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ORIGINAL REPORT

MEASURING ENVIRONMENTAL BARRIERS FACED BY INDIVIDUALS LIVING WITH STROKE: DEVELOPMENT AND VALIDATION OF THE CHINESE VERSION OF THE CRAIG HOSPITAL INVENTORY OF ENVIRONMENTAL FACTORS

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Objective: **To develop and validate a Chinese version of the Craig Hospital Inventory of Environmental Factors.**
Design: **Descriptive case-series.**
Subjects: **A total of 107 individuals with chronic stroke and 56 age-matched healthy subjects.**
Methods: **The English version of the 25-item Craig Hospital Inventory of Environmental Factors was translated into Chinese using standardized procedures, and then administered to both the stroke and control groups. The same questionnaire was administered again to the stroke group 1–2 weeks after the first session.**
Results: **The Craig Hospital Inventory of Environmental Factors had good internal consistency (Cronbach's alpha = 0.916) and test-retest reliability (intra-class correlation coefficient = 0.845). It also had significant association with Personal Wellbeing Index (r_s = –0.379, p = 0.001) but not with Fugl-Meyer Assessment upper limb (r_s = –0.107, p = 0.320) and lower limb motor scores (r_s = –0.032, p = 0.768) among stroke subjects, thus demonstrating convergent and discriminant validity, respectively. The mean Craig Hospital Inventory of Environmental Factors score in the stroke group was also significantly higher than that in controls (p = 0.020), thus showing good known-groups validity.**
Conclusion: **The Chinese version of the Craig Hospital Inventory of Environmental Factors is a reliable and valid tool for evaluating the perceived environmental barriers experienced by people with chronic stroke.**

Key words: cerebrovascular accident; community; environmental factors; participation; quality of life; chronic stroke.

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INTRODUCTION

Stroke is a major public health problem and cause of long-term disability (1). The sudden onset of disability following a stroke event may disrupt the continuity of an individual's life experience (2). Individuals with stroke often experience limitations in participation in community activities (3–6). According to the International Classification of Functioning, Disability and Health (ICF) developed by the World Health Organization (WHO) (7), the interaction between the individual and the environment can play a key role in determining the level of participation in society (8, 9).

To obtain a clearer understanding of environmental barriers faced by patients after stroke and to better assess the effect of intervention programmes, a standardized assessment of environmental factors is essential. Several measures have been developed to quantify environmental facilitators (i.e. factors that increase participation) or barriers (i.e. factors that reduce participation) in people with disabilities, such as the 84-item Measure of the Quality of the Environment (MQE) (6, 10) and the 61-item Facilitators and Barriers Survey (FABS) (11). However, these questionnaires are quite lengthy and require a long period of time for completion, which may not be feasible in daily clinical practice, particularly in community rehabilitation settings where the patient to therapist ratio is often high. Moreover, the MQE does not address the frequency of encountering environmental obstacles (10, 12). The FABS, on the other hand, has shown only low to moderate internal consistency and test-retest reliability (11).

Another measure of environmental factors is the ICF Core Set for Stroke, which was originally developed to define the spectrum of problems in different aspects of functioning in patients with stroke (13–15). The extended version consists of 37 categories pertaining to the component environmental factors. The inter-rater reliability of the Core Set, however, was found to be only moderate (kappa = 0.41) when used in patients with stroke (15).

The 25-item Craig Hospital Inventory of Environmental Factors (CHIEF) (16) is a common tool used to assess environmental barriers (Table I). It has demonstrated good psychometric properties in samples of people with and without disabilities (17). CHIEF addresses both the frequency and severity of the environmental barriers encountered, and covers different domains (i.e. physical, attitudinal, service, productivity, and policy) of barriers that hinder people from doing what they need and want to do. CHIEF also takes less time to administer compared with MQE and FABS. A short

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Table I. *Items in the Craig Hospital Inventory of Environmental Factors (CHIEF) questionnaire*

