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HEALTHY AGING RESEARCH

Domiciliary environmental risk factors for accidental falls among community-living older persons: A prospective 12-month study

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Abstract

Background: Falls are common internationally among the elderly. This study examined domiciliary environmental risk factors attributable to accidental falls among community-living older persons living in high-rise buildings in Hong Kong.

Methods: Over the preceding 6 months, 592 older persons were recruited from a housing resource center for baseline assessments. Among them, 456 participants completed monthly telephone follow-ups for 12 months. A home visit for environmental inspection was conducted within 3 days for those who reported falls in an indoor environment. The environments of participants with or without falls were compared for analysis.

Results: Seventy-seven participants reported falls (indoor: outdoor = 1:2) over the preceding 12 months. The fall rate was 24.8%, and the one-year prevalence of falls (persons with at least one fall) was 16.7%; for two or more falls it was 3.9%. Self-reported previous falls in the preceding 12 months (OR 2.88, CI 1.67-7.17), female gender (OR 8.91, CI 0.27-0.47), and self-reported diabetes mellitus (OR 3.55, CI 1.10-3.55) were significant predictors for fallers with at least one fall. Significant differences were found between the homes of fallers and non-fallers in the sites of hazards with respect to seating (p = .011), toilets (p = .018), and kitchens (p = .026), particularly with steps or stair railings (p = .009).

***Conclusions*:** This study supports the existence of a difference in environmental risk factors between fallers and non-fallers in high-rise buildings, and the results can be generalized to other domiciliary environments for community-living older persons in most urban cities.

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Introduction

Falls are common domestic accidents among older people around the world. In Hong Kong, approximately 26% of community-living older persons have suffered a fall; in a representative sample, the one-year prevalence rate of falls was 17-19% [1, 2]. Accidental falls have both intrinsic and extrinsic causes. A comprehensive review of 16 studies showed that falls were associated with the following risk factors (listed in descending order of their relative risk): muscle weakness, history of falls, gait deficits, balance deficits, use of assistive devices, visual deficits, arthritis, impaired activities of daily living (ADL), depression, cognitive impairments and advanced age [3], and that psychotropic medications are linked to falls [4, 5]. Many of these factors involve personal causation, therefore it is still unclear exactly how much of an effect environmental hazards have on the risk of falling among older people [6]. In fact, some studies show no association between environmental hazards and falls [7, 8] and the existence of home hazards alone is insufficient to cause falls except among those older people with only fair balance and limited mobility, or with a history of falls [8]. A recent Cochrane review concluded that interventions to improve home safety do not seem to be effective except in people with severe visual impairment [9]. However, another meta-analysis of randomized controlled trials for environmental interventions in falls prevention demonstrated that the risk of falls was reduced by 21% of the overall population and 39% among populations at high risk for falls [10]. Although evidence supporting the use of home environment assessment and intervention alone as a strategy to reduce falls in community-dwelling older adults is mixed, the evidence in support of home assessment and adaptation as a part of a multi-factorial fall program is strong [11].

Other studies report several environmental risk factors that strongly increase the rate of falls [12]. Retrospective studies have revealed that between 35% and 45% of elderly falls are caused by home hazards, such as poor lighting, inadequate bathroom grab rails, inadequate stairway banisters, exposed electrical cords, clutter on floors and the ubiquitous throw rug [13-17]. Apart from these hazards, flooring materials have been identified as a major factor in falls [18]. Some researchers have taken the question from the opposite perspective, starting with people who had fallen and comparing their environments to those who had not. One study found that the homes of 45 older people who had fallen had fewer handrails and more uneven floors compared with age- and sex-matched controls [19]. Similarly, people who had one or more environmental hazard in their homes were more likely to have reported falling in the last three months [20]. However, competence may not always be protective. One study found that environmental hazards were more likely to contribute to falls in vigorous older people than in frail ones [21]. Vigorous adults may overestimate their ability to overcome obstacles or underestimate the risks of familiar environments.

Hong Kong is the world's most densely populated city packed with high-rise buildings, with 98% of its people living in multi-story residential buildings and nearly half living in public housing [22]. It is thus worth identifying the risk of environmental hazards for this unique living environment, which may be not consistent with that of rural areas. Therefore, this study started with older people who had fallen and compared their environments with those who had not. We aimed to investigate the risk of falls through a follow-up group of community-living older people in Hong Kong using phone calls prospectively for one year to identify these risks. We also examined differences in the location and features of the hazards between domiciliary environments for older people with and without falls through follow-up home visits.

