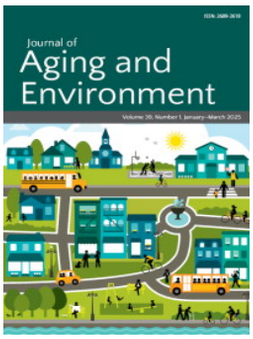

Journal of Aging and Environment

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/wjhe21

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To cite this article: Bo Kyong Seo, Kin Yuen Tam, Yichen Dang & Karen Lee (04 Apr 2025): The Effects of Proactive Home Modifications for Aging in Place: Evidence from Hong Kong, Journal of Aging and Environment, DOI: 10.1080/26892618.2025.2478405

To link to this article: https://doi.org/10.1080/26892618.2025.2478405

Published online: 04 Apr 2025.

JOURNAL OF AGING AND ENVIRONMENT
https://doi.org/10.1080/26892618.2025.2478405

The Effects of Proactive Home Modifications for Aging in Place: Evidence from Hong Kong

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ABSTRACT

To promote a housing environment that can support healthy aging in place, home modifications have been encouraged not only for older adults with past fall injuries or disabilities but also for those without particular functional limitations as preventive home interventions. This study examines the environmental challenges Hong Kong's community-dwelling low-income older adults experience at home and the effectiveness of home modifications on their daily lives. The results show that home modifications significantly reduced older adults' fear of falling, improved their life satisfaction, and strengthened self-efficacy regarding independent living despite structural limitations in the current housing conditions and financial burden.

KEYWORDS

aging in place; home intervention; environmental risks; fear of falling; life satisfaction

1. Introduction

The rapid aging of the world's population has placed 'aging in place' at the center of the elderly policy in many countries (Scharlach et al., 2016). The Center for Disease Control in the US defines aging in place as "the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level" (Bengtson & Settersten, 2016). This notion points to the importance of environmental support for older people to remain in their familiar homes and communities, given their declining functional and cognitive abilities.

A home is the fundamental environment that shapes the quality of life among older people, who tend to spend the majority of their time at home daily (Wahl & Oswald, 2016). To older people, a home provides a sense of freedom and safety, functions as a place for social interaction, and strengthens emotional connection that reflects self-identity (de Jonge et al., 2011). As residents grow older, however, some elements of their houses become

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environmental hazards that hamper independent daily activities at home. The ecological model of aging suggests that people with lower levels of competence (i.e., functional and cognitive abilities) tend to experience greater pressure from environmental hazards (Lawton & Nahemow, 1973). Such negative environmental experiences will likely compromise the benefits of aging in place (Ahn et al., 2020). Therefore, modifying a home helps older adults better deal with the environmental pressure they feel at home (Stark et al., 2009).

A number of studies contend that home modifications are effective in fall prevention, improve older people's functional independence and autonomy, and enhance their psychological well-being (Ahmad et al., 2013; Aplin et al., 2015; Carnemolla & Bridge, 2020; Hwang et al., 2011; Keall et al., 2015; Pynoos et al., 2010; Stark et al., 2009, 2017; Wahl & Oswald, 2016). Research also suggests that enhanced functional independence following home modifications strengthens self-efficacy and reduces carers' burdens, contributing to enhanced family relationships (Tanner et al., 2008). However, contrasting results have also been reported. Some researchers found no evidence of a link between home interventions and fall prevention or functional competence (Cockayne et al., 2021; Sheffield et al., 2013; Wahl et al., 2009). These unexpected results imply that the effects of home modifications require a contextualized understanding of the interventions and their impacts (Chase et al., 2012; Lord et al., 2006; Sánchez-González et al., 2020).

This paper examines the effects of home modifications on community-dwelling older adults in Hong Kong, one of the most rapidly aging cities in the world. The proportion of persons aged 65 or above in Hong Kong's population was 21% in 2021 and is projected to increase to 31% by 2039 (Census and Statistics Department, 2020). As the fast growth of the aged population has pushed up the demand for elderly care services, the Government of Hong Kong has strived to promote 'aging in place as the core, institutional care as back-up' as the primary goal of its elderly care policy (HKSAR Government, 2023) and geared toward creating an age-friendly city.