Item	Question
1	Transportation[a]
2	Design home
3	Design work
4	Design community
5	Natural environment[a]
6	Surroundings[a]
7	Information[a]
8	Education/training
9	Medical care[a]
10	Equipment
11	Technology
12	Help home[a]
13	Help work[a]
14	Help community
15	Attitudes home[a]
16	Attitudes work[a]
17	Attitudes community
18	Support home
19	Support work
20	Support community
21	Discrimination[a]
22	Services community
23	Policies business[a]
24	Education/employment policies
25	Government policies[a]

[a]Items included also in the short-form.

form containing 12 items is also available (18). The objectives of the study were to develop a Chinese version of CHIEF and to establish its reliability and validity when used in stroke patients of Chinese origin.

MATERIAL AND METHODS

Sample size calculation

A previous study showed that environmental factors (measured by MQE) were significantly associated with participation level (measured by the Assessment of Life Habits or LIFE-H), with a medium effect size (6). We expected a similar effect size when CHIEF scores were correlated with personal wellbeing. Based on correlation analysis, the minimum sample size required for the study was 82 individuals with stroke ($\alpha = 0.05$, power = 0.8, effect size = 0.3 (medium)).

In addition, a previous study has shown that the stroke group has lower level of community reintegration than controls, with a large effect size (19). We thus expected a similar between-group difference in environmental factors. A minimum sample size of 26 control subjects was required to detect a significant between-group difference in CHIEF scores ($\alpha = 0.05$, power = 0.8, effect size = 0.8).

Subjects

A convenience sample of people with stroke was recruited from stroke self-help groups in the local communities. The inclusion criteria were: (*i*) a diagnosis of stroke, (*ii*) time since stroke onset of 1 year or longer (i.e. chronic stroke), (*iii*) aged 18 years or above, (*iv*) no significant cognitive deficits (Abbreviated Mental Test score ≥ 6), (*v*) community-dwelling, (*vi*) had lived in Hong Kong for at least 1 year at the time of data collection, and (*vii*) discharged home from the hospital at least 6 months previously. The exclusion criteria were: (*i*) living in nursing homes, (*ii*) receptive or expressive aphasia, (*iii*) other neurological conditions in addition to stroke, and (*iv*) other serious illnesses that precluded participation.

A convenience sample of age-matched non-disabled controls was also recruited from the local community centres for elderly people and an existing database of non-disabled individuals who had enrolled in previous studies of the research group. The inclusion and exclusion criteria were the same as those for the stroke group except for the history of stroke. Ethical approval was granted by the Ethics Review Committee of Hong Kong Polytechnic University. The study procedures were thoroughly explained to each participant by a research team member. Informed, written consent was obtained from each participant before the study began. The study was conducted in accordance with the Declaration of Helsinki.

A total of 208 individuals (152 people with stroke, and 56 controls) volunteered for the study and were screened to determine whether they met the eligibility criteria through a telephone interview. Of these, 107 individuals with stroke and 56 controls fulfilled all eligibility criteria and were enrolled in the study. For those individuals who were deemed eligible, a face-to-face interview was conducted in order to obtain the relevant information (e.g. medical history, mobility status). We acknowledged that the final sample size was greater than the estimated sample size derived from our power calculation. The power calculation only provided us with the minimum sample size required to yield significant results. During the subject recruitment period, a large number of people expressed interest in our study. We decided to allow the eligible individuals to participate in the study, even after the estimated sample size was reached, for two reasons. First, the budget and manpower allocated for the project was adequate for us to handle a study sample of more than 150 people. Secondly, having a larger sample size would further increase the statistical power.

