Kasetsart Journal of Social Sciences 44 (2023) 1155–1166

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

Reducing the risk of falls in homes for older adults in Thailand

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Article Info

Article history:
Received 19 August 2022
Revised 2 January 2023
Accepted 20 February 2023
Available online 17 November 2023

Keywords:
environment,
falls,
home modification,
older adults,
Thai

Abstract

Falls can have a significant impact on the lives of elderly people in Thailand. This research focuses on the intrinsic and environmental factors related to these falls. The study surveyed elderly people living in rural areas (Chiang Mai and Khon Kaen) and urban areas (Rangsit, Bangkok and Songkhla). Although the intrinsic fall risk result shows no significant difference between elderly people in the rural and urban areas, those in the rural areas had slightly higher fall risk factors, including advanced age, defective walking ability and fall experiences. The findings regarding environmental conditions show that older adults in rural areas had a higher risk of falls than those in urban areas. The research methods included community selection, participants and housing selection, design and cost estimation and home modification. The study surveyed 203 elderly participants, and half of their houses were selected for renovation. Home modification was performed in 100 dwellings, including 99 bathrooms, 71 main entrances and corridors, 43 bedrooms, 29 stairways, and 22 kitchens. A comparison of the before and after renovation fall risk scores suggests that the overall environmental risk decreased by 52 percent. Bathroom modifications resulted in the greatest decrease in fall risk (81%), followed by modifications of illumination (58%), bedrooms (47%), and main entrances and corridors (42%). The bathroom was a key point of risk reduction because it was the most hazardous area, and its modification resulted in the most notable risk reduction.

Introduction

Most houses for older adults in Thailand are not built according to universal design guidelines. They are fabricated for lifestyles in the Thai region. Research shows that one-third of elderly people fall each year in the US (Maggi et al., 2018). The emergency medical unit reports from 2011–2015 showed that in the Thai population, at least three older adults fell and died daily (Non-Communication Diseases Bureau, 2017; TCIJ, 2020). However, only two percent of homes were modified for elderly living in Thailand (Jamroennusit, 2018). About 40 percent of the reported deaths were female. The northern region of Thailand has the highest fall rate, at 12–21 percent per 100,000 people. This is triple the rate in the mid region (Department of Disease Control, 2016). Most modified houses were in Bangkok and the southern

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https://doi.org/10.34044/j.kjss.2023.44.4.20
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region, while houses in the north were the least renovated at 18 percent (Aekpalakarn, 2014).

Ageing in place is an important concept for older adults to remain healthy in their homes. Universal designs can offer safer living environments. While a single-storey house is potentially safer for older adults, most elderly people in Thailand live in two-storey or elevated houses (44%), and about half of them (49%) need to use the stairs daily. This cultural influence may lead to an increased risk of falls. This is because in the traditional Thai house, the main living area is on an elevated floor, which requires a stairway entry from a raised basement. These are common all over the country, particularly in the north. About 37 percent of houses in the north are elevated houses, followed by 30 percent in the mid region (National Emergency Medical Institute, 2019).