However, it seems that the city's residential environment does not meet older people's environmental needs adequately. About 29% of the community-living older population falls each year, and almost half the falls occur indoors (Fong et al., 2023). The constantly declining multigenerational co-residence in the city has raised concerns about community-living older people's safety and well-being (Phillips et al., 2018). Although Hong Kong's public housing sector adopted universal design principles in the planning and design of new estates in the early 2000s, the public housing estates built before the implementation of these new design guidelines, as well as

private residential communities that have been exempted from such design requirements, are constantly exposed to environmental constraints, which are particularly unsuitable for many older residents. Furthermore, the city's notoriously small per capita living space (the median per capita floor area of a dwelling was 16 sq m in 2021, smaller than Japan's 19.5 sq m or Singapore's 25 sq m) is likely to pose a significant challenge to older people in coping with the increasing environmental pressure when staying at home (Legislative Council, 2022). However, upgrading old residential buildings to be suited for aging in place has not been readily feasible to date in Hong Kong due to the complicated procedure required to obtain a consensus among multiple owners and the building owners' unwillingness to make costly refurbishments of aging buildings (Ling & Lee, 2019). Given the systemic limitations to making the indoor housing environment more age-friendly, individuals' proactive and voluntary actions to modify their homes have increasingly become essential.

However, home modifications are not a common practice in Hong Kong. They have been provided mainly to those with physical disabilities with the aid of occupational therapists (Li & Au Yeung, 2016). Public awareness of home modification services is generally low, particularly among older adults who do not currently have conspicuous occupational challenges (Li & Au Yeung, 2016). Therefore, little has been known about the effects of home modifications on Hong Kong's older people. Furthermore, the effectiveness of environmental hazard reduction through home interventions has been investigated largely among older people with falling history and mobility limitations (Lord et al., 2006). How home modifications influence community-dwelling older adults without apparent functional limitations or falling history has been understudied.

In this regard, the paper reports on the home environmental challenges experienced by community-living older adults in Hong Kong and the influences of home modifications on older adults' daily lives. Adopting a mixed-method approach, our study will inform policy-making for promoting an age-friendly housing environment in general and the implementation of effective home modifications in particular. The integration of qualitative evidence with quantitative results will add valuable insights into the existing literature on home modifications dominated by quantitative studies (Puts et al., 2017).

2. Methods

This paper reports on the outcomes of Hong Kong's small-scale home modification project implemented by Habitat for Humanity Hong Kong (hereafter 'Habitat'), a local non-governmental organization dedicated to

housing services for those in need. Acknowledging the importance of an age-friendly residential environment for aging Hong Kong, Habitat carried out home modification services for community-living older people from August 2022 to June 2023. We took part in this project as a project evaluation team and engaged in designing the evaluation tool and analyzing the outcomes on the service recipient elderly households.

We used a mixed-methods approach involving a one-group pretest-posttest study followed by focus group discussions to obtain a more integrative understanding of the impact of home modification. A one-group pretest-posttest study is a robust quasi-experimental research design that can examine the effect of a specific intervention by comparing the outcome of measures before and after the intervention among the same nonrandom group of participants. Ethics approval was obtained from the authors' university (HSEARS20220831001). The data was collected upon the participants' written consent, and an HK$50 voucher was provided to all participants.

2.1. Participant recruitment, pre-survey, and home assessment

Since this project was a pilot study to explore the feasibility of a more extensive follow-up project, a priori power analysis and strict eligibility criteria were not applied during the recruitment of the participants. Our selection criteria include: 1) age 55 and older, 2) living in the community (not institutionalized), 3) not bed-bound, and 4) cognitively able to engage in the survey. Given the available resources and time allowed for the project, Habitat was referred to 104 participants by local social service organizations, 95 of whom completed the assessment of their home environments and pre-surveys with the Habitat project team's assistance.