Methods

Participants

We recruited a sample of 592 participants aged 65 years and older, living independently in community dwellings in Hong Kong, by convenience sampling at a housing resource center (the Center) over 12 months. Participants were excluded if they (1) lived in old age homes or elderly hostels, (2) lived in simple village houses or simple stone huts, (3) had communication difficulties, or (4) scored less than 6 on the Abbreviated Mental Test (AMT) (Hong Kong version) [23]. Those with poorer cognitive performance (as indicated by the AMT score) were excluded because they would be less reliable in recall and ability to report their fall history over the previous 12 months [24]. To obtain a more representative sample, we recruited subjects according based on a quota sampling strategy that stratified the study participants by five age groups according to the distribution of the Hong Kong Population Census of 2007 [22].

Baseline assessment

Face-to-face interviews and baseline assessments were completed at the center. We sought informed and written consent from participants before data collection and recorded demographic information and assessment results. We used the following operational definitions: (1) A fall was any event resulting in a person coming to rest inadvertently on the ground not due to sustaining a sudden blow, a loss of consciousness, or a sudden onset of paralysis such as stroke or an epileptic seizure [4, 25]; (2) base rate refers to the incidence of falls among participants over the prospective 12 months after attending the assessment and education session at the Center; and (3) indoor environment included the living space and the environment (e.g. internal pathways) within the apartment or building.

Instruments

Four instruments were used in the assessments: body mass index (BMI), the Timed Up & Go Test (TUGT) [26], the Functional Reach Test (FRT) [27] and a visual acuity test with a Snellen chart. Five occupational therapy students who had undergone training by experienced occupational therapists were responsible for conducting the assessments with participants. The TUGT is an objective, valid and reliable measurement of mobility that measures the time taken by an individual to stand up from a standard armchair, walk for 3 metres, turn around and walk back to the chair and sit down again [26]. The reported predictive validity, and intra- and inter-reliabilities were high [28]. The FRT is a measure of balance and is the difference between arm's length and maximal forward reach using a fixed base of support [27]. It has good to excellent reliability in older community dwelling populations [29]. Participants were also asked to report their health conditions and to evaluate the environmental and personal factors leading to reported falls or domestic accidents at home or within their housing estates over 12 months after the baseline assessment at the Center.

Follow-up

Follow-up was completed via telephone calls by occupational therapy students made to all participants every month prospectively for a total of 12 months after the baseline assessment. Each phone interview lasted for 5-10 minutes. We also requested information about subsequent falls, details of management, medical consultation and hospital admissions.

Home visits

Two registered occupational therapists conducted home visits to those who reported accidental falls at home during the telephone follow-up. The therapist identified and documented environmental hazards using a standardized instrument - the Westmead Home Safety Assessment (WeHSA) [30], which is of satisfactory content validity and inter-rater reliability [31]. The WeHSA is a comprehensive environmental assessment that provides an extensive list of potential hazards about the environment and was developed as a tool for occupational therapists to identify environmental hazards in the homes of persons who are at risk of falling [30]. In order to compare the differences in domiciliary environments for older people with and without falls, we randomly selected from the study sample a group of non-fallers with same number of participants of each age strata that matched closely with that of the fallers on the age for home visits immediately after 12 months. They were used as controls for the comparison of domiciliary environments with that of fallers.

Statistical analysis

We reported demographic data with percentage and range and interpreted the base rate according to (1) the rate of incidents for falls (number of incidents per 100 people in one year), (2) the one-year prevalence of incidents (people with at least one incident over the previous 12 months) and (3) the prevalence of recurrent incidents in one year (people with two or more incidents over the previous 12 months). We used t-tests to analyze any differences in environmental hazards between the fall and non-fall groups, and Chi-square tests to test the association between falls and risk factors. Using forward logistic regression, we constructed the preliminary prediction of risk factors for falls. The significance level was set at $p = 0.05$.

Results

A flowchart of participants in the study is shown in Fig. 1. A total of 592 participants were recruited over 6 months, with a mean age of 75 (SD = 6.7). Of these, 80.6% (n = 477) were female, and 32.9% (n = 195) had not received formal education.

