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DETERMINANTS OF PERCEIVED PHYSICAL ENVIRONMENT BARRIERS AMONG COMMUNITY-DWELLING ELDERLY IN TAIWAN

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Abstract: *Objectives:* To test the hypothesis that mobility, activities of daily living, and the interaction between them can play a key role in determining perceived physical environment barriers among community-dwelling elderly. *Design:* Cross-sectional. *Setting:* Community. *Participants:* One hundred and ninety-seven community-dwelling elderly with more than 7 points on the Short Portable Mental State Questionnaire and less than 7 points on the Geriatric Depression Scale (15 items). *Intervention:* None. *Measurements:* Time Get-up and Go test (TUG), the subscales of basic activity of daily living (BADL)/instrumental activities of daily living (IADL) of the Hierarchy of Care Required (HCR), and the physical/structural subscale of the Craig Hospital Inventory of Environmental Factors in Community-dwelling Elderly in Taiwan were used to measure mobility, activities of daily living and perceived physical environment barriers, respectively. Hierarchical linear regression analyses were used to test the study hypothesis. *Results:* Significant and positive relations were found to exist between perceived physical environment barriers and (1) the TUG time (β=.300, $p<.05$), and (2) the IADL score for the HCR (β=.322, $p<.05$), respectively. A significant and negative relation existed between perceived physical environment barriers and the interaction term (the TUG time and the IADL score for the HCR) (β=-.211, $p<.05$). *Conclusion:* Mobility, IADL and the interaction between them are found to be significant determinants of perceived physical environment barriers in the community-dwelling elderly under consideration. Strategies targeting the enhancement of mobility among community-dwelling elderly are suggested to lead to improvements in the degree to which physical environment barriers are perceived. This beneficial effect could be greater in the case of elderly individuals with better IADL function.

Key words: Mobility, activities of daily living, perceived physical environment barriers, community-dwelling elderly.

Background

Over the course of life people are exposed to various risks foIn Taiwan, the average disability population among the elderly people (65 years and above) from the year 1997 to 2012 was 313,481 (gradually increasing from 148,001 in 1997 to 411,444 in 2012), according to government statistics (1). Elderly people with disabilities often experience difficulties in daily living because of problems associated with activity limitations and participation restrictions. Disability in elderly people and the increasing need for both formal and informal care, such as primary health care, rehabilitation, long-term care, and support for informal caretakers, will inevitably affect the elderly, their families, and the health care system as the population continues to age (2).

The addition of functional evaluation to traditional clinical physical and neurological examinations provides information that is important in the comprehensive assessment of elderly people (3-5). Disability can be identified accurately through responses to a wide variety of questions about the ability to perform activities ranging from basic activities of daily living to instrumental activities of daily living. Increasingly, functional status has also been characterized through the use of measures of physical performance, which are objective tests of subjects' performance of standardized tasks, evaluated according to predetermined criteria that may include counting repetitions or timing of an activity (6). These measures have been shown to correlate with disability, institutionalization, and death (7-9).

The International Classification of Functioning, Disability and Health (ICF) (11), which focuses on health and functioning, is a uniform international classification for describing health conditions. The ICF model has been applied in clinical assessment and monitoring of functioning in elderly individuals undergoing post-acute rehabilitation as well as in monitoring the functioning of community-dwelling elderly (12-14). The ICF model takes three components of health, including physical functions and structures, activities, and participation, into consideration. In the ICF model, personal and environmental contextual factors are observed as important variables of health status (15, 16).

Disability is a negative interaction between the functional impairments of an individual and his or her environment (17, 18). These interactions are described as being potentially bidirectional relationships that exist between the ICF components (11, 19). Therefore, to understand perceived physical environment barriers in community-dwelling elderly, it is important to understand the other relevant components,

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including body functions/structures, activity/participation, and personal contextual factors.