In the pre-survey questionnaires, six outcome measurements of older adults' functional independence and psychological well-being were used to examine the impact of home modifications on older adults' well-being. *Activities of Daily Living* (ADL) were measured based on the modified Chinese version of the Barthel index of Activities of Daily Living (Collin et al., 1988), widely used in gerontology research. ADL indicators measured the extent to which the participants function independently and have mobility in daily activities in 10 aspects, including feeding, mobility, grooming, toilet use, bladder, bowels, transfer, dressing, stairs, and bathing. Each of the ten indicators is assessed based on a 3- or 4-point scale (0 = "need someone else's help", 5 = "need minor help", 10 = "do not need help", 15 = "completely do not need help"). The total score ranges from 0 to 100, and a higher total score indicates more functional independence and better mobility.

Instrumental Activities of Daily Living (IADL) was measured based on the Chinese version of Lawton Instrumental Activities of Daily Living (IADL-CV) (Tong & Man, 2002). IADL indicators assess the extent to which older adults need assistance for living independently in the community by evaluating their abilities in using the telephone, transportation, shopping, medication management, money management, meal preparation, housework, laundry, and handyman work. Each of the nine items was measured based on a 3-point scale (0="need help", 1="need minor help", 2="do not need help"). The total score ranges from 0 to 18, and a higher total score indicates a higher level of independence.

The impact of home modifications on older adults' fall prevention could be best assessed by comparing participants' actual fall experience at home before and after the modifications. However, this method was not feasible due to the short project time frame. Instead, we compared *participants' perceived fall risks* using two indicators. One is fear of falling, measured with a single item, 'To what extent are you afraid of falling at home?' on a 5-point scale (1 = not afraid at all, 5 = very afraid). While this indicator measures the overall perception of the fall risks, the second indicator, fall efficacy, was used to capture the participants' confidence in not falling when doing daily activities at home. We used the modified Falls Efficacy Scale (Tinetti et al., 1990) consisting of ten items with a 10-point scale (1 = very confident, 10 = not confident at all). The total score ranges from 10 to 100, and a higher total score indicates a lower level of fall efficacy.

The participants' *psychological well-being* was measured in two dimensions: quality of life and life satisfaction. Given the complexity and length of the prevailing indicators of the quality of life, a single question, 'How would you rate the quality of your current life?' was asked using a five-point scale (1 = not very good, 5 = very good). Life satisfaction was measured using the Satisfaction with Life Scale (SWLS) (Diener et al., 1985), which consists of five items on a seven-point scale (1 = very dissatisfied, 7 = very satisfied). The total score ranges from 5 to 35, and a higher total score indicates a higher level of life satisfaction.

The participants' *demographic and socioeconomic attributes* were also collected regarding gender, age, education level, employment status, marital status, monthly household income, number of co-residing family members, housing tenure (owner occupation vs rental), housing type (public vs private), housing size, length of residency (year), and wheelchair use (yes vs. no).

Table 1 reports the descriptive statistics of the 95 participants' socioeconomic and demographic characteristics. It was found that 60% of the participants were female, and the mean age of the participants was 76. Half of them received primary education only, or none, and almost all (96%) were

Table 1. Pre- and post-test participants.

Category		%	Mean	Std. Dev.	Min.	Max.
Gender	Male	40.22				
	Female	59.78				
	Total	100				
Age			76.053	9.502	58	99
Education	Primary school or below	49.47				
	Secondary school	27.37				
	College/university or above	23.16				
	Total	100				
Employment status	Currently engaged in work	4.21				
	Retired/never worked	95.79				
	Total	100				
Marital status	Single/widowed	55.91				
	Married/spouse alive	44.09				
	Total	100				
Monthly household income	HK$1-5000 or below	82.11				
	HK$5001-10000	9.47				
	HK$10001-15000	2.11				
	HK$25,001-30,000	2.11				
	HK$30,001 or above	4.21				
	Total	100				
Number of co-residing family members	0	40.43				
	1	42.55				
	2	11.70				
	3 or more	5.32				
	Total	100				
Housing tenure	Owner occupation	36.84				
	Rental	63.16				
	Total	100				
Housing type	Public	65.96				
	Private	34.04				
	Total	100				
Housing size	199 ft^2 or less	12.63				
	200-299 ft^2	23.16				
	300-399 ft^2	29.47				
	400-499 ft^2	16.84				
	500-599 ft^2	5.26				
	600-699 ft^2	4.21				
	700 ft^2 or above	8.42				
	Total	100				
Length of residency (years)			28.7065	13.9399	1	50
Wheelchair use	Yes	13.68				
	No	86.32				
	Total	100				
Fall experience at home	Yes	18.97				
	No	81.03				
	Total	100				