Cultural adaptation of Craig Hospital Inventory of Enviromental Factors

CHIEF is designed to identify the barriers in 5 major dimensions of the environment that may impede participation by people with disability, namely: accessibility, accommodation, resource availability, social support, and equality. It provides a characterization of the severity of perceived barriers to social participation based on self-report. Each item was rated based on two scales. First, a frequency score on a 5-point scale (0: never, 1: less than monthly, 2: monthly, 3: weekly, 4: daily) was used to indicate the frequency with which barriers were encountered. Secondly, a magnitude score on a 3-point scale (0: no problem, 1: little problem, 2: big problem) was used to denote the extent of the problem a 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 barrier. The frequency by magnitude product score of different individual items were summed and then averaged to yield 5 subscale scores (Physical/Structural, Attitudes/Support, Services/Assistance, Work/School, and Policies) and total CHIEF score. A higher CHIEF score indicates a greater impact of environmental barriers.

Permission was obtained from the original authors of CHIEF before the initiation of the translation process. The cultural adaptation process was conducted in accordance with the standardized procedures outlined by Beaton et al. (20). The first stage involved the forward translation of the English version of the CHIEF into Chinese by two bilingual translators whose mother language is Chinese. One of these translators is a physiotherapist, who may provide a more clinical perspective (20). The other translator is a professionally trained translator with no clinical background. As this translator has no prior knowledge of the concepts being measured by CHIEF (i.e. naive translator), she may be more likely to detect ambiguity in the original questionnaire and generate a translated questionnaire that is free of jargon (20). Each of these 2 translators independently generated a Chinese version of the original CHIEF.

In the second stage, the two Chinese versions of CHIEF produced in the first stage and the original CHIEF were examined by the same two translators, and the results were then merged to generate a single Chinese version of the CHIEF. In the third stage, two different individuals independently translated the Chinese version of CHIEF back into English (i.e. backward translation). These two translators, with physiotherapy and psychology backgrounds respectively, were blinded to the original CHIEF in order to avoid bias in the backward translation process (20). Amendments to the translated Chinese version were made if any inconsistencies were found.

In the fourth stage, a validation committee was formed. The committee consists of 4 individuals (a social worker, a clinical researcher, and two physiotherapists), who are competent in both Chinese and English. The committee examined the preliminary version of the translated questionnaire in 4 areas of equivalence, namely, experiential, semantic, idiomatic, and conceptual (20), and made revisions as necessary. Next, 5 community-dwelling individuals with stroke who were naive to the CHIEF questionnaire were invited to participate in pilot testing of the revised version of the questionnaire and provide feedback on the translated questionnaire. Minor changes to the questionnaire were made to yield the final Chinese version of CHIEF (CHIEF-C).

Data gathering

In the first recording session, a trained interviewer administered the CHIEF-C to all participants in both the stroke and control groups. The CHIEF-C was administered by interview in person rather than by telephone, because conducting the interview face-to-face would ensure that the questions were answered by the participants themselves, rather than someone else (e.g. family members, friends). The self-administration method was not used either, because it would not allow for any opportunity to clarify misinterpretations if there was misunderstanding of questions or response choices (21). This was important, especially considering that a substantial proportion of our subjects had received no school education (Table II). In addition, incomplete or incorrectly filled out questionnaires would also be a potential concern, if CHIEF-C was self-administered (21).

If the individual were not working or attending school, the items in the School/Work subscale were recorded as "not applicable" and re-coded as "0" for both frequency and magnitude scores for subsequent data analysis, as per the guidelines developed by the original developers of CHIEF (17). Within 1–2 weeks after the first assessment session, the same interviewer re-administered the CHIEF-C to the stroke group, in order to establish test-retest reliability.

To evaluate the construct validity of the CHIEF-C, one could assess how it relates to other tests of the similar and different constructs (21). In convergent validity, two measures believed to assess similar traits should yield a good correlation. To assess convergent validity, the validated Chinese version of the Personal Wellbeing Index (PWI) was also administered to the stroke group in the first recording session and the results were then correlated with the CHIEF-C scores (21). It is well known that the environment is a major domain of wellbeing or quality of life (22). We postulated that PWI, being a measure of wellbeing, would show a significant correlation with CHIEF-C. The PWI contains 7 items and is a generic measure of subjective wellbeing (23). Each item was rated on an 11-point scale (ranging from 0 to10). The scores for each item were multiplied by a factor of 10, and then summed and averaged to yield a mean PWI score (23).