The Craig Hospital Inventory of Environmental Factors (CHIEF) is a tool commonly used to assess environmental barriers (20). The CHIEF has been used to investigate perceived environmental barriers in people with strokes (21, 22), traumatic brain injuries (23), and spinal cord injuries (24). The revised Chinese version of the CHIEF for community-dwelling elderly in Taiwan (CHIEF-CET) has been shown to have good psychometric properties when used in community-dwelling elderly (25). There are four subscales in the CHIEF-CET, including the physical/structural subscale, the services/assistance subscale, the attitudes/support subscale, and the policies subscale. The physical/structural subscale has been applied to disabilities in the community-dwelling elderly in Taiwan (25).

Due to the increasing prevalence of disabilities in the elderly and the potentially bidirectional relationship of this phenomenon with perceived physical environment in the ICF model, it is suggested that an increasing acknowledgment of the importance of perceived physical environment barriers in community-dwelling elderly is warranted. The objective of this study was to discover the determinants of perceived physical environment barriers among community-dwelling elderly in Taiwan.

Methods

This was a cross-sectional study. We utilized face-to-face administration of the study instruments. The participants were enrolled from two community service centers in Tainan City, Taiwan. All the inhabitants who regularly came to these two community service centers in 2012 to get their blood pressure taken were selected to participate in this study. The study was conducted by a trained physician from December 2012 until August 2013. Participants included 204 community-dwelling elderly, aged above 65 years, who had resided in the same community for at least 12 months. Exclusion criteria were (1) being diagnosed with dementia or 7 points or below on the Chinese version of the Short Portable Mental State Questionnaire (SPMSQ) (26), (2) 7 points or above on the Chinese version of the Geriatric Depression Scale 15 items (scores can range from 0 to 15, with a cut-off point of 7 or greater suggesting a large number of depressive symptoms) (27), and (3) could not perform Time Get-up and Go test with or without their mobility aids. A total of 202 subjects agreed to participate in the study. Two cases were excluded because their SPMSQ scores were 7 points or below. Three cases were excluded because their Geriatric Depression Scale 15 item scores were 7 points or above. Finally, there were 197 community-dwelling elderly included in the data analyses. Written informed consent statement forms were obtained from the respondents. The right to withdraw and the autonomy of the respondents were explained. Ethical permission to conduct the study was obtained from the Institute Review Board of the National Cheng-Kung University Hospital, College of Medicine, National Cheng Kung University (Approval No.: B-ER-101-184).

Mobility

We used mobility to represent body function. Mobility was assessed using the Time Get-up and Go (TUG) test. In the TUG test, the participant was instructed to rise from a chair, walk 3 meters, turn around, walk back, and to sit back down in the chair (28). The time from rising out of the chair until being seated again was measured in seconds. A shorter time indicated better mobility. The TUG test can be completed by most elderly individuals even with their mobility aids. Excellent intra- and inter-individual reliability (ICC=0.99) (28) has been reported, as well as high TUG test-retest reliability (ICC=0.97) in a similar test situation (29). This test has been used extensively in geriatric and rehabilitation medicine to examine the level of mobility that would be required for the performance of activities required for daily living in older people (30).

Basic activities of daily living (BADL) and Instrumental activities of daily living (IADL)

Basic activities of daily living (BADL) and instrumental activities of daily living (IADL) were assessed by the subscales of the Hierarchy of the Care Required (HCR) (31, 32). The HCR combines 3 subscales, including the BADL, the IADL, and cognition and emotion (C&E). Every subscale has 6 activities, and each is divided into 5 levels. The six BADL tasks include eating, hygiene (including grooming and bathing), clothing, sphincter control, moving, and mobility. The six IADL tasks include making a meal, shopping, telephoning, financial management, medication, and transportation. The six C&E tasks include comprehension, expression, social interaction, memory, meta-emotion, and reality-testing. The item responses for each task were scored 1 to 5 (1, no need for help; 2, intermittent; 3, supervision; 4, need assistance all the time; 5. unable to do). The scores for the six different BADL and IADL tasks were summed up as the scores for the BADL and IADL subscales, respectively. Lower scores on a BADL and IADL subscale indicate less BADL and IADL disability, respectively. The HCR has been tested in nursing home residents and community-dwelling elderly in Taiwan with acceptable internal consistency, inter-rater agreement, test-retest reliability, criterion validity, discriminative validity, and construct validity. (31, 32). The Cronbach's α ranged from 0.88 to 0.98, and 67%-86% of the variation in the HCR subscales was explained. In the case of the community-dwelling elderly in Taiwan, the Cronbach's α has been shown to range between 0.68 and 0.98 (31, 32). The three HCR subscales have been tested using the Rasch analysis model with acceptable fitness (mean square fit values between 0.7 and 1.3) (31). Rasch analysis determines the internal consistency of the scale by assessing whether each item meets the criteria for unidimensionality (33). When the data fit the model, the ordinal data are converted to interval measures expressed as log-odds units or logits. These fit statistics (infit, outfit) are reported as mean square (MnSq). MnSq represents the observed variance divided by the expected variance; therefore, the desired value for the MnSq is 1. For questionnaires, a range of Mnsq fit values between 0.7 and 1.3 are considered acceptable (34, 35).