unemployed at the time of the survey. 56% were single or widowed, and over 80% had a monthly household income of less than 5000 Hong Kong dollars. 63% were tenants, and 66% lived in public housing. The relatively lower socioeconomic status of the participants seems attributable to the fact that the participants were referred by local social organizations that served disadvantaged households in the community. About 65% lived in units with limited sizes (smaller than 400 square feet), and 19% experienced falls at home in the past. The generally long residency in the current house (29 years on average), a large number of single-person households (40%),

and a non-negligible share of wheelchair users (13.7%) clearly indicate that it is essential to help the elderly participants adapt their homes to promote active aging in the current place. However, it should be noted that these characteristics of the participants do not necessarily represent older adults in Hong Kong since they were selected based on convenience sampling.

During pre-surveys, the participants' home environments were also assessed using the 'Double Smart Assessment Indicators for Elderly-Friendly Community' developed by the Jockey Club Design Institute for Social Innovation (JCDISI) at The Hong Kong Polytechnic University. This indicator set was formulated in 2021 through co-creation activities to judge the age-friendliness of older adults' housing conditions quantitatively. The initial indicators were then reviewed, revised and validated by a group of experts in elderly services (JCDISI, 2022). The finalized indicator set consists of 67 items evaluating safety and comfort level (22 items) and age-friendliness of the overall housing environment and specific locations in the house (e.g., bedroom, bathroom, kitchen, living room, entrance), as well as the availability of age-friendly equipment/device (45 items), and higher aggregated scores indicated more favorable home environments.

2.2. Home modifications and post-surveys

Considering the results of the preceding home assessments and pre-surveys as well as the participants' financial conditions, 62 out of 95 participants, the maximum number of households that Habitat could finance with the funds available, were selected and received modification services. Five participants were removed before the post-surveys due to institutionalization or demise. Therefore, 58 households participated in the post-surveys after 2–3 weeks of the home modifications.

A total of 43 types of modifications were implemented, resulting in four modifications per house on average. Handrail installation, bathing chair placement, safety chair placement, and anti-slip floor treatment were the most frequently implemented modifications in the participants' homes. Their primary functions include removing environmental hazards, placing fall (or bump) prevention measures, and installing equipment or devices to improve older persons' independent activities, sleep quality and hygiene. The modification in each home took one to two days to complete.

After two to three weeks of home modification, the participants were asked to administer post-surveys, during which only the primary outcomes, i.e., ADL, IADL, fear of falling, fall efficacy, quality of life, and life satisfaction, were measured. These outcome measurements before and after the intervention were compared using a paired sample t-test. If the changes are significant, home modifications would be considered to have impacts older

people's lives. In the final analysis, three participants were excluded due to the noticeably different procedure of the home modifications (e.g., self-financed; only minor changes).

2.3. Focus groups

Following the one-group pretest-posttest study, three focus groups were conducted to gain a more nuanced understanding of older adults' environmental needs at home and the effects of home modifications. Participants included six older adults who participated in the pre and posttest study, five caregivers of the survey participants (Table 2), and four caseworkers who referred the elderly survey participants to Habitat. The elderly and caregiver participants were recruited through the caseworkers' referrals. We used a focus group guide with semi-structured interview questions to guide discussions on the difficulties and risks derived from the environment, intervention impacts, and improvement suggestions.