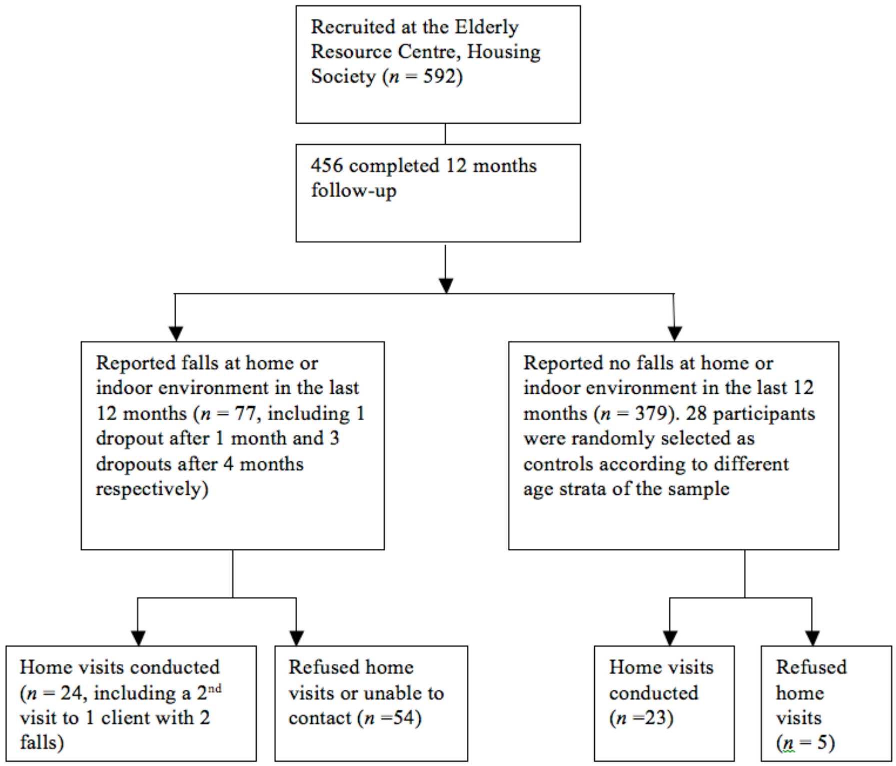

Figure 1. Flow chart of participants

All participants lived in public (43.6%) or private (32.6%) housing. Slightly less than one-third, 30.6%, were living alone, while 20.1% were living as couples with their spouse or partner and 1.7% were living with the maid. A larger proportion, 47.6%, was living with other family members. In terms of mobility, 97.1% could walk independently outdoors, and most (78.4%) did not require walking aids. Within the home, 71.6% could take care of light household duties independently, and 46.8% could perform heavy household duties independently. More than three-quarters, or 76.4%, had chronic diseases: 48.5% suffered from high blood pressure, 19.4% from diabetes, 19.3% from eye disease, and 10.6% from cardiac disease. Finally, 19.9% reported falls and 7.9% reported domestic accidents over the preceding 12 months. Of the 592 participants, 456 completed follow-ups over 12 months. The overall dropout rate was 23% (136/ 592).

The characteristics of fallers who completed the follow-up are described in Table 1 (n = 73). Seventy-seven participants reported falls in the last 12 months (including 1 dropout after 1 month and 3 dropouts after 4 months), yielding a fall rate of 24.8%; the one-year prevalence of falls (people with at least one fall) was 16.7%, and 3.9% for two or more falls. Of all falls, 36.3% occurred at home or within the building/housing estate, while 63.6% occurred outdoors. Most fallers lived in public housing estates (37.7%) with 32.5% in private housing. Most falls (88.93%) occurred during daytime, and most indoor falls happened in dining areas (16.9%), at toilet/bathroom (6.5%) and in the kitchen (3.9%).

Table 2 shows the results comparing demographic and functional parameters in fallers and non-fallers. No significant difference was found except for the number of people who did and did not have diabetes (p = 0.044) (Table 2).

Logistic regression analysis showed that self-reported previous falls in the preceding 12 months (OR 2.88, CI 1.67-7.17), female gender (OR 8.91, CI 0.27-0.47) and self-reported diabetes (OR 3.55, CI 1.10-3.55) were independent predictors for fallers with at least one fall (Table 3). Logistic regression analysis showed that previous falls in the preceding 12 months (OR 3.48, CI 1.16-10.41), self-reported arthritis (OR 3.10, CI 1.04-9.26) and self-reported diabetes (OR 6.00, CI 1.46-24.49) were independent predictors for fallers with two or more falls (Table 3).