The risk of falls among older adults is attributable to multiple factors, including intrinsic, behavioural and extrinsic (environmental) risk factors. Although some scholars reported that reducing hazards in the house was not an effective fall-prevention strategy for the general elderly population (Gill et al., 2000), others concluded that home modifications helped to reduce fall risk in elderly people with fall experience and mobility limitations (Lord et al., 2006; Northridge et al., 1995). Intrinsic factors include advanced age, female gender, chronic diseases, physical movement capability and vision impairment (American Geriatrics Society, 2012; Appeadu & Bordoni, 2022; Pynoos et al., 2010). An elderly individual aged 65 years or older would have had at least one fall experience, and falls are one of the causes of morbidity and mortality in elderly people aged 75 years and above (Pighills et al., 2019). Advanced age (above 80 years old) and being female can double the risk of falls compared to younger males (Appeadu & Bordoni, 2022). Some chronic diseases are also associated with falls. These include stroke, Parkinson's disease, hypertension, diabetes, gout, arthritis, heart disease and chronic obstructive pulmonary disease (COPD) (Sibley et al., 2014). Risk-taking behaviours, such as exercise, health monitoring, individual daily routines and social participation, are other behavioural factors that can have an impact (Faul et al., 2009). Fall experiences can also impact fall risk prediction. A longitudinal study in Vietnam showed that 40.5 percent of patients who fell within a 12-month period had recurrent falls (Vu et al., 2020). The other risk factors mentioned are reduced muscle strength, polypharmacy (defined as taking over four medications) and pain (Appeadu & Bordoni, 2022). Environmental factors can play an important role in fall risk in elderly people. Environmental risk is associated with 30–50 percent of falls (Rubenstein, 2006); therefore, many countries suggest home improvement guidelines to reduce environmental hazards for elderly people. These include countries such as Australia (Australian Commission on Safety and Quality in Healthcare, 2009), the US (American Geriatrics Society/British Geriatrics Society clinical practice guideline, 2010) and Britain (National Institute for Health and Care Excellence, 2015). Research has shown that 80 percent of homes for older adults contained at least one fall risk factor. In addition, 39 percent of homes contained five or more risk factors (Carter et al., 2000). The same research confirmed that the degree of risk depends on the number of risk factors in the environment. An older person's environment accommodates their current behaviour and lifestyle; however, their physical capacity and health status will decrease with age. This may increase their environmental risk and trigger falls (Glass & Balfour, 2003). If the person-environment interaction is adequate to support the needs and desired lifestyles of elderly people, the risk of falls will be reduced. Research confirms that environmental modifications can effectively prevent falls in elderly individuals with a high risk of falling (Pighills, et al., 2016). Physical limitations can have an impact on the level of safe interaction with the environment (Iwarsson et al., 2009). In particular, bathrooms are reported to be the most dangerous area for falling, because falls in the bathroom are more frequent, cause more physical injury, and occur from many fall hazards in one space. Studies have shown that bathroom modifications can reduce falls (Gell et al., 2020; Ng et al., 2021).

To reduce falls, prevention and rehabilitation programmes for caregivers and elderly people are required to provide comprehensive education on the multiple risk factors for falls among elderly individuals. Research scholars agree that multiple approaches to addressing fall risk can be an effective intervention for older adults, including environmental fall risk, home modifications, physical practice, and cognitive capacity practice (Feldman & Chaudhury, 2008). Older adults should be educated on fall risk assessment and prevention, should have regular vision and medication checks, and should have access to assistive technology to prevent falls (Chase et al., 2012).

The objectives of this study are to understand the risk factors associated with falls among elderly people living in rural and urban areas, and to address how fall risk can be reduced by home modification strategies in the Thai context. The conceptual framework covers five intrinsic factors: age, gender, chronic diseases, fall experiences and walking ability; and five main environmental risk areas: bathroom, surrounding, bedroom, lighting, corridor and stairs. Research methods include a literature review, the development of an assessment tool, community selection, participant and house selections, design and cost estimations, and house modification.

Methodology

The study was conducted in four stages. The first three stages were related to housing selection. First, the community was required to have a strong leader and have over 10 years of successful senior welfare activities. These two characteristics would sustain healthy and safe behaviour of the elderly in the community. All targeted communities needed to be under the town or city municipality of the province. Five selected communities in five main areas of Thailand include the Nhong Tong Pattana community in Chiang Mai representing the north, the Nhong Sang community in Khon Kaen representing the north-east, the Rangsit community in Pathum Thani representing the middle, the Lertsuksom community in Bangkok representing the capital, and the Songkhla municipality community in Songkhla representing the south. Communities in Chiang Mai and Khon Kaen were in rural areas, while Rangsit, Bangkok and Songkhla were in urban areas. The urbanisation of the community was classified by population in the area: rural area (< 1,000 people/km^2) and urban area (> 1,000 people/km^2). Chiang Mai (587 people/km^2) and Khon Kaen (789 people/km^2) were in rural areas, while Rangsit (4,051 people/km^2), Bangkok (6,887 people/km^2), and Songkhla (1,050 people/km^2) were in urban areas (Department of Provincial Administration, 2022).