Perceived physical environment barrier (PPEB)

Perceived physical environment barriers were measured using the physical/structural subscale of the CHIEF-CET (25). There are 5 items in this subscale, including design of home, design of community, natural environment (e.g. temperature, terrain, climate, etc), surroundings (e.g. lighting, noise, crowds, etc.), and technology(e.g. computer, consumer electronics, etc.). Each item was rated based on two scales to describe how often and how much the physical environment problem existed. First, a 5-point frequency scale (0: never, 1: less than monthly, 2: monthly, 3: weekly, 4: daily) was used to indicate the frequency with which perceived physical environment barriers were encountered. Secondly, a 3-point magnitude scale (0: no problem, 1: a little problem, 2: a big problem) was used to indicate the extent of the problem a perceived physical environment barrier typically presents. Based on the rating of these two items, a frequency by magnitude product score was calculated (score range 0–8) to indicate the overall impact of the perceived physical environment. The product scores of frequency by magnitude for the different individual items were summed up as the total score for PPEB. A higher score on the physical/structural subscale of the CHIEF-CET indicates more perceived physical environment barriers.

Personal contextual factors

The personal contextual factors included age, gender, education, living arrangements, financial status, and self-rated health status (using a 5-point Likert scale: 1-very poor, 2-poor, 3-fair, 4-good, 5-very good). We dichotomized gender, education, living arrangements, and financial status as follows: gender (female/male), education (illiterate/literate), living arrangements (living alone/not living alone), and financial status (lower-ranking family: average personal income in a family per year < 6,400 US$/non-lower-ranking family > 6,400 US$).

Statistical analysis

Descriptive statistics were used to characterize the samples. The PPEB scores on the physical/structural subscale of the CHIEF-CET according to dichotomized personal contextual factors were given as the means and standard deviations. Differences between the two groups were tested using a Student's t test. Correlations of the PPEB scores on the CHIEF-CET subscale with age, self-rated health, the time for the TUG test, the BADL score and the IADL score of the HCR subscales were calculated using Spearman's rho. Hierarchical linear regression analyses were used to test the study hypotheses. The dependent variable, the PPEB score, was first regressed on personal contextual factors and the TUG time, then on the BADL score for the HCR, and finally on the IADL score for the HCR as well as the interaction term (the TUG time and the IADL score). With a sample size of at least 100, up to 10 variables could be entered into the regression model (36). All analyses were performed by using the Statistical Package for the Social Sciences (vers. 19.0, SPSS, Chicago, IL, USA).