Table 1. Characteristics of fallers (n = 73)

Characteristics	Fallers, n (%)
Number of falls within 1 year	73(100.0)
1	61 (79.2)
2	12 (15.6)
3	2 (2.6)
4	1 (1.3)
5 or more	1 (1.3)
Site of falls	73 (100.0)
Indoors	28 (36.3)
Outdoors	44 (63.6)
Environment of indoor falls, n (%)	28 (36.3)
Dining area	13 (16.9)
Bedroom	1 (1.3)
Kitchen	3 (3.9)
Bathroom/toilet	5 (6.5)
Main flat entrance	2 (2.6)
Public area (within apartment)	2 (2.6)
Public area (within housing estate)	1 (1.3)
Other	1 (1.3)
Activity participation during falls	73 (100.0)
Toileting	2 (2.6)
Dressing	1 (1.3)
Bathing	2 (2.6)
Changing position/transfer	3 (3.9)
Household tasks (other than food preparation)	2 (2.6)
Going in/out	1 (1.3)
Cannot recall	17 (22.1)
Strolling inside housing building or housing estate	3 (3.9)
Activity outside housing estate	42 (57.5)
Time of fall	73 (100.0)
Daytime	68 (88.3)
Evening (6:00-12:00 PM)	4 (5.2)
Midnight	5 (6.5)
Medical consultation after fall	73 (100.0)
Yes	19 (24.7)
No	53 (75.3)

Significant differences were found in domiciliary environments between both fallers (n = 24) and non-fallers (n = 23) in the sites of fall hazards (e.g. accessibility and height of fixtures and equipment) with respect to seating (p = 0.011), toilets (p = 0.018), and kitchens (p = 0.026) and feature of fall hazards in the number of steps and stair railings (p = 0.009) as measured by the WeHSA (Table 4). Among the top 10 individual hazards among fallers (n = 24) and controls (n = 23) as charted by the WeHSA, the top three indoor environmental hazard features were obstacles in internal traffic ways (e.g. corridors, thresholds, curbs, etc.), floor mats and ladders/chairs used for climbing (Table 4).

Discussion

The estimates for fall rate and prevalence in this prospective study were similar to those reported in previous studies [1, 2], except that the prevalence of falls and the fall rate were slightly lower in value. We found the one-year prevalence of falls to be 16.7%, and 3.9% for two or more falls, while the fall rate per 100 people was 24.8%. These figures are consistent with previous studies on falls [10, 11]. In general, the participants in our study were in fact quite healthy; of these, 78.4% did not rely on walking aids, and 97.1% could ambulate independently outdoors. Further, 46.8% were independent even in undertaking heavy household duties.

Our findings suggest that self-reported previous falls over the preceding 12 months were a major factor associated with the occurrence of one or more falls (2.88 times greater than those without previous falls) and repeated falls (3.48 times greater than those without previous falls) among our sample of older people.

This study shows that among fallers, most falls were secondary to previous falls over the preceding 12 months [25]. Although self-reporting of fall events has been criticized of under-reporting of actual fall events [32], we still believe that the clinical value of this retrospective self-reported method to reflect the actual conditions of falls is still being widely used in fall studies and should not be overlooked. In studies of falls, researchers should be careful about the reliability of self-report health and therefore we chose those participants who had passed the cut-off score of the AMT in order to have a more reliable recall of falls history.

Table 2. Comparison of demographic and functional parameters in fallers and non-fallers