The second stage was to select the elderly participants and investigate their conditions. Elderly people who continually engaged in senior welfare activities and had not modified their houses were nominated by their communities to participate in the project. Approximately 40 older adults from each community comprised a total of 203 participants in the survey. The survey was conducted via a questionnaire interview related to health and an assessment of environmental risk. The fall risk assessment tool adopted from the Thai Falls Risk Assessment Test (Thai-FRAT) (Thiamwong et al., 2008) consists of five issues, 27 questions referring to health conditions associated with falls, including age, gender, comorbidity diseases, three-to-six months fall experience and walking ability. The two top factors affecting fall risk the most were fall experience and walking ability. Fall experience within three to six months was the most dominant evidence of fall risk since a previously fallen elderly individual had a high potential to fall again (Ong et al., 2022; Vu et al., 2020). Walking ability was briefly investigated by three tests: the get up and go test, balance test and fall risk test. People with little to moderate defects in walking ability were considered to have walking fall risk. The participants who had fall experiences with poor walking ability scores were interviewed in-depth about their experiences. Elderly dwellings were also assessed for fall hazards with the environmental fall risk assessment tool. This investigated three levels of hazards in 15 areas (Jarutat, 2019). For example, '0-points' if the bedroom was on the first floor without steps and '3-points' if the bedroom was on the second floor with an unsafe stairway. The full score of the environmental assessment tool was 49 points, with extra points for living in the elevated Thai traditional house and the bathroom located outside of the house.

Third, in the referendum process for house selection, 100 selected houses in five communities were approved throughout the referendum process in the community before full measurement. Each community considered the fall risk scores for all 40 elderly cases and nominated 20 houses for modification. The fall risk level was classified as low-, medium- and high-risk levels. There were 44 points for health risk and 49 points for environmental risk, a total of 89 points for the fall risk assessment tool. The three risk levels were 0–29 points for low risk, 30–53 points for medium risk, and greater than 53 points for high-risk levels. Elderly people who had high health risk scores and lived in areas with high environmental risk scores would first be prioritised in a high-risk list case. Elderly people who had no funds to modify their environment were also prioritised.

The fourth stage was the design and construction phase. Full measurements of the selected houses were obtained, designs and cost estimations were proposed and renovations were performed. Because of the limited time

and budget of the project at approximately 20,000 Baht per dwelling (625.20 USD in 2021), house modifications were prioritised to the three most hazardous areas in the house, including bathrooms, surrounding areas of the house, corridors and stairs. The same environmental fall risk assessment was conducted within three months after renovation to compare the conditions. This research was approved by the Human Research Ethics Committee, No. CMUREC 63/271.

Results were analysed in basic, correlation and t-test statistical analyses. Fall risk was analysed separately and jointly between intrinsic and environmental factors. Environmental risk reduction after home modification was also analysed. The rural and urban results were also compared to understand fall risk conditions in both areas.

Results

Fall Risk for Elderly People

Based on the health risks related to falls, three factors were identified to increase the risk of falls for older adults around the country. First, older adults in rural areas had a higher degree of defective walking ability than those in urban areas, particularly those in the north and northeast. Considering the percentages of people with defective walking abilities from three fall risk tests, the elderly in the north and northeast showed the highest risk of defective walking ability, (55%, 60% and 37.5% with a total of 152.5%) and (52.5%, 67.5% and 22.5%, with a total of 142.5%), respectively. The elderly in the urban areas showed much fewer walking defects (approximately 87.5% in total) over the three tests. Over half of the elderly showed defects on the get up and go test, except those in Bangkok. Figure 1 shows that older adults living in urban areas had fewer defective walking abilities, especially in terms of balance and fall risk.

Second, age was also associated with fall risk among older adults in Thailand. Considering age with fall experiences, older elderly people had more falls than those who were younger. The older age group showed the greatest number of falls. Although the 80+ years elderly proportion was only 21 percent, they had experienced more falls than the other two groups, at 36 percent within the last six months (Figure 2). This denoted that one of every three older people aged 80 years and over had fall experiences within six months of occurrence. This is in contrast to the situation of the younger elderly groups. Fall experiences in the 60–79 year old group were 18–21 percent, which means only one in every five people had a fall.

Third, elderly people in rural areas had more fall experiences than those in urban areas. Regarding age range, 10 and 12 elderly individuals fell in Chiang Mai and Khon Kaen within six months, while only five elderly individuals fell in Rangsit and Bangkok. Note that in Songkhla, 11 elderly people experienced falls. However, there were age range differences in the rural and the urban areas since the participants in the rural areas were older than those in the urban areas. While the average age of all five areas was 71.8 ± 8.5 years, the proportion of early (60–69 years), moderate (70–79 years), and late (80+ years) older groups in the research were 71 percent, 73 percent, and 22 percent, respectively. The average age of elderly individuals in rural areas was 74.5 ± 9.3 years (72.8 ± 10.5 and 76.2 ± 7.4 years old in Chiang Mai and