On the other hand, in discriminant validity, two measures that assess different phenomena should yield low correlation (21). To assess discriminant validity, the Fugl-Meyer Motor Assessment (FMA) (24), a measure believed to assess a different attribute compared with CHIEF-C, was administered to the stroke group in the first recording session, and the results were then correlated with the CHIEF-C scores. We postulated that FMA score would show a low correlation with CHIEF-C. The 50-item FMA was used to assess the level of motor recovery in the hemiparetic upper and lower extremity. A score of 0–2 was given to each item (0 = no performance, 1 = partial performance, 2 = complete performance). The scores for individual items were summed to yield an upper extremity (maximum: 66) and lower extremity motor score (maximum: 34). FMA has demonstrated excellent intra-rater ($r = 0.995$–0.996) and inter-rater reliability ($r = 0.89$–0.95) (24, 25).

Statistical analysis

All of the statistical analyses were performed using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). A significance level of 0.05 was set for all analyses. For the CHIEF-C scores, the median and interquartile range were presented. The mean and standard deviation (SD) were also presented because they are commonly used in the literature.

The internal consistency of the CHIEF-C was assessed by Cronbach's alpha using the data obtained from the stroke group. The test-retest reliability of CHIEF-C subscale and total scores were tested by the intraclass correlation coefficients ($ICC_{3,1}$) (21).

The minimal detectable difference (MDD) value of the CHIEF-C total score was estimated using the following formula (21):

$MDD = 1.96 \times SEM \times \sqrt{2}$,

where SEM is the standard error of measurement.

SEM of the CHIEF-C subscale and total scores were calculated using the following formula (21):

$SEM = Sx \sqrt{(1 - rxx)}$,

where Sx is the standard deviation, and rxx is the reliability coefficient.

To assess construct validity (i.e. convergence and discrimination), we used Spearmans' rank correlation coefficient to determine the degree of association of the CHIEF-C total scores with the PWI and FMA motor scores. The CHIEF scores were compared between the stroke and control groups using Mann-Whitney *U* test to establish known-groups validity. To further explore the clinical correlates of

Table II. *Subject characteristics*

Variable	Stroke group ($n = 107$)	Control group ($n = 56$)
Basic demographics		
Age, years, mean (SD)	62.6 (11.6)	64.0 (11.9)
Sex, men/women, *n*	68/39	31/25
Education, none/elementary/secondary/post-secondary, *n*	16/43/40/7	10/18/23/5
Marital status, single/married/divorced/widowed, *n*	9/79/8/11	3/48/2/3
Living situation, living alone/living with someone, but usually alone/living with someone and rarely alone throughout the day, *n*	15/31/61	6/45/5
Use of walking aid required in outdoor environment, *n*	42	0
Number of co-morbid conditions, median (range)	2 (0–7)	0 (0–5)
Number of medications, median (range)	3 (0–15)	0 (0–10)
Stroke characteristics		
Number of subjects with recurrent stroke, *n*	28	
Duration since first stroke, years, mean (SD)	4.6 (4.3)	
Type of stroke, haemorrhagic/ischaemic/unknown, *n*	36/65/7	
Side of paresis, left/right, *n*	47/60	

SD: standard deviation.

CHIEF scores in stroke patients, we used Spearman's rank correlation coefficient to examine the degree of association between the CHIEF-C total scores and other relevant demographic variables (e.g. age, post-stroke duration). All of the above analyses were repeated for the 12 items included in the short form of the questionnaire.