The focus group data analysis followed a systematic approach to ensure consistency and transparency. All sessions were audio-recorded and transcribed verbatim to preserve linguistic features and contextual meaning (Braun & Clarke, 2006). Our analytical process involved multiple stages: (1) initial familiarization with the data through repeated reading of transcripts while noting preliminary impressions; (2) open coding, where transcripts were systematically coded line-by-line to identify key concepts: environmental challenges, modification impacts (falls, independence, relationships with caregivers, other aspects), and barriers to or concerns about home interventions (Creswell, 2013); (3) thematic categorization, where similar codes were grouped into broader categories to identify recurring themes and relationships across the dataset (Braun & Clarke, 2006); (4) theme

Table 2. Focus group participants.

	Participant	Age	Gender
		Older people who received modifications	
1	A	66	M
2	B	78	F
3	C	86	M
4	D	74	F
5	E	85	F
6	F	63	M
		Caregivers (elderly users' spouse or brother)	
7	A	80s	M
8	B	80s	F
9	C	70s	M
10	D	70s	M
11	E	80s	F
		Caseworkers (staff in neighborhood elderly centers)	
12	A	–	F
13	B	–	M
14	C	–	M
15	D	–	F

refinement through iterative review and comparison across participant groups (elderly users, caregivers, and caseworkers); and (5) interpretation and integration with quantitative findings (Creswell, 2013). Particular attention was paid to both consensus viewpoints and divergent perspectives across the different participant groups. This approach allowed us to identify recurring patterns while preserving the richness of individual experiences regarding home modifications.

3. Results

While quantitative and qualitative methods were employed sequentially, this section reports the results in an integrated manner to address each research question.

3.1. Older adults' home environmental challenges

The home assessment result based on the "Double Smart Assessment Indicators" illustrates the extent to which participants' homes are safe, comfortable, and age-friendly (Table 3). It shows that the safety and comfort levels were moderately favorable regarding the overall environment (mean: 3.554 out of 5) and specific home hazards (mean: .751, meaning 75.1% of the participants had no specific hazards). However, the bathroom was found to be the location with the highest concern (about 67% of the participants had hazards in their bathrooms), and 50% did not have safety-related equipment/devices (e.g., emergency call device, induction hob, thermostatic system) installed at home. As for the age-friendliness, the overall home environment (mean: 3.475 out of 5), entrance (mean: 3.87), living room (mean: 3.772), toilet/bathroom (mean: 3.593), and bedroom (mean: 3.809) showed generally favorable conditions. However, age-friendly equipment or devices (e.g., hydraulic door hinge, overfill alarm, toilet grab bars) were not common among the participants (only 18% had at least one

Table 3. Summary of the home assessment results (mean scores by section).

Indicators	Scale	Mean	Std. Dev.	Min.	Max.
Overall home environment	5-point	3.554	.586	2.25	4.875
Bathroom	Binary	.626	.263	0	1
Home hazard	Binary	.751	.236	0	1
Equipment	Binary	.502	.211	0	1
Overall home environment	5-point	3.475	.484	2.25	4.917
Entrance	5-point	3.879	.675	2.429	5
Living room	5-point	3.772	.74	2.25	5
Toilet/bathroom	5-point	3.593	.834	1.333	5
Bedroom	5-point	3.809	.996	1.5	5
Equipment	Binary	.179	.141	0	.6
Wheelchair-specific	5-point	2.755	.895	1.667	4.667

5-point scale: 1 = unfavorable condition, 5 = favorable condition; binary scale: 1 = favorable, 0 = unfavorable.

at home), and wheelchair use was not very convenient at home (mean: 2.755).

Our focus groups exhibited that these spatial obstacles at home could become environmental hazards to older adults, particularly when they are associated with older people's declining physical functions. One of the most perilous challenges faced by the elderly participants was the *risk of falling*. The elderly participants in focus groups consistently expressed concern that the slippery bathroom floor was particularly hazardous. Another common obstacle mentioned by the focus group participants was the step to the balcony and the bathroom. Elderly individuals often had to lift their feet to enter the bathroom and were prone to tripping on the step.