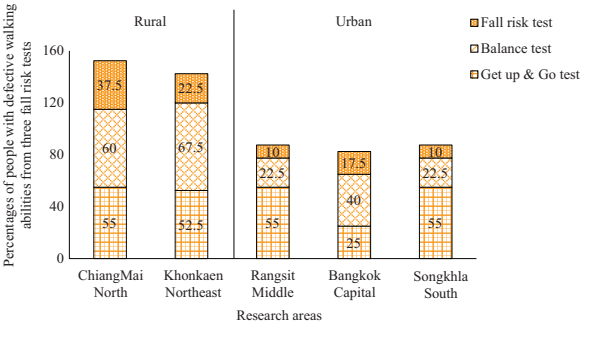

Figure 1 Percentages of people with defective walking abilities from three fall risk tests

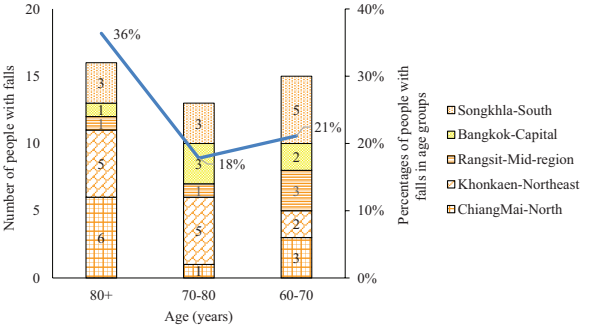

Figure 2 Fall experiences by age

Khon Kaen, respectively). This was 4 years older than the 70.0 ± 7.5 years' average age in the urban areas (68.4 ± 6.3, 69.4 ± 8.4 and 72.2 ± 7.1 years old in Rangsit, Bangkok and Songkhla, respectively). About one-third of elderly people in the rural areas were above 80 years old (32% in Chiang Mai and 43% in Khon Kaen), and more than one-third of those in the urban areas were below 70 years old (46% in Rangsit, 48% in Bangkok and 34% in Songkhla) (Figure 3). However, the correlation coefficient values between age ranges and falls in rural and urban areas were not statistically significant (0.19 in rural *vs*. 0.04 in urban areas). Older age groups in rural areas tended to fall more than those in urban areas. Figure 4 shows that the older the people in rural areas were, the higher the number of falls. However, the number of falls was the reverse in urban areas. The number of falls of younger elderly people was higher in urban areas than in rural areas.

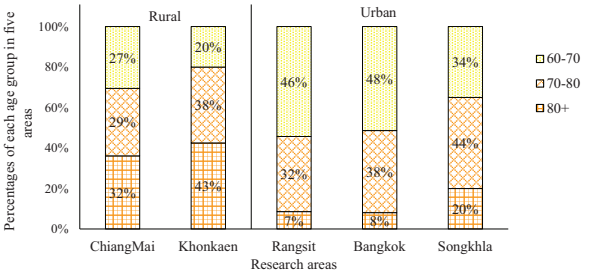

Figure 3 Age groups of the five areas

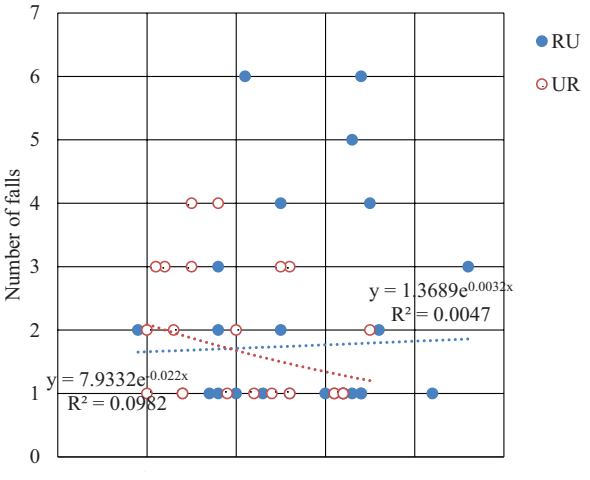

Figure 4 Correlation between number of falls and age of people with falls

Third, the number of falls among elderly people in each habitat was different; those in rural areas were slightly higher than those in urban areas. Elderly people in the rural areas Chiang Mai and Khon Kaen had more fall experiences (25%) than those in the urban areas Bangkok and Rangsit (below 15%) (Figure 5). In all five areas covered by the study, elderly people in Khon Kaen encountered the highest number of falls, with 30 percent of them having fallen in the last three months. The exception was Songkhla. Although Songkhla was in the urban area, it showed the second highest number of falls, at 27 percent, similar to the cases in the rural areas. The urbanisation of Songkhla could influence these falls, since its population density and local authority scale were the lowest among the urban communities (Department of Provincial Administration, 2022). This denotes that general services for the elderly may not be at the same level as the Rangsit and Bangkok communities, which were located in the inner city.