RESULTS

Participant characteristics

The characteristics of the participants are described in Table II. The median and mean CHIEF-C score of the stroke group was 0.24 and 0.51, respectively (interquartile range = 0.52; SD = 0.64). On average, the motor impairment level of the hemiparetic upper and lower limb was moderate, as reflected by the FMA motor score (mean = 65.6, SD = 24.0). Among the various demographic variables measured, a higher CHIEF-C score was significantly correlated with younger age ($r_s = –0.259$, $p = 0.007$). Living alone was also associated with higher CHIEF-C score ($r_s = –0.218$, $p = 0.027$).

Reliability

The internal consistency of the CHIEF-C long form was excellent (Cronbach's $\alpha = 0.916$). Seventy-one of the 107 individuals with stroke participated in a second assessment session, in which the CHIEF-C was administered again for establishing test-retest reliability. Comparison of the scores obtained in the first and second recording sessions revealed moderate to good test-retest reliability, with $ICC_{3,1}$ values ranging from 0.669 to 0.793 for the 5 subscale scores, and 0.845 for the total score (Table III). The level of agreement for all subscale and total scores between the two sessions was above that expected by chance ($p < 0.005$). The MDD value for the CHIEF-C total score was 0.69.

When only the 12 items included in the short form were analysed, the internal consistency remained high (Cronbach's $\alpha = 0.889$). The test-retest reliability was slightly decreased when the short form was used, with $ICC_{3,1}$ values varying from 0.595 to 0.774 for the subscale and 0.800 for the total scores (Table III). The MDD of the total score was slightly increased, to 0.87, if the short form was used.

Validity

When all items were analysed, the CHIEF-C total score showed a significant moderate correlation with PWI score ($r_s = –0.379$, $p = 0.001$), thus demonstrating convergent validity. No significant correlation wad found, however, between CHIEF-C total score and FMA upper limb ($r_s = –0.107$, $p = 0.320$) and lower limb motor scores ($r_s = –0.032$, $p = 0.768$) (i.e. discriminant validity). The CHIEF-C scores obtained from the stroke group were then compared with those from the control group ($n = 56$, mean age = 64.0 years, SD = 11.9 years). The CHIEF-C total score ($p = 0.020$), Services/Assistance ($p = 0.034$) and Physical/Structural ($p = 0.040$) subscale scores were significantly higher in the stroke group than controls (Table IV).

When only the items contained in the short form were analysed, the results were similar. The CHIEF-C total score remained significantly associated with the PWI score ($r_s = –0.334$, $p = 0.004$), but not with the FMA upper limb ($r_s = –0.077$, $p = 0.473$) and lower limb motor scores ($r_s = –0.027$, $p = 0.803$). When compared with controls, the stroke group had significantly higher ratings in the CHIEF-C total score ($p = 0.001$) and subscale scores ($p < 0.05$), except the Policies ($p = 0.128$), and Work/School subscales ($p = 0.325$) (Table IV).

DISCUSSION

In this study, a cultural adaptation of the CHIEF questionnaire was performed to facilitate measurement of environmental barriers among Chinese individuals with chronic stroke. The results showed that the CHIEF-C has good psychometric properties when used in the Chinese stroke population in Hong Kong.

Table III. *Test-retest reliability of the Chinese version of the Craig Hospital Inventory of Environmental Factors (CHIEF-C) scores in the stroke group (*n = 71*)*