Characteristics	Fallers (N = 73)	Non-fallers (N = 388)	*p* value
Gender, n (%)	73 (100.0)	388 (100)	0.000**
Male	2 (2.7)	86 (22.2)	
Female	71 (97.3)	302 (77.8)	
Age, mean±SD	74.1±6.1	74.6±6.9	0.571
Education, n (%)			
No formal education	31 (42.5)	105 (27.1)	0.024
Primary	21 (28.8)	161 (41.5)	
Lower secondary	10 (13.7)	33 (8.5)	
Upper secondary	6 (8.2)	48 (12.4)	
Finished middle school	1 (1.4)	24 (6.2)	
Tertiary	4 (5.5)	17 (4.4)	
Living environment, n (%)			
Public housing estate	26 (35.6)	169 (43.6)	0.776
Housing ownership scheme	12 (16.4)	41 (10.6)	
Private housing	25 (34.2)	133 (34.3)	
Rented room	1 (1.4)	5 (1.3)	
Senior citizen hostel	5 (6.8)	22 (5.7)	
Squatter hut/temporary house	4 (5.5)	17 (4.4)	
Other	0 (0)	1 (0.26)	
Living alone, n (%)			
Yes	28 (38.4)	112 (28.9)	0.127
No	45 (61.6)	276 (71.1)	
Living with couple only, n (%)			
Yes	8 (11.0)	86 (22.2)	0.027
No	65 (89.0)	302 (77.8)	
Capable of light household duties, n (%)			
Yes	9 (12.3)	120 (30.9)	0.001
No	64 (87.7)	268 (69.1)	
Capable of heavy household duties, n (%)			
Yes	40 (54.8)	212 (54.6)	1.000
No	33 (45.2)	176 (45.4)	
Use of walking aid, n (%)			
Yes	19 (26.0)	75 (19.3)	0.206
No	54 (74.0)	313 (80.7)	
Number of chronic diseases, n (%)	63 (86.3)	294 (75.8)	0.428
Co-morbidities, n (%)			
Stroke	3 (4.1)	12 (3.1)	0.716
Dementia	0 (0)	0 (0)	---
Osteoporosis	6 (8.2)	19 (4.9)	0.169
Arthritis	6 (8.2)	14 (3.6)	0.110
Parkinson's disease	0 (0)	1 (0.3)	1.000
High blood pressure	39 (53.4)	194 (50.0)	0.543
Diabetes mellitus	22 (30.1)	70 (18.0)	0.044*
Eye disease	19 (26.0)	71 (18.3)	0.214
Low blood pressure	0 (0)	1 (0.3)	1.000
Chronic chest disease	0 (0)	6 (1.5)	1.000
Asthma	1 (1.4)	7 (1.4)	1.000
Cardiac disease	8 (11.0)	38 (9.8)	0.695
Depression	0 (0)	5 (1.3)	0.375
Cancer	2 (2.7)	5 (1.3)	0.227
Previous upper limb fracture	0 (0)	0 (0)	---
Previous lower limb fracture	0 (0)	2 (0.5)	1.000
Low back pain	1 (1.4)	4 (1.0)	0.568
Number of drugs taken, n (%)	73 (100.0)	388 (100.0)	
Nil	21 (28.8)	116 (29.9)	0.939
1-3	44 (60.3)	256 (66)	
4 or more	8 (11.0)	16 (4.1)	
Timed up and go test, mean ±SD	13.9 ±5.3	13.3±3.5	0.249
Forward reaching (cm), mean ±SD	24.0±5.9	24.7±5.9	0.375
Body mass index (BMI), mean ±SD	24.2±3.4	24.1±3.7	0. 922
Abbreviated Mental Test (AMT), mean ±SD	8.8 ±1.3	9.0±1.3	0.205
Visual acuity (left), mean ±SD	5.3±1.7	5.5±1.8	0.813
Visual acuity (right), mean ±SD	5.7±1.6	5.5±1.8	0.418

$^*p \leq 0.05$; $^{**}p \leq 0.01$

In the literature, gait problems and balance disorders are common causes of falls [3]; common sense also suggests that fallers have poorer balance than non-fallers and that the TUGT, as well as mobility performance with or without walking aids, is useful for assessing mobility and quantifying locomotor performance [26]. Unlike the findings of a previous retrospective study [2], we found no significant differences in balance or walking speed as assessed by the FRT and the TUGT between the fallers and non-fallers. We also found that females had a higher risk of falling, but we did not find that the risk increased significantly with the number of drugs taken per day. Previous studies have shown similar results with females having more falls than males [33]. The significant difference between the two groups in terms of a previous history of falls is in line with common sense that falls tend to occur more among older people with poor balance or among frail individuals.