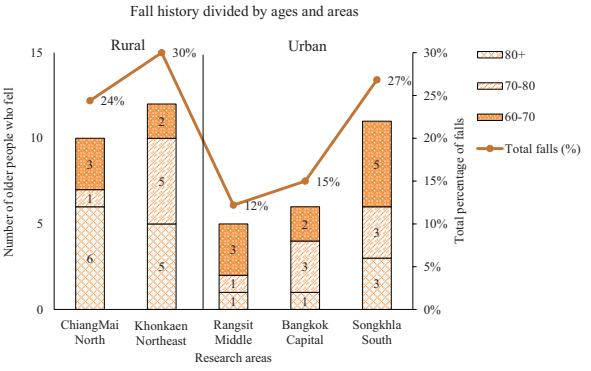

Figure 5 Number of older people who fell, illustrated by age groups and areas

Environmental Renovations to Elderly People's Dwellings to Reduce Environmental Risk

This research included 100 houses renovated in five areas and four regions. Six environmental risk areas were categorised: bathrooms, the areas surrounding the house, bedrooms, lighting, corridors and others. The bathrooms posed the highest risk for falls. Of these 100 houses, 99 bathrooms were renovated. This included toilet changes, floor level adjustments and handrail installations. Based on the environmental fall risk assessment tool, bathrooms posed the highest risks of falling, at 508 points from full

score hazards. This was reduced to 95 points after renovation (Figure 6). The second highest risk for falls was the surrounding area of the house, including the entrance and the circulation around it. Seventy-one entrances and circulations around the houses to the bathroom and the kitchen were renovated. The hazardous score for the surrounding area was initially 464 points; this was reduced to 269 points after renovation. Corridors and stairs were the third environmental risk, and this risk improved from 307 to 197 points after renovation. In addition, 29 corridors including stairways and 22 kitchens were renovated; however, their environmental hazard scores were still moderate. The top fourth hazardous area was the bedroom. Altogether, 43 bedrooms were renovated, resulting in a hazard reduction from 123 to 65 points after renovation. The overall modification included 99 paired handrail installations, 78 seated toilet installations, 56 upgraded surrounding pathways, 48 lighting fixture installations, 46 door changes, 30 slope pathway constructions, and two re-constructed bathroom structures.

Environmental fall risk scores for each house were reduced after renovation. Overall, fall risk scores for the 100 houses declined by 52 percent compared to the pre-renovation scores. The bathroom risk score reduced the most, with 81 percent risk reduction, followed by lighting reduced by 58 percent, bedroom by 47 percent, and outdoor circulation by 42 percent. Comparing before and after environmental risk scores in each area, all five areas show a significant value from the paired *t*-test (p = .00) on risk reduction (Table 1). The average environmental risk scores of all five areas reduced from 16.12 to 7.60 points after renovation. It was noted that the intrinsic risk assessment score after renovation rarely changed and no falls were reported.

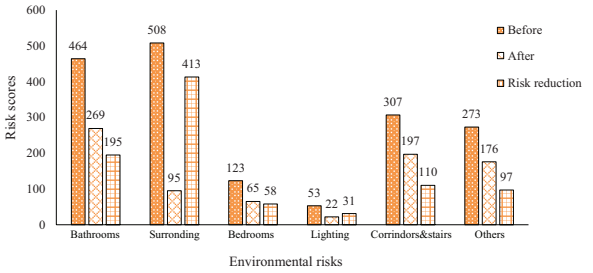

Figure 6 Environmental risk score comparison before and after renovation

Comparison between Rural and Urban Areas

The results from a comparison between urban and rural areas showed that there were differences in intrinsic risks between the older adults living in both areas, but the environmental risk scores in the rural areas had a higher fall risk than those in urban areas. There were three discussed pieces of evidence. First, the elderly in rural areas had slightly worse health factors relating to fall risks than those in urban areas. Health factors associated with fall risks included non-communicable chronic diseases (NCDs), such as hypertension, gout, arthritis, diabetes and polypharmacy. However, there was no significant difference (p = .18) in health risk scores between the participants in rural and urban areas. Second, the elderly in the rural areas who had a fall experience within the last three months also had more health issues related to falls than those who had no fall experience. Figure 7 shows that three risk scores and three-month falls in rural areas were slightly higher than those in urban areas. However, there were unclear differences in 6-month fall experiences between the two settings.