Results

A total of 197 participants aged 74.7 ± 6.8 years (41.6% men) were enrolled in this study. Table 1 shows the study population characteristics. Difficulty with mobility was the most common among the six BADL tasks (19.3% of the total study population). Difficulty with shopping was the most common among the six IADL tasks (21.8% of the total study population). The six cognition and emotion tasks were all independent in our study population. Comparison of the PPEB scores between the two dichotomized groups according to gender, education, living arrangements, and financial status were tested using a Student's t test. Dichotomized personal contextual factors that showed a significant association ($p<.05$) with the PPEB score were education and living arrangements (Table 2). Correlations of the PPEB scores for the CHIEF-CET with the frequency and magnitude domain of each item (including design of home, design of community, natural environment, surroundings, and technology) showed significantly positive correlations with the PPEB scores for the CHIEF-CET subscale, as shown in Table 3. In each item, the correlation coefficient of the frequency domain was higher than that of the magnitude domain. Age, the TUG time, the BADL score, and the IADL score for the HCR subscale showed significantly positive correlations with the PPEB score of the CHIEF-CET subscale, as shown in Table 4. On the other hand, self-rated health showed a significantly negative correlation with the PPEB score for the CHIEF-CET subscale. The results of the hierarchical linear regression analyses are shown in Table 5. The PPEB scores for the CHIEF-CET were found to have significantly positive correlations with the TUG time($\beta=.300$, $p<.05$) and the IADL score of HCR ($\beta=.322$, $p<.05$). However, significantly negative correlations were found to exist between the PPEB score and the interaction term of the TUG time and the IADL score for the HCR ($\beta=-.211$, $p<.05$). The relationship of the PPEB score with the CHIEF-CET and the TUG time was moderated by the IADL score of HCR. We dichotomized our study population into two groups, including independent in all IADL tasks (N=90) and not independent in all IADL tasks (N=107). We then carried out the regression analysis for each group and compared the slope of the TUG time for each group. In the group independent in all IADL tasks, the slope of the TUG time was 0.346 ($p<.05$). In the group not independent in all IADL tasks, the slope of the TUG time was 0.328 ($p<.05$), which was lower than for those that were independent in all IADL tasks.

Table 1
Study population characteristics. Data are presented as mean ± standard deviation or absolute number (%)

Sample characteristics	Descriptive statistics (N=197)
Age (years)	74.74 ± 6.79
Gender	
Female	115 (58.4%)
Male	82 (41.6%)
Education	
Literate	148 (75.1%)
No formal education	49 (24.9%)
Living arrangement	
Live with spouse/children or others	166 (84.3%)
Live alone	31 (15.7%)
Financial status	
Non-lower-ranking family	165 (83.8%)
Lower-ranking family	32 (16.2%)
Self-rated health	1.83 ± 0.80
TUG time (second)	11.56 ± 3.34
0-10 seconds	109 (55.3%)
>10 seconds	88 (44.7%)
BADL score of HCR	6.33 ± 0.54
Independent in all BADL tasks	139 (70.6%)
Not independent in all BADL tasks	58 (29.4%)
IADL score of HCR	7.11 ± 1.29
Independent in all IADL tasks	90 (45.7%)
Not independent in all IADL tasks	107 (54.3%)
C&E score of HCR	6 ± 0
PPEB score of CHIEF-CET	3.35 ± 4.00
Design of home	0.47 ± 0.77
Design of community	0.74 ± 1.13
Natural environment	0.53 ± 0.79
Surroundings	0.75 ± 1.15
Technology	0.85 ± 1.18

TUG, Time Get-up and Go test; BADL, basic activities of daily living; IADL, instrumental activities of daily living; HCR, the Hierarchy of the Care Required; PPEB, perceived physical environment barriers; CHIEF-CET, the Craig Hospital Inventory of Environmental Factors for the Community-dwelling Elderly in Taiwan.

Discussion

The results of the TUG test, the IADL score for the HCR, and the interaction terms between them were important determinants of perceived physical environment barriers in the community-dwelling elderly under consideration in this study. The results were also consistent with the ICF model, which postulates body function, activity and participation to be an influential determinant of perceived environment. In a recent study, Chang et al. found that interaction between the individual and the environment can play a key role in determining the level of participation in the society (18). Their results combined with those of this study could lead to the supposition that the relationship between activity/participation and the environment is bidirectional, as mentioned in the ICF model.

In our study, mobility, activities of daily living, and personal contextual factors accounted for 22.3% of the variations in perceived physical environment barriers. In recent years, there have been many studies focusing on the relationship between perceived environment and physical activity in different populations (37-39). Activity-friendly environments have been identified as promising strategies by which to increase physical activity levels in populations (37-39). However, these studies have seldom taken mobility and activities of daily living into consideration. Mobility, IADL and the interaction of mobility and IADL are important determinants of perceived physical environment barrier in the community-dwelling elderly in Taiwan. We suggest researchers take mobility and activities of daily living into serious consideration when assessing factors related to perceived environment.