> *The balcony is the only way to the washroom, but walking on the step to the balcony was never easy. Because of the Polio disease, my sister's leg is fragile. I know the situation will get worse in future. (Caregiver C)*

> *The step between the room and the balcony is troublesome. When you go out to the toilet, you need to go over the step … [My wife] can't move one side of her body due to Polio, so the feet are powerless. (Caregiver D)*

Some caseworkers expressed concerns about the fall risks induced by the inappropriate position of the electricity meter and high kitchen cabinet and cloth hanging rack for wheelchair users. Some elderly participants also reported forgetting to switch off the stove after cooking. While using an electronic stove could partially address this issue, the participants also mentioned that forgetting to turn off the power could still be a problem. A social worker serving older people also stated:

> *Some older people's memories are declining, especially those who are living alone and have cognitive impairments. It will be dangerous if they forget to turn off the gas stove when they cook. (Caseworker D)*

These quotes exhibit how the housing environment that functions normally for ordinary people could become a substantial environmental hazard to older people and that the impact of environmental obstacles on older adults is likely to be augmented by not only their physical frailty but also their cognitive decline.

Another interesting finding is that older adults' need for home adaptation also arises from their weakening bodies, necessitating assistive equipment to maintain basic hygiene and comfort.

> *In winter, I do not take a shower that often because it's cold. So, I wish I could have something to keep the bathroom air warm so I could feel comfortable in the shower. (Elderly user D)*

> *I feel freezing in my bathroom because it faces north. The bathroom on the top floor is hot in summer and very cold in winter. Older people do not feel comfortable using their bathrooms under extreme weather. (Elderly E)*

3.2. The effects of home modifications

The impact of home modifications in this project was assessed based on the quantitative evidence derived from service recipients' evaluation, pretest-posttest study and qualitative focus groups. The participants were generally satisfied with the modifications (mean score of satisfaction mostly over 4.0 out of 5) and perceived them as helpful in making their daily activities easier (mean score of usefulness mostly over 4.0). A few items, such as a rollator, bathboard, water tank repair, wheelchair ramp slope, replacement of foldable table, and portable grab handle, received a relatively lower score (mean score 3.0). Although the small number of households that implemented the respective items does not seem to allow us to make a confirmative judgment on the efficacy of those modifications, the relatively lower scores appear to indicate that there is room for improvement in terms of implementation, such as choosing appropriate products and hiring skillful contractors.

The paired-sample t-test result for the pretest-posttest study proved the positive effects of home modifications on older adults' lives in selected dimensions. Table 4 shows that the improvements in fear of falling, fall efficacy, and life satisfaction were statistically significant. This result indicates that the participants became less afraid of falling (3.771→2.896, $p = .001$), had more confidence in not falling at home (39.435→27.27, $p = .009$), and became more satisfied with their life (4.346→5.014, $p = .001$) after the modifications. The insignificant change in IADL was somehow expected since the IADL indicators pertain mostly to community-scale independence, which might not be strongly influenced by internal home intervention. However, the insignificant change in ADL was unanticipated, which could be explained by our small sample size and short interval between modification and post-survey, given the positive effect on ADL in another study with a larger sample size (see Paone et al., 2022). It is assumed that the insignificant change in the quality of life could be attributable to using only a single item in our study instead of a standardized scale with multiple indicators.

In addition, the focus group participants provided much positive feedback on the modifications. Most importantly, the elderly users,

Table 4. Paired-sample t-test result.

	Obs	Pre	Post	Diff	St Err	*t*-value
ADL	53	80	79.906	.094	2.393	.05
IADL	52	10.577	11.077	−.5	.44	−1.15
Fear of falling	48	3.771	2.896	.875**	.222	3.95
Falls efficacy	37	39.435	27.27	12.165**	5.479	2.95
Quality of life	44	3.159	3.272	−.114	.088	−1.3
Life satisfaction	41	4.346	5.014	−.668**	.174	−3.85

Note: ADL, IADL, Falls efficacy: total score; Fear of falling, quality of life, life satisfaction: mean score.
**$p < 0.01$.

caregivers, and social workers agreed that home modifications helped older residents complete daily activities more easily and safely. In particular, the safety chair, handrails, and non-slippery floor materials seem very helpful.