Table 1 Environmental fall risk reduction from house renovation

Environmental fall risk conditions	Total of 5 areas	Chiang Mai [North]	Khon Kaen [Northeast]	Rangsit [Middle]	Bangkok [Capital]	Songkhla [South]
Before renovation envi. fall risk score	16.12	22.65	12.7	16.15	16.4	12.7
After renovation envi. fall risk score	7.6	8.6	7	8	7.35	7.05
Houses (*n*)	100	20	20	20	20	20
p - value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: The 'envi. fall is score' is from 'environmental fall risk score'.

Lastly, rural environments pose higher risks than urban environments. Environmental risk scores in rural areas showed a significantly higher risk of falling than in urban areas (*t*-test: $p = .00$). The average environmental risk scores in the rural areas were 22.65 and 17.78 in Chiang Mai and Khon Kaen, respectively and the scores in the urban areas were 16.15, 16.40 and 12.7 in Rangsit, Bangkok and Songkhla, respectively (Figure 8). The first reason for this was the layout of the rural houses. It was common to locate bathrooms outside the house in remote areas, since their sanitary system was a ground water supply with a cesspool sewage system. Figure 9 shows that more than two-thirds of the bathrooms in rural areas were outside, while only one-sixth of those in urban areas were outside. Second, squatter toilet systems are common in remote areas. All bathrooms in this research were squatter toilets, and these were changed to seated toilets. Using squatter toilets in wet bathrooms can lead to accidents, such as loss of balance, slips and falls, even among elderly people who are accustomed to using it, as their physical strength reduces with age. Third, using outside bathrooms posed risks for elderly people, since they had to walk through uncertain corridors without cover, and in some cases, to a bathroom with a squatter toilet. Therefore, elderly people in rural areas not only confronted detached bathrooms outside the main house and suffered from the use of squatter toilets, but also required walking in dark and unsafe outdoor areas to reach the bathrooms.

With the modifications, all toilets were changed to seated models with paired handrails. Doors and lighting were installed in the modified bathrooms. Most surroundings were modified with sufficient lighting and even pathways. Many bathroom structures in rural areas were also renovated since they were unsafe and decayed. They were also renovated for safety and universal design reasons. Figures 10–11 show the before and after pictures of a modified bathroom in Chiang Mai. Although the setting of the bathroom could not be reoriented, the pathway between the house and the bathroom was built to increase safety.