Table 3. Logistic forward regression analysis of demographic and functional parameters for fallers in prospective 12-month follow-up (n = 461)

Fallers (with at least 1 fall)	OR	95% CI	*p*
Self-reported previous fall events in the preceding 12 months	2.88	1.61-5.17	0.000
Female gender	8.91	0.27-0.47	0.003
Self-reported diabetes mellitus	3.55	1.10-3.55	0.023
Percentage correctly classified = 84.2%			
Fallers (with 2 or more falls)			
Self-reported previous fall events in the preceding 12 months	3.48	1.16-10.41	0.026
Self-reported arthritis	3.10	1.04-9.26	0.043
Self-reported diabetes mellitus	6.00	1.46-24.49	0.013
Percentage correctly classified = 96.7%			

For extrinsic factors, we found no significant differences in the types of housing between fallers and non-fallers. We did, however, find significant differences in environments between the two groups, in the areas of fall hazards (e.g. accessibility and height of fixtures and equipment) with respect to seating, toilets and kitchens, and with the feature of steps and lack of stair railings as measured by the WeHSA. This is of particular importance in our study with older people living in high-rise residential buildings. The finding of environmental differences between fallers and non-fallers in household environmental hazards is inconsistent with some previous studies [7, 8]. Although some of these studies did not find differences in home hazards between fallers and non-fallers, they claimed it was the interaction between an older person and exposure to environmental factors that are predictive of falls in older adults and varies over time according to the individual's competence [12, 34].

Table 4. Comparison of environmental hazards for indoor fallers and controls after home visits

Characteristics	Indoor fallers (n = 24)	Controls (n = 23)	Mann-Whitney U	*p*
WeHSA hazard areas, mean±SD				
External traffic ways	1.8±4.3	1.4±1.3	211.0	0.141
General	3.2±2.8	3.6±2.3	241.0	0.452
Internal traffic ways	3.6±2.6	3.2±1.8	274.0	0.965
Living area furnishings	0.1±0.3	0.0±0.0	253.0	0.162
Seating	0.3±0.5	0.8±0.9	173.5	0.011*
Bedroom	1.1±1.3	0.7±0.9	228.5	0.275
Footwear	0.2±0.4	0.1±0.3	254.0	0.418
Bathroom	2.0±1.6	1.6±1.6	239.5	0.425
Toilet	2.2±1.9	1.0±1.4	168.0	0.018*
Kitchen	3.3±2.1	2.0±1.2	174.0	0.026*
Laundry	1.5±1.6	1.5±1.5	272.0	0.930
Medication	0.1±0.3	0.0±0.2	265.0	0.580
Safety call system	0.5±0.5	0.3±0.5	210.5	0.104
Total	19.8±12.4	16.4±7.8	240.5	0.449
WeHSA hazard features, mean±SD				
Slippery surfaces	1.0±1.5	1.0±1.6	275.0	0.981
Obstacles in traffic ways	1.5±1.6	1.7±1.4	240.0	0.425
Poor illumination	0.8±0.9	0.4±0.6	199.0	0.112
Floor mats	1.4±1.6	1.7±1.4	225.0	0.259
Footwear	0.2±0.4	1.0±0.3	254.0	0.418
Ladder/chair used independently in community dwellings for climbing	1.3±1.4	1.4±1.0	240.5	0.434
Bath	1.0±1.0	1.2±1.3	256.5	0.662
Uneven pathways	0.8±2.1	0.4±0.9	262.5	0.714
Cords on floor	0.0±0.0	0.0 ±0.0	276.0	1.000
Steps/stair railings	1.4±1.3	0.5±0.9	162.0	0.009*

WeHSA – Westmead Home Safety Assessment
*$p \leq 0.05$

A person must have a high level of competence to cope effectively with an environment with high demands. Usually older people will not fall if they are capable of protecting themselves by adapting to the environment, such as steep stairs. But the person may be vulnerable to falls and the environment can become risky for those with deteriorating health conditions, such as declining balance and mobility, as well as for those with a history of falls [7, 8, 35]. The physical environment, especially in small living cubicles in multi-story buildings such as those in Hong Kong, can become increasingly dangerous as a person's competence declines with age. Because of the congested living areas, older adults living in small areas tend to store and retrieve items in high places by climbing up and down stools or furniture of different heights. Older adults with an unstable gait may fall when they can no longer cope with climbing up a flight of stairs because of a loss of ability to maintain balance, meaning that they cannot respond adaptively to the environment. Environmental modifications thus may be useful for inducing a positive environment and reducing the risk of falls as soon as rehabilitation professionals detect the relevant changes in intrinsic factors for the individual [37, 38]. In fact, the updated clinical practice guidelines for prevention of falls in older persons strongly recommended adaptation or modification of home environment (i.e. rating A) to eligible individuals [11]. One randomized controlled trial found that environmental adaptation is relatively useful in highly frail older adults with a history of falls [36]. The findings of the present study also indicate that environmental factors should not be overlooked in higher risk areas such as small self-contained toilets and kitchens as well as steps and curbs in multi-story buildings. In these situations, a redesign of storage layout may be useful to reduce the risk of falling. A recent study found that older patients about to be discharged from the hospital have little knowledge about appropriate falls prevention strategies that could be used after discharge despite their increased falls risk during this period [39], and that for a national representative sample of community-living older adults who reported a history of a fall, 34.5% had made a residential adjustment but only 32.6% of those who made adjustment had home modifications [40]. Taken together, the findings of our study will raise public awareness about environmental hazards for older people in falls prevention, especially those who are suffering from chronic diseases, such as diabetes, arthritis, etc.