	CHIEF-Time 1		CHIEF-Time 2			
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	$ICC^{3,1}$	*p*-value
Long-form						
Subscale						
Policies	0.58 (1.03)	0.00 (1.00)	0.55 (1.09)	0.00 (0.50)	0.686	< 0.001
Physical/structural	0.66 (0.84)	0.33 (1.00)	0.80 (1.12)	0.33 (1.00)	0.708	< 0.001
Work/school	0.15 (0.38)	0.00 (0.00)	0.14 (0.40)	0.00 (0.00)	0.672	< 0.001
Attitudes/support	0.44 (0.78)	0.20 (0.60)	0.41 (0.67)	0.20 (0.00)	0.793	< 0.001
Services/assistance	0.53 (0.65)	0.29 (0.71)	0.50 (0.79)	0.14 (0.57)	0.669	< 0.001
Total	0.51 (0.57)	0.28 (0.56)	0.52 (0.69)	0.28 (0.60)	0.845	< 0.001
Short-form						
Policies	0.73 (1.31)	0.00 (1.00)	0.77 (1.43)	0.00 (1.00)	0.595	< 0.001
Physical/structural	0.93 (1.27)	0.50 (1.50)	1. 20 (1.61)	0.50 (2.00)	0.697	< 0.001
Work/school	0.18 (0.49)	0.00 (0.00)	0.18 (0.53)	0.00 (0.00)	0.515	< 0.001
Attitudes/support	0.58 (1.03)	0.00 (1.00)	0.58 (0.95)	0.00 (1.00)	0.689	< 0.001
Services/assistance	0.67 (0.88)	0.00 (1.00)	0.78 (1.00)	0.25 (0.75)	0.774	< 0.001
Total	0.63 (0.70)	0.33 (0.84)	0.66 (0.84)	0.42 (0.92)	0.800	< 0.001

ICC: intraclass correlation coefficient; IQR: interquartile range.

Table IV. *Comparison of the Chinese version of the Craig Hospital Inventory of Environmental Factors (CHIEF-C) scores between the stroke and control groups*

	Stroke ($n=107$)		Control ($n=56$)		
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	p-value
Long-form					
Subscale					
Policies	0.49 (0.98)	0.00 (0.50)	0.25 (0.75)	0.00 (0.00)	0.183
Physical/structural	0.72 (0.93)	0.33 (1.00)	0.43 (0.59)	0.17 (0.79)	0.040*
Work/school	0.11 (0.33)	0.00 (0.00)	0.17 (0.58)	0.00 (0.00)	0.432
Attitudes/support	0.47(0.84)	0.20 (0.60)	0.29 (0.49)	0.00 (0.40)	0.065
Services/assistance	0.55 (0.78)	0.29 (0.86)	0.30 (0.41)	0.14 (0.57)	0.034*
Total	0.51 (0.64)	0.24 (0.52)	0.31 (0.36)	0.16 (0.43)	0.020*
Short-form					
Subscale					
Policies	0.59 (1.24)	0.00 (0.50)	0.23 (0.77)	0.00 (0.00)	0. 128
Physical/structural	1.10 (1.41)	0.50 (1.50)	0.49 (1.26)	0.00 (0.50)	0.001*
Work/school	0.12 (0.41)	0.00 (0.00)	0.17 (0.48)	0.00 (0.00)	0.325
Attitudes/support	0.64 (1.12)	0.00 (1.00)	0.27 (0.57)	0.00 (0.38)	0.009*
Services/assistance	0.70 (0.94)	0.25 (1.00)	0.39 (0.59)	0.00 (0.69)	0.042*
Total	0.64 (0.73)	0.42 (0.75)	0.32 (0.43)	0.13 (0.50)	0.001*

*Significant between-group difference ($p<0.05$).
SD: standard deviation; IQR: interquartile range.

Environmental barriers faced by individuals with stroke

The mean CHIEF-C total score obtained from the stroke group was 0.51, which is quite comparable to the CHIEF total score previously reported in people with traumatic brain injury (mean = 0.89), but slightly lower than people with spinal cord injury (mean = 1.25) (17). Among the 5 subscales, the Physical/Structural subscale shows the highest score, just as in patients with spinal cord injury and traumatic brain injury (17). In Hong Kong, which is an extremely densely populated city, characterized by heavy traffic, crowded public places and relative lack of wheelchair accessible buildings and facilities, it is not surprising that individuals living with residual stroke impairments may encounter some physical environmental barriers that restrict their social participation.