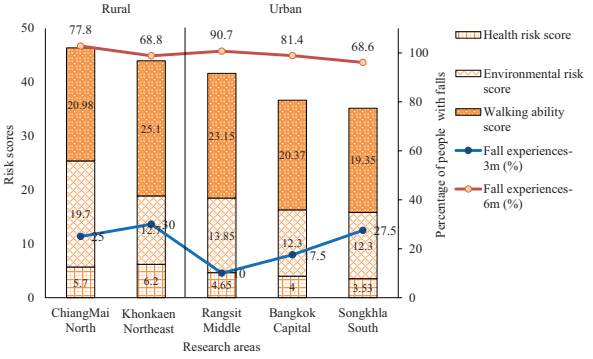

Figure 7 Scores of health and environmental fall risks

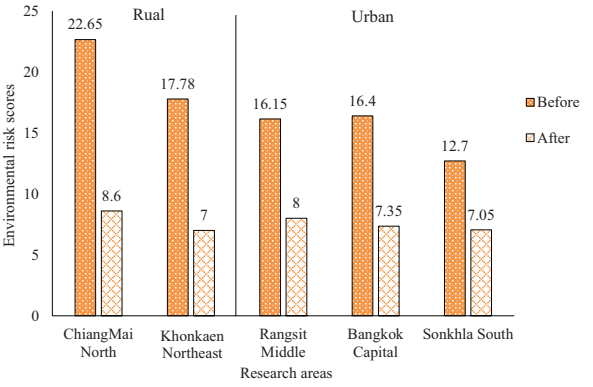

Figure 8 Environmental risk scores before and after renovation in five areas

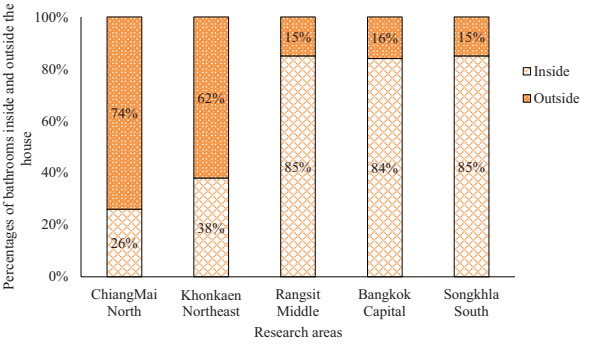

Figure 9 Percentages of bathrooms inside and outside the house in five areas

Figure 10 Bathroom outside the house in Chiang Mai before modification: (A) the targeted elderly house, (B) the bathroom without an appropriate pathway, (C) the squatter toilet, and (D) the steep ladder to the main living of elevated house

Figure 11 Bathroom outside the house in Chiang Mai after modification: (A) new bathroom with strong construction, (B) a column for roof structure, (C) seated toilet with handrails, and (D) an appropriate pathway to the bathroom

Discussion

Risk Comparison between Rural and Urban Areas

Fall risk for older adults who live in rural and urban areas has been debated for decades. Most scholars report that the elderly in rural areas fall more frequently than those in urban areas. The main factors are unsafe environments (Cho et al., 2013; Rongmuang et al., 2016), including soil pathways, slippery floors, and non-asphaltic walkways, such as gravel or red earth pathways (Yoo et al., 2016). Research supports the fact that elderly people in rural areas have more fall-related risks than those in urban areas. In India, modification guidelines were recommended for elderly people's homes; however, this was suitable for Western-style homes located in the urban areas (Chacko et al., 2017). Rural houses in the Indian study were similar to those in the Thailand study, as they were built below standard and the guidelines could not be applied. They also had more fall hazards than urban houses. Furthermore, the health conditions of elderly people could be poorer in rural areas than in urban areas because elderly people in rural areas have limited access to quality health services. However, comparisons between India and Thailand studies are limited since India's did not cover the urban community in the research scope.

There are two more possible explanations for the higher intrinsic fall risks for elderly rural dwellers in this study. First, the targeted elderly in rural areas were older than those in urban areas, so they could have more fall risks. Research has shown that among elderly people, the older the age the more risk of falling (Pighills et al., 2019). Second, the results suggest that elderly people in rural areas have poorer walking abilities.

In contrast, research has suggested that older adults living in urban areas have a higher fall risk than those living in rural areas. According to in-depth interviews with elderly people with fall experiences, the fear of falling among urban dwellers was lower than among rural dwellers, contributing to more fall incidents in urban areas, as the elderly are less careful. Fear of falling can reduce the risk of falls among elderly people, since this makes them prepare themselves by walking carefully, getting up slowly and using assistance equipment (Phongphanngam & Nawai, 2020). Older adults with a fear of falling had 0.28 times fewer fall incidences compared to those who were not fearful. However, this research focused on individual factors, including health and house conditions and environmental fall risks in public areas. The fear of falling was not within the scope of this study. Based on the findings of this research, the elderly in rural areas show stronger evidence of fall risk than those in urban areas.

Fall Risk Reduction by Environmental Renovation

Environmental modification can significantly reduce fall risk. Scholars agree that there is strong evidence that home modification can be an effective intervention to reduce fall risk in elderly people (Chase et al., 2012; Feldman & Chaudhury, 2008; Stark et al., 2017). Research suggests that home modification can reduce fall risks by 19–21 percent in all categories and help achieve a 38–39 percent reduction in high risk groups (Gillespie et al., 2012).