This study has limitations. To our surprise, many dropouts occurred at the beginning of the study. Although 456 participants completed the study, the overall dropout rate was 23% (out of 592). The most likely reason was that nearly all participants visited the Center only once for assessment. They did not develop strong ties with the Center and are thus less motivated to participate in a long-term, 12-month follow-up. Another limitation was that the participants were selected in a convenience sample that might not represent the geographic distribution of the total population of older people in Hong Kong. And third, co-morbidities, such as medical conditions, history of drug use and the disease incidence, were based only on self-reporting rather than medical records. This affects our ability to generalize from the results compared with taking real medical histories into account.

Conclusions

Using a prospective study, we determined the base rate of falls and important extrinsic factors contributing to falls for a group of community-living older people in Hong Kong. This study supports the existence of significant differences in environmental risk factors between fallers and non-fallers in high-rise buildings in urban areas and the results can be generalized to other domiciliary environments for community-living older persons in most of the urban cities in the world. These results can be used as a reference for home environmental adaptation or modification. Local authorities should identify older individuals living in the community with a previous history of falls so that they may consider improving their environment for fall prevention.

References

1. Chu LW, Chi I, Chiu AY. Falls and fall-related injuries in community-dwelling elderly persons in Hong Kong: a study on risk factors, functional decline, and health services utilisation after falls. Hong Kong Med J. 2007;13:8-12.
2. Fong KNK, Siu AMH, Au Yeung K, Cheung SWS, Chan CCH. Monitoring falls in a retrospective study of community-living elderly in Hong Kong. Hong Kong J Occup Ther. 2011;21:34-41.
3. American Geriatric Society, British Geriatrics Society, and American Academy of Orthopedic Surgeons. Panel on falls prevention. Guidelines for the prevention of falls in older persons. J Am Geriatr Soc. 2001;49:664-72.
4. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial. J Am Geriatr Soc. 1999;47:850-3.

5. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis: I. Psychotropic drugs. J Am Geriatr Soc. 1999;47:30-9.
6. Fong KNK, Leung DPK. Preventing falls for older people living in the community. In: Tong KW, Fong FNK, editors, Community care in Hong Kong: Current practices, practice-research, and future directions. Hong Kong: City University of Hong Kong Press; 2014;267-91.
7. Gill TM, Williams CS, Tinetti ME. Environmental hazards and the risk of nonsyncopal falls in the homes of community-living older persons. Med Care. 2000;38:1174-83.
8. Lord SR, Menz HB, Sherrington C. Home environment risk factors for falls in older people and the efficacy of home modifications. Age Ageing. 2006;35:ii55-9.
9. Gillespie LD, Robertson MC, Gillespie WJ, Lamb SE, Gates S, Cumming RG, et al. Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Review (Online). 2004; CD007146
doi:10.1002/14651858.CD007146.pub2.
10. Clemson L, Mackenzie L, Ballinger C, Close JCT, Cumming RG. Environmental interventions to prevent falls in community-dwelling older people: A Meta-analysis of randomized trials. J Aging Health. 2008;20:954-71.
11. Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. Summary of the updated American Geriatrics Society/British Geriatrics Society clinical guideline for prevention of falls in older persons. J Am Geriatr Soc. 2011;59:148-57.
12. Iwarsson S, Horstmann V, Carlsson G, Oswald F, Wahl H. Person-environment fit predicts falls in older adults better than the consideration of environmental hazards only. Clin Rehabil. 2009;23:558-67.
13. Campbell AJ, Borrie MJ, Spears GF, Jackson SL, Brown JS, Fitzgerald JL. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. Age Ageing. 1990;19:36-41.
14. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent non-syncopal falls: a prospective study. JAMA. 1989;261:2663-8.
15. Parker M, Twenlow T, Pryor G. Environmental hazards and hip fractures. Age Ageing. 1996;25:322-5.
16. Sattin RW, Rodriguez JG, DeVito CA, Wingo PA. Home environmental hazards and risk of fall injury events among community-dwelling older persons. J Am Geriatr Soc. 1998;46:669-76.
17. Tinetti ME, Doucette J, Claus E, Marotoli R. Risk factors for serious injury during falls by older persons in the community. J Am Geriatr Soc. 1995;43:1214-20.
18. Drahota A, Gal D, Windsor J. Flooring as an intervention to reduce injuries from falls in healthcare settings: An overview. Qual Ageing. 2007;8:3-9.
19. Isberner F, Ristzel D, Sarvela O, Brown K, Hu P, Newbolds D. Falls in elderly rural home health clients. Home Health Care Ser Q. 1998;17:41-51.
20. Fletcher PC, Hirdes JP. Risk factors for falling among community-based seniors using home care services. J Gerontol. 2002;57A:M504-10.
21. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls in community elderly. New Eng J Med. 1998;319:1701-7.
22. Population and household statistics analysed by District Council District 2008. [Internet]. Hong Kong: The Census and Statistics Department. c2009- [cited on 2009 Jan 21]. Available from http://www.censtat.gov.hk
23. Chu LW, Pei CK, Ho MH, Chan PT. Validation of the Abbreviated Mental Test (Hong Kong version) in the elderly medical patient. Hong Kong Med J. 1995;1:207-11.
24. Ganz DA, Higashi T, Rubenstein LZ. Monitoring falls in cohort studies of community-dwelling older people: Effect of the recall interval. J Am Geriatr Soc. 2005;53:2190-4.
25. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing. 2006;35:ii37–41.
26. Podsiadlo D, Richardson S. The timed "up & go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc.1991;39:142-8.
27. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: A new clinical measure of balance. J Gerontol Med Sci. 2007;45:M192-7.
28. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the timed up & go test. Phy Ther. 2000;80:896-903.
29. Giorgetti MM, Harris BA, Jette A. Reliability of clinical balance outcome measures in the elderly. Phys Ther Res Int. 1998;3:274-83.
30. Clemson L. Westmead Home Safety Assessment (WEHSA). Australia: Co-ordinates Publications; 1997.
31. Clemson L, Fitzgerald MH, Heard R, Cumming RG. Inter-rater reliability of a home fall hazards assessment tool. Occup Ther J Res. 1999;19:83-100.
32. Mackenzie L, Byles J, D'Este C. Validation of self-reported fall events in intervention studies. Clin Rehabil. 2006;20:331-9.
33. Ziere G, Dieleman JP, Hofman A, Pols HA, van der Cammen TJ, Stricker BH. Polypharmacy and falls in the middle age and elderly population. Brit J Clin Pharmaco. 2006;6:218-23.
34. Lawton MP, Nahemow L. Ecology and the aging process. In: Eisdorfer C, Lawton MP, editors. The psychology of adult development and aging.

Washington, DC: American Psychological Association; 1973. p. 619-74.

35. Speechley M, Tinetti M. Falls and injuries in frail and vigorous community elderly persons. J Am Geriatr Soc. 1991;39:46-52.

36. Nikolaus T, Bach M. Preventing falls in community-dwelling frail older people using a home intervention team (HIT): results from the randomized falls – HIT trial. J Am Geriatr Soc. 2003;51:300-5.

37. Carter SE, Campbell EM, Sanson-Fisher RW, Redman S, Gillespie WJ. Environmental hazards in the homes of older people. Age Ageing. 1997;26:195-202.

38. Tse T. The environment and falls prevention: Do environmental modifications make a difference? Aust Occup Ther J. 2005;52:271-81.

39. Hill A, Hoffmann T, Beer C, McPhail S, Hill KD, Oliver D, et al. Falls after discharge from hospital: is there a gap between older peoples' knowledge about falls prevention strategies and the research evidence? Gerontologist. 2011;51:653-62.

40. Leland N, Porell F, Murphy SL. Does fall history influence residential adjustments? Gerontologist. 2010;51:190-200.