> *I used to change clothes in bed, which was very inconvenient, but now, I have this* [safety] *chair, which helps me to keep balance when I change clothes or watch television. (Elderly user A)*

> *Now my new bed is lower than the previous one, which was too tall and made me fall easily. When I nearly fall, I can grab the handrail, and it helps me to rebalance. … Thanks to the new anti-slippery materials in the bathroom, now I don't have to take off my slippers to enter the bathroom. (Elderly user F)*

> *I had to go out to turn on or off the light in the living room, but now the switch is inside my bedroom. It's very convenient. (Elderly user D)*

Although the preceding pretest-posttest study did not show a statistically significant change in older adults' ADL, this qualitative evidence clearly indicates that home modifications positively affect older people's safety and daily activities. The insignificant change in ADL could be related to the result of our follow-up paired t-test by subgroups with different levels of ADL (results not shown in this manuscript) that the positive effect of home modifications on fall efficacy was significant only among those with 'moderate' levels of ADL. Home modifications are unlikely to improve the safety of older people with notably poor mobility since they need carers' assistance anyway, even after modifications; similarly, those with high independence in mobility may not necessarily recognize the difference yet.

The focus groups also demonstrated that home modifications influenced older residents' psychological well-being, which was also demonstrated in the quantitative analysis. Many focus group participants stated that older residents have become more confident when performing daily activities and gained a sense of safety and control.

> *After recovering from a heart stroke, I always thought it would be good if I could have handrails in the bathroom and kitchen. Now, I feel more secure, safe, and confident at home. (Elderly user A)*

> *Before, I had to rely on my child whenever I walked inside their homes. But now I don't have to ask for his help so much, and I can do more on my own. It feels great. (Elderly user E)*

Social workers also noticed that after using the home modification service, elderly clients have become more interested in the elderly services available in the community. They stated that Hong Kong's older people tend to have reservations about using elderly services, but after using home modification services, they are now more willing to apply for other services.

It shows that improving older adults' independence and safety through modifications can enhance their autonomy and empowerment subsequently, as also found in other research (e.g., Goddard et al., 2024).

One unintended outcome was that some elderly service users who completed modifications at their homes began encouraging their neighbors and friends to use the modification services. This indicates older adults' satisfaction with and appreciation of the modifications made to their homes and their willingness to share their positive experiences with others. This outcome fosters a sense of community and social support among older adults and helps raise awareness of the importance of home modifications among a wider older population.

> *One of the main positive impacts was that some older people discovered the benefits of the modifications; not only did it help them to develop self-confidence to live alone, but it also helped them realise the existence of support available out there. […] This* [modification] *service has encouraged old people to look around their homes and try to seek help. (Caseworker B)*

In effect, we found that the home assessment process has helped increase older adults' and case workers' awareness of the environmental challenges faced by older people at home and the types of home modifications available in the community.

> *The elderly people told us they were not aware that the previous spatial configuration would hinder them from doing daily activities; luckily, they learned about the risks through this pilot program. (Caseworker C)*

> *This project helped me better understand older clients' difficulties at home. Now, my colleagues and I can alert them and give them tips about how to solve home safety problems. (Caseworker D)*

The positive outcome of home modifications was not limited only to older people and case workers. We found that home intervention significantly relieved caregivers' care burden. In particular, the caregivers stated that the installation of handrails helped their elderly family members walk safely at home, and they felt more relaxed and at ease.

> *I feel relieved when my sister moves around. Now, she can hold on to the handrails, and I don't need to feel worried much. It reduced disputes in my family and improved our sleep quality. I can spare extra time for other things. (Caregiver C)*

> *The bathroom floor is not slippery now. It reduced my workload since I don't have to follow her into the bathroom. It is perfect now. (Caregiver E)*

> *We were most scared of unexpected slips. Older people may not know what to do without handrails, but we worry less now. (Caregiver A)*

As seen in these quotes, home modifications contribute to alleviating caregivers' care burden and stress and improve family relationships and interaction.