Among nondisabled community-dwelling elderly, objective measures of lower-extremity function have been shown to be predictive of subsequent disability. Measures of physical performance may identify elderly with a preclinical stage of disability who may benefit from interventions intended to prevent the development of frank disability (40). Several studies have shown that older persons with difficulty in mobility have an increased risk for the onset of disability. (41, 42). Poor walking ability has been demonstrated to be a predictor of decline in IADL. However, predictors of improvement in IADL have been commonly associated not only with physical health but also with mental and social health. It may not be easy to improve IADL by merely incorporating good mobility functioning without environmental contextual factors, personal contextual factors, and intact cognition.

We also noted that difficulty with shopping was the most common in the IADL tasks in our study population. Everyone needs to shop for essential groceries and other household goods. However, when a person's mobility decreases, this essential activity becomes a significant problem (43). This is when shopping services for the elderly become a vital part of living. The city our participants resided is a densely populated city with a relative lack of age-friendly shopping facilities. It was not surprising that elderly individuals might encounter restrictions related to shopping.

The PPEB score in our study population was slightly higher than that found in Korean community-dwelling elderly (3.21). (44). In a comparison of each item, the Korean community-dwelling elderly had higher scores for design of home (0.52), surroundings (0.96) and natural environment (0.73) and lower scores in technology (0.73), and design of community (0.29) (44). Policymakers might need to pay more attention to

Table 2
Comparison of the PPEB score of CHIEF-CET according to gender, education, living arrangement, and financial status

	PPEB score of CHIEF-CET			
	N	**Mean**	**SD**	**p**
Gender				
Female	115	3.2	3.7	0.46
Male	82	3.6	4.4	
Education				
Literate	148	3.0	3.9	0.037*
No formal education	49	4.4	4.2	
Living arrangements				
Live with spouse/children or others	166	3.1	3.9	0.047*
Live alone	31	4.8	4.3	
Financial status				
Non-lower-ranking family	165	3.2	4.0	0.36
Lower-ranking family	32	3.9	3.9	

*<.05

Table 3
Correlations of the PPEB score of CHIEF-CET with the frequency and magnitude domain of each item (including design of home, design of community, natural environment, surroundings, and technology)

		PPEB score of CHIEF-CET (N=197)
		ϱ
Design of home		
	Frequency domain	.724**
	Magnitude domain	.653**
Design of community		
	Frequency domain	.833**
	Magnitude domain	.776**
Natural environment		
	Frequency domain	.760**
	Magnitude domain	.733**
Surroundings		
	Frequency domain	.813**
	Magnitude domain	.736**
Technology		
	Frequency domain	.798**
	Magnitude domain	.751**

**<.01

technology and design of community to improve the perceived physical environment barriers in community-dwelling elderly in Taiwan.

Table 4
Correlations of the PPEB score for the CHIEF-CET with age/self-rated health/the BADL score for the HCR/the IADL score for the HCR/TUG time

	PPEB score of CHIEF-CET (N=197)
	ρ
Age	.317**
Self-rated health	-.349**
TUG time	.540**
BADL score of HCR	.402**
IADL score of HCR	.585**

**<.01

Among the five subscales, the subscale related to technology had the highest score in our study population (Table 1). Limitations related to activities of daily living have been shown to moderate the relationship between internet use and depression (45). In the elderly, poor self-reported health status has been associated with depression (46). On the contrary, technology use, such as use of the Internet, has been found to reduce the probability of depression in retired elderly (47). Depression and poor self-rated health have been identified as the risk factors for the development of functional limitations (48). Thus, intervention programs aimed at facilitating technology use should be able to protect against mobility limitation and dependence related to instrumental activities of daily living in community-dwelling elderly directly or through some intermediate factors, such as depression and self-rated health, among others.

