be higher in Asian countries; the prevalence rate of fear of falling in Taiwan is 53.4% [88], in Korea 76.6% [89], while the prevalence rate of fear of falling in the US is approximately 23 to 43% [90]. This difference could result from differences in demographic characteristics, such as age, history of fall or cultural factors [91]. Furthermore, falls self-efficacy (self-perceived confidence in performing daily physical activities) was also related to

postural balance, according to the research of a cohort study by Pua et al. in Singapore, reporting that elderly people with high fall efficacy but poor postural balance are at greater risk for falls [92]. This corresponded with a systematic review reporting that fear of falling was related to being female, falls, gait abnormalities, and depression [93].

#### *4.2.2 Extrinsic risk factors*

##### *4.2.2.1 Multiple medication use*

The results of this current review were consistent with results from related studies [5, 6] finding that multiple medication use posed as a risk factor of falls. Multiple medication use was found to be common among elderly people resulting from multiple medical conditions among this group. Another possible reason is that multi-medication use could increase fall risk due to possible side effects of medications, in particular those causing dizziness, impaired balance, or impaired decision making [94].

##### *4.2.2.2 Assistive device*

This review found that walking aids might increase fall risk similar to the findings from several other studies [6, 45, 95]. Several reasons for using walking aids among elderly people include impairment, muscle weakness, balance or gait deficit, etc. All of these reasons are recognized risk factors of falls [6]. However, one study in this review showed that the use of a walking aid could decrease the risk of falls. This suggests that several factors contribute to the results of using gait aids in reducing falls risk. Using the proper type of walking aid matched to the ability of the user, together with proper knowledge on how to use the assistive device would help increase walking ability [96].

##### *4.2.2.3 Home environmental hazards*

This review found that home environment was associated with falls, similar to the findings of a related systematic review by Letts et al. The review covered key environmental factors including lighting, need for stair and bath rails, clutter, and wet surfaces [97]. Currently, various home environment or home hazard assessments are available; therefore, researchers should select the most appropriate type of assessment with good psychometric properties to evaluate the home environment such as HOME FAST [98], HSSAT [99], or WeHSA [100].

This systematic review showed common risk factors for falls in Asian countries including demographic factors, medical and health conditions, physical performance, physical activity, cognitive performance, fear of falling, and environmental hazards. These factors were similar to those fall risk factors reported by related review studies conducted in Western countries [5, 6]. There were some additional factors such as specific pain at the back or knee region and sleep quality mentioned as possible risk factors for falls in Asia studies.

This review encountered limitations. First, the current review included only studies or reviews published in English. This excludes several studies published in other languages officially used in Asian countries. In addition, many Thai students' theses were not included in this review. Finally, this review gathered reviews or studies covering only 9 countries that might not fully represent the whole of Asia.

## 5. Conclusion

This systematic review provided useful information about the incidence of falls and risk factors for falls among elderly people living in Asian communities. The incidence of falls in Asian countries was lower than that reported in Western countries. In addition, some fall risk factors including specific pain (back, knee region) and sleep quality also referred to fall risk factors in Asia. These factors should be considered as fall risk factors for screening in community-dwelling elderly people in Asia.

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