Previous studies have found a higher impact of environmental factors than ours. For example, using the ICF Core Set for Stroke, Algurén et al. (13) showed that approximately half of the stroke patients reported "physical geography" as a barrier to participation. Approximately 24% of the sample also perceived "transportation services, systems and policies" as a barrier. In Rochette et al. (6), various environmental factors (e.g. governmental and public services, physical environmental and accessibility, equal opportunity and political orientations) were identified to be moderate environmental barriers (MQE score at approximately 2 out of 3) by their chronic stroke patients. The difference in the instruments used may partly account for the difference in results. Firstly, the number of items in CHIEF was less than MQE (84 items) and ICF Core Set (37 items). Secondly, the difference in structure of individual test items may have an impact on the results. In MQE and ICF Core Set for Stroke, each environmental factor can be rated as a facilitator or barrier on a 7-point scale (–3: major obstacle, 0: no influence, +3: major facilitator), and a 9-point scale (–4: complete barrier; 0: no barrier or facilitator; +4: complete facilitator), respectively (6, 10, 13–15). The frequency of encountering environmental obstacles was not considered in these instruments. In contrast, CHIEF only measures environmental barriers, but not facilitators. The computation of CHIEF score was based on both the size of the problem that a barrier presented and the frequency with which the barrier was encountered. Thirdly, the difference in structure of the questionnaires as a whole may also contribute to the difference in findings. For example, in the ICF Core Set for Stroke, a more substantial proportion of items (total of 7) is devoted to the domain of attitudes (i.e. individual attitudes of health professionals, friends, immediate family members, personal care providers, acquaintances, etc.), whereas in CHIEF, only 3 items are used to measure attitudinal barriers in different settings (home, work, community).

The discordance in results may also be due to the difference in subject characteristics. Our stroke group is substantially more chronic (mean post-stroke duration = 4.6 years) than that in previous studies (3–6 months post-stroke) and may thus have better adjusted to the restrictions imposed by the environmental barriers (6, 13). Another explanation of the relatively modest CHIEF score may be related to the fairly good level of mobility demonstrated by our subjects, with 39% of individuals with stroke being able to walk without any walking aids (Table II). Last, but not least, how the environmental barriers were perceived may be substantially influenced by the difference in culture.

It is intriguing that younger age was associated with more perceived environmental barriers in the stroke group. Further examination of the data revealed that younger age was significantly associated with less co-morbid conditions ($r_s=0.384$, $p<0.001$). The proportion of walking aid users among stroke patients younger than the age of 65 years was also significantly lower than their older counterparts. Thus, a potential explanation of the inverse relationship between age and environmental barriers is that the younger stroke survivors may be more inclined to go out and participate in community activities due to their better general health condition and mobility level. However, the more frequent participation in community activities also inevitably leads to more frequent encounters with potential environmental barriers, compared with those who choose to stay at home. Another possible explanation is that the younger individuals living with stroke may compare their level of activity and participation with their non-disabled peers of a similar age, and thus set a higher expectation for themselves, which may in turn contribute to the higher level of perceived environmental barriers.

It was found that the stroke survivors who were living alone tended to have a higher degree of perceived environmental barriers. This is consistent with the results of a previous stroke study in showing that living alone was associated with a lower level of satisfaction with community reintegration (19). Community support thus becomes even more important for these individuals who have less family support. The coordination of patient care after hospital discharge should ensure that these individuals have access to community resources.

Reliability

The Cronbach's α value (0.916) and test-retest reliability reported here (ICC = 0.845) are similar to what was previously reported by the original authors of CHIEF (Cronbach's $\alpha = 0.930$, ICC = 0.926) (16, 17). However, their data were collected from mixed samples of individuals with and without disability (spinal cord injury, traumatic brain injury and others). Our study is the only one that assesses the reliability of the CHIEF in the stroke population, and the results demonstrate good reliability. This study also yields the MDD value (0.69), which represents the smallest difference that would reflect a real change in the CHIEF-C score (21). The MDD value found here would be useful in determining whether the experimental intervention has caused any real difference in perceived environmental barriers in future stroke intervention trials.