Exercise has some benefits in frail elderly individuals without frank disabilities although uncertainty still exists with regard to which exercise characteristics (type, frequency, duration) are most effective (49). According to our study, perceived physical environment barriers were found to have significantly positive correlations with the TUG time and the IADL score for the HCR. Strategies targeting the enhancement of mobility among community-dwelling elderly are suggested to lead to improved perceived physical environment. However, because of the higher slope of TUG time in the regression model in the community-dwelling elderly, which were independent in all IADL tasks, this beneficial effect could be greater in elderly individuals with better IADL function.

Study limitations

There were some limitations in this study. First, because this was a cross-sectional study, a causal effect of mobility, activities of daily living and perceived physical environment barriers cannot be claimed. Future research involving

Table 5
Hierarchical regression predicting the PPEB score for the CHIEF-CET as a function of demographic factors, self-rated health, the TUG time, the BADL score for the HCR, and the IADL score for the HCR

	Step 1	**Step 2**	**Step 3**						
	R	**Adjusted R^2**	**β**	**R**	**Adjusted R^2**	**β**	**R**	**Adjusted R^2**	**β**
	.459	.182		.471	.189		.512	.223	
Age			.037			.037			.034
Gender			.075			.077			.071
Education			-.037			-.003			.024
Living arrangement			-.056			-.059			-.032
Financial status			.075			.063			.074
Self-rated health			-.154			-.146			-.065
TUG time			.317**			.234*			.300*
BADL score						.145			.011
IADL score									.322*
The interaction between the TUG time and the IADL score									-.211*

*p<.05; **p<.01

longitudinal studies of mobility, activities of daily living and perceived physical environment are warranted. In this study, we assumed environmental barriers to be a dependent variable and treated mobility and ADL as independent variables. However, the relationship between them may be bi-directional. This means if we remove the barriers in the daily environment through providing an assistance device (a cane or computer training), this may improve their TUG and IADL scores. The associations between mobility, activities of daily living, and environment need further longitudinal studies intended to investigate the possible causations among them.

Next, this study was based on 197 subjects from two community service centers. The relatively small population size and relatively acceptable mobility function might have limited the statistical power of the detected associations in the regression model, such as the BADL. In this study, we also measured mobility using the TUG test, which has been used extensively in geriatric medicine to examine balance, gait speed, and the functional ability that is required for the performance of basic activities of daily living in older adults [50]. Third, a limited number of variables were included in the model because of the relatively small sample size and the foundational nature of the study. Future research considering background related to major health conditions, such as diseases, records of visits to outpatient clinics for treatment, as well as physical activity, important medications, activity and participation, and environmental and personal contextual factors are warranted.

Finally, the generalizability of the findings is limited to community-dwelling elderly residing in similar geographic and physical environments to that of the sample in this study. It might be difficult to justify generalizing the results of this study for the entire population of Taiwan without any further information. Because these two communities are ordinary urban communities in Taiwan, the results may be applicable to other urban communities in Taiwan. Therefore, the results are still valuable for researchers and policy makers in Taiwan.

Conclusions

Mobility, IADL and the interaction of mobility and IADL were found to be significant determinants of perceived physical environment barriers in the community-dwelling elderly individuals in this study, after controlling for possible confounding factors. Strategies targeting the enhancement of mobility among community-dwelling elderly individuals are suggested to lead to improvements related to perceived physical environment barriers. This beneficial effect could be greater for elderly individuals with better IADL function.

Competing interests: The authors declare that they have no competing interests.

Authors' contributions: All six authors have substantially contributed to the study. WCL, JHC, NWG, YCL, PCH and TSK designed the present study. WCL and TSK enrolled the subjects, extracted the data, performed the statistical analysis, and wrote the original draft. All six authors revised the draft critically and gave final approval of the version to be published.

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Ethics: The study complies with the current laws of Taiwan. Written informed consent statement forms were obtained from the respondents. The right to withdraw and autonomy of the respondents were explained. The study received ethical permission from the Institute Review Board of the National Cheng-Kung University Hospital, College of Medicine, National Cheng Kung University (Approval No.: B-ER-101-184).

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