However, we also found that the structural and spatial constraints in Hong Kong's old residential buildings could compromise the effectiveness of this home intervention.

> *The basin in the toilet is so small since the toilet itself is so narrow that I often hit my head on the basin. (Elderly user B)*
>
> *All the light switches in my home are in the living room, so I need to walk outside to the bedroom to turn on the bedroom light. It is inconvenient and dangerous. (Elderly user E)*
>
> *It is difficult for caregivers to help their older family members shower at home because the bathroom is small. (Caseworker C)*
>
> *Some old flats have narrow corners or irregular room shapes. So, older people in wheelchairs cannot easily turn around. It's also impossible for caregivers to hold the wheelchair and walk through the corridor. (Caseworker B)*

This clearly shows that Hong Kong's old housing units, designed without much consideration of age-friendliness many decades ago, do not fully cater to the environmental needs of elderly residents whose functional abilities rapidly decline. Since it is impossible for the residents to change the structure or the original fixtures of their homes easily, the positive effects of home modifications are likely to be limited to some extent.

4. Discussion and conclusions

Environmental challenges at home are detrimental to older people's aging in place. This paper demonstrated that there exist evident environmental barriers at home faced by community-living older people in Hong Kong, and home modifications could be an effective intervention to reduce environmental hazards and improve older people's life satisfaction and family relations. Despite the relatively small sample size due to the financial constraints for large-scale home modification programs, our study is distinctive from prior research in that it concerned not only fall-preventive aspects of home intervention but also the overall age-friendliness of older people's indoor housing environment. As the study population includes older adults without a past falling history or home injuries, our findings capture the effect of *proactive* home modifications on ordinary aged people without functional problems.

While the study substantiated the positive effects of home modifications, it offers insights into the effective implementation of home interventions for aging in place. First, our follow-up analyses by subgroups with different ADL levels seem to inform relevant service providers' consideration of which elderly groups should be prioritized. While home modifications turned out to be ineffective in improving older adults' ADL *per se*, their effects on fall efficacy and life satisfaction were insignificant among those

who already had poor functional capacity. Yet this result does not mean that older adults with a low level of ADL should be excluded from home modification services. Rather, it may signify that they need other types of (or more intensive) home interventions or combined interventions (e.g., modifications accompanied by rehabilitation). Meanwhile, the positive effects among older adults with moderate and high levels of ADL are indicative of the necessity for expanding home modification services beyond older people at high risk for falls or with a past falling history. More accessible home environment assessment tools that are similar to those used in our study could facilitate the promotion of proactive home interventions among those who desire to age in place.

Although occupational therapists were consulted for the development of the home assessment indicators used in this study, the environmental assessments and decision-making on what and where to modify were primarily led by the discussion between the study participants and the experienced Habitat practitioners. Given that older adults' dissatisfaction with home modification outcomes often originates from the lack of engagement in the implementation process (Lo Bianco et al., 2020), the study participants' informed decision-making might have been related to their consistently high satisfaction with the modification outcomes.

Considering the profile of the study participants, i.e., low-income public rental housing tenants, securing sufficient financial resources for the modification services seems a critical factor for the success of home modification programs. In our study, about five thousand Hong Kong Dollars were earmarked for the modification work in each household, which was fully funded by a local social organization. If older people were required to accommodate this cost from their side, the number of participants would have been significantly smaller, and the same degree of satisfaction might not have been guaranteed. Therefore, financial support, particularly for low-income older adults, seems imperative.

This study has limitations, such as the relatively small sample size, overrepresentation of low-income groups, and a short interval between the pretests and post-tests, which made it impossible to assess the changes in the participants' actual falling experiences in the long term. Measuring a wider range of outcomes with a larger sample would contribute to advancing our understanding of the effects of proactive home modifications on community-dwelling older adults.

Acknowledgements

We would like to thank the Jockey Club Design Institute for Social Innovation and Habitat for Humanity Hong Kong for their assistance in data collection. The authors used ChatGPT-4o to check grammatical/spelling errors.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Habitat for Humanity Hong Kong.

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