The research shows that bathroom renovation was a key point of risk reduction since 56 percent of the bathrooms were hazardous. The risk was reduced by 81 percent after modification. This is supported by a study in Maryland that identified 54 percent of bathrooms as hazardous in 174 surveyed dwelling units of elderly persons, followed by stairs (40%) and entryways (28%) (Yonge et al., 2017). Scholars agree that bathroom modifications can reduce fall risk (Gell et al., 2020). Stairs in this study were also hazardous, at 34 percent risk score, which reduced to 22 percent after renovation. Likewise, research in Vietnam showed that too-high stairs in remote areas were strongly recommended for home modification (Vu et al., 2020). Research has also confirmed that improvements in poor night light, door obstruction and slippery bathroom floors had significant correlations with recurrent fall prevention (Lim & Sung, 2012). About 40 percent of elderly people who had repeated falls had no bathroom modifications (Ng et al., 2021). The second hazardous area for falls was the area surrounding the house, including the entryway. This research confirms that stairs and entryways have a high risk of falling. Most older adults in rural areas in Thailand living in detached houses have a hazardous surrounding area with a pathway to the outside bathroom and steep stairs to the main living area of the elevated houses. India also reported a 73 percent modification of the outside bathroom (Chacko et al., 2017), which is consistent with the 68 percent outside bathroom modification in the rural areas in this study. The elderly people in India also used non-western toilets, including squatter toilets and pit latrines. Comparing environmental hazard modifications in the Indian and Thailand studies, 62 percent and 78 percent of the toilets were non-western styled, 98 percent and 99 percent had no handrails, and 44 percent and 56 percent of areas surrounding the houses had hazards (slip floors, stones and leaves), respectively. These areas have a high-risk score for falling in both rural and urban areas.

Some scholars have suggested that environmental hazard improvement would be effective for the elderly with limited mobility or health problems, irrespective of environmental quality (Gill et al., 2000). Those scholars also agreed that environmental safety could allow the elderly to feel more comfortable to live and move (Rand et al., 2011). Although this study was not focused on poor health and mobility conditions of the participants, those elderly people had lived in the below-standard environment and had no budget for home modifications. Home modification in this study not only improved the safety environment but also upgraded the standard of the elderly people's quality of life. The renovation budget was the key constraint of home modification in the poor elderly in both rural and urban area.

Besides universal design, several environmental design techniques are suggested to reduce falls. A zero-step entrance, roll-in shower bathroom and low-profile thresholds, such as high-contrast trim and glare-free surface are some strategies to create an anti-fall environment (Pynoos et al., 2012). Technology gadgets are also beneficial in providing assistance to older adults, such as motion-sensor lighting and automatic open-close doors (Pynoos et al., 2005). Help call equipment is also recommended in this research, which will allow elderly individuals to easily call for help from neighbours in remote houses in rural areas. In this research, most houses

could not afford these techniques. Some advanced techniques used in several houses in the urban area were motion-sensor lighting and anti-slip surfaces attached at the edge of stair wells.

Both health/personal factors and environmental factors play a role in fall reduction. Effective fall prevention programmes should include fall risk assessment combining health and environment evaluation, rehabilitation courses, and physical and cognitive capacity practice (Feldman & Chaudhury, 2008). Moreover, individual health checks and self-education on fall prevention are essential for providing elderly individuals with knowledge of self-care. Elderly people should have regular vision and health checks and should understand and use fall prevention assisted technology (Chase et al., 2012).

Conclusion

Although there are several arguments related to the difference in fall risk between rural and urban areas, this research concludes that the elderly living in rural areas have a higher risk than those in urban areas due to health risk status and poor environmental quality with many hazards. Home modification can significantly help reduce fall risk in both rural and urban areas.

In conclusion, considering both intrinsic and environmental factors, the results suggest that elderly people in rural areas were slightly at risk related to falls more than those in urban areas. Although there was no significant difference between health risk and falls of the elderly in the rural and the urban areas, those in the rural areas showed a higher proportion of defectiveness of walking ability, older age related to fall experiences, and higher number of falls. Environmental risk assessment of houses in rural areas showed a significantly higher fall risk than those in urban areas, due to the layout of the bathroom, the squatter toilet and the pathway between the house and the bathroom. Modification of the bathrooms and surrounding house was the most effective strategy for reducing environmental fall risk in this research. Home modification should be performed by an expert from assessment to the construction process for a comprehensive universal design and safety within an appropriate budget. However, the renovation budget was the key constraint of poor elderly people in both rural and urban areas.

Limitations

This study is one of seven studies in the research series ‘Appropriate housing for Thai Elderly to promote physical and mental health by Age friendly community concept’. The criteria for area selection and the sampling size of participants in each community were in the other studies within the series. Therefore, inferential statistics were not presented in this research. Due to the project’s limited construction budget, the number of targeted houses in each community was fixed at 20 modified houses. These houses could help the community represent as a role model of a safe environment and sustain local senior services in the community. Several parameters were not included in the study and suggested for future study, such as fear of falls, falls in public space and in-depth study on walking ability related to falls.

Conflict of Interest

The authors declare that there is no conflict of interest.

Funding

This research was funded by the 2020 National Research Council of Thailand (NRCT) Fund and partially supported by Chiang Mai University.

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