Validity

The results showed that CHIEF-C total score was significantly associated with PWI scores, but not with FMA motor scores, thus demonstrating good construct validity. Specifically, higher CHIEF-C scores (more perceived environmental barriers) were significantly associated with lower PWI scores (less personal wellbeing). The negative impact of environmental barriers on wellbeing has also been demonstrated in other patient groups. For example, Whitneck et al. (26) found that the CHIEF total score was significantly associated with the Satisfaction with Life Scale score ($r_s = -0.39$, $p < 0.05$) in patients with traumatic brain injury. It is also interesting that the FMA motor scores are not significantly associated with the CHIEF-C scores, confirming that FMA and CHIEF-C measure different phenomena (i.e. discriminant validity). The former is a measure of physical impairment, whereas the latter is a measure of environmental factors. Our finding is also in line with the study by Whitneck et al. (26), which found that CHIEF score was not significantly related to physical independence ($r_s = -0.11$) in patients with traumatic brain injury. Taken together, the findings suggest that more severe bodily impairment does not necessarily translate into more perceived environmental barriers.

When the CHIEF-C scores from the stroke group were compared with the control group, significant between-group differences were found in the total scores and most subscale scores, thus indicating good known-groups validity. The Work/School subscale score did not demonstrate any significant between-group difference, however (Table IV). This is probably due to the fact that, in our study, 93 out of 107 individuals in the stroke group were not working or attending school at the time of data collection and therefore they chose "not applicable" for the items in the Work/School subscale. We used the established guidelines described by original authors of CHIEF (17) to re-code the items in the Work/School subscale to zero for both frequency and magnitude, indicating "no environmental barrier". This may account for the lack of difference in Work/School subscale score between the two groups. The Attitude/Support subscale showed a significant between-group difference in the short form version, but not in the long form version. When analysing this subscale in more detail, it was found that item 18 (Support in home), which exists only in the long form version, did not show a significant between-group difference. The results may indicate that overall, the participants in the stroke group perceived that they had received adequate support and encouragement from others at home. As aforementioned, those who were living alone tended to have a higher level of perceived environmental barrier. However, these individuals only constitute 14% of our sample (Table II).

Long form vs short form

Overall, regardless of whether the items for the long form or short form were used for analysis, similar results were generated. The internal consistency values were good for both versions (Cronbach's α > 0.85). Although a slight decrease in test-retest reliability was detected in a few subscales if only the items of the short form were analysed, the overall test-retest reliability of the scale was largely unaffected (ICC values close to 0.9). Convergent, discriminant and known-groups validities remained well established when the short form was used. The CHIEF short form is thus a reasonable alternative if time constraints do not allow administration of the long form.

Limitations and future research directions

This study has several limitations. First, CHIEF only assesses the environmental barriers, and not the facilitators, whereas conceptual models of disability suggest that the environment can act as a facilitator and as a barrier to participation (27). Further research is needed to compare measures such as the CHIEF, that focus on barriers, with those such as the MQE, that also consider the positive aspects of the environment when used in the stroke population.

Secondly, CHIEF assesses only subjective perceptions of the impact of environmental barriers. The relation between the perceived and actual barriers is uncertain (16). More study is required to examine the relationship between individual perceptions and more objective community assessments.

Thirdly, subject-proxy agreement was not evaluated. A moderate subject-proxy agreement (ICC = 0.618) was found in the original CHIEF, using a mixed sample of people with and without disabilities (17). Future research should address the subject-proxy agreement of the CHIEF-C.

Finally, the participants in this study had a fairly good level of mobility, which may affect the generalizability of the results. However, in Hong Kong, those with severe disability after stroke are likely to be institutionalized. Thus, our sample is quite a good representation of community-dwelling people living with chronic stroke in the local context.

Conclusion

The CHIEF-C is a reliable and valid tool for evaluating the environmental barriers experienced by people with chronic stroke. The CHIEF-C short form is a reasonable alternative if administering the long form is not feasible due to time constraints.

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