 Occupational Therapy International, **12**(1), 44-59, 2005

Changes in accessibility and usability in housing: An exploration of the housing adaptation process

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ABSTRACT: The purpose of a housing adaptation is to enhance daily activities and to improve housing accessibility and usability by removing physical barriers in the home. The aim of this study was to investigate longitudinal changes in housing accessibility among clients receiving grants for housing adaptations. Baseline assessments were administered one month before the housing adaptation, with the first follow-up after two to three months, and the second follow-up after eight to nine months. The Housing Enabler and the Usability in My Home instruments were used to collect data from 131 consecutively enrolled clients living in general housing. Accessibility and usability improved significantly, the number of physical environmental barriers decreased and dependence on mobility devices increased, but at different times along the process. The results indicate the complexity of the housing adaptation process and the need to consider person–environment interactions over time. The methodology seems useful for quality development of assessment, intervention and evaluation processes in housing adaptations performed by occupational therapists.

Key words: housing accessibility, environmental barriers, housing adaptations

Introduction

Two of the major purposes of occupational therapists are to enable performance of activities of everyday living and to promote health and wellness (Canadian Association of Occupational Therapists, COAT, 1997), as well as community participation (World Health Organization, WHO, 2001). One common intervention within community-based occupational therapy is the adaptation of physical environments, e.g. in the house (CAOT, 1997, Law et al., 1996). Using the definition in current Swedish legislation (SFS, 1992:. 1574), a housing adaptation is an individually designed alteration of permanent physical features in the house and the immediate outdoor environment, in order to reduce the demands from the physical environment, and to enhance the performance of daily activities (Boverket, 2000).

Countries have different regulative frameworks for providing and financing housing adaptations, governing the type of adaptations provided. For example, according to current Swedish legislation (SFS, 1992: 1574), the full costs for a housing adaptation can be granted for preventive, rehabilitative or long-term care reasons. The client makes formal application for the grant, which is administered and financed by the municipalities. The need for a housing adaptation grant has to be certified by a professional, and in the majority of cases this is administered by the community occupational therapist. Consequently, even if a housing adaptation is administered under its own legislative framework, the intervention is often part of a rehabilitation process involving other interventions as well. The group of people receiving housing adaptation grants is diverse with elderly people constituting around 75% of the total (Boverket, 2003).

Research on housing adaptations is scarce, and in spite of considerable public costs (e.g. in Sweden €83m in 2002) (Boverket, 2003) only few evaluations have been conducted, focusing, for example, on functional status among frail elderly persons (Mann et al., 1999), or on the relationship between lung capacity and housing conditions among younger adults with asthma (Frisk et al., 2002). Furthermore, cross-sectional studies do not provide sufficient knowledge useful for describing rehabilitation processes over time, indicating that longitudinal evaluations are imperative in order to describe the direction, magnitude, and pace of change (Gitlin et al., 2001; Golant, 2003). However, longitudinal evaluations of housing adaptations have not been conducted, and to date systematic, research-based strategies for such evaluations are lacking.

In order to arrive at strategies useful for evaluation purposes, concepts reflecting the objectives of an intervention must be clearly delineated and operationalized. This study was based on conceptual definitions successively developed over more than 10 years of methodological development and empirical research on accessibility to the physical environment, integrating experiences from occupational therapy, traffic planning and engineering (Iwarsson and Ståhl, 2003). According to Iwarsson and Ståhl (2003), accessibility is a relative concept, describing the encounter between the individual's functional capacity and physical environmental barriers. That is, accessibility can be described by juxtaposing the person's functional capacity (personal component) with environmental barriers (environmental component). In accessibility the personal component is based on objective information on functional capacity, while the environmental component complies with official norms and standards for the physical environment, implying that accessibility is mainly objective in nature. Usability implies that a person should be able to move around in, be in and use the environment on equal terms with other individuals. As in accessibility, in usability, information on the person–environment encounter is imperative, but more important, there is a third component distinguishing usability from accessibility, i.e. the activity component. The three components of usability are the person, the environment, and the activity (P–E–A). The personal component can be expressed in terms of functional capacity of the individual (Iwarsson et al., 1998), his or her motivation, coping resources, adaptive strategies (Schultz and Heckhausen, 1997), roles, habits, interests (Kielhofner, 2002), etc. Even if the environmental component encompasses physical, social, and attitudinal aspects (WHO, 2001), for research on usability in housing this component reasonably can be delimited to the barriers in the physical housing environment and its close surroundings (Iwarsson, 2003). Finally, the activity component relates to the person's repertoire of activities, defined for the particular situation (CAOT, 1997; Fänge and Iwarsson, 2003), and its characteristics. When included in usability the three components are subjectively oriented and judged from a personal perspective, taking into account subjective evaluations and expressions. Further, usability is explicitly transactional in nature, implying that the components are less distinct and more interwoven than those of accessibility (Iwarsson and Ståhl, 2003).

For accessibility research, a feasible way to operationalize functional capacity (the personal component) is to identify functional limitations, i.e. restrictions in the person's ability to perform fundamental physical and mental actions in daily life (Nagi, 1991; Verbrugge and Jette, 1994). According to the terminology used in the current version of the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001), functional limitations are part of the activities and participation component. That is, the ICF component is very comprehensive and not suitable for the stringent operationalization of concepts necessary for accessibility research (Carlsson et al., 2002). Consequently, in this study the more specific definition of functional limitation given above (Verbrugge and Jette, 1994) is used. In order to arrive at as objective information as possible, functional limitations should be assessed from a professional perspective.

In concordance with current ICF terminology (WHO, 2001), the environmental component of accessibility can be operationalized as physical environmental barriers. These are based on official norms and guidelines for environmental design, and in terms of accessibility they should be assessed from a professional perspective (Iwarsson and Ståhl, 2003; Iwarsson and Slaug, 2001). However, for usability research the environmental component can be operationalized as physical environmental aspects reflecting the client's subjective evaluation of the environment. Given housing adaptation's focus on the removal of environmental barriers in relation to a specific client, in order to arrive at valid strategies for evaluations, the environmental component should be assessed both from the client and the professional perspective, that is, both subjectively and objectively.

In order to develop strategies useful for evaluation of housing adaptations, the aim of this study was to investigate longitudinal changes in housing accessibility, the personal and environmental components of accessibility, and physical environmental aspects of usability in a group of clients receiving housing adaptation grants.

Methods

Design

The methodology was organized into three phases: (1) baseline assessments (T1) were conducted up to one month before the housing adaptation, (2) first follow-up (T2) occurred two to three months after the adaptation was completed, and (3) the second follow-up (T3) was performed after eight to nine months.

Study district and sampling procedure

In order to reflect the variety of housing standards and conditions in different municipalities, a medium-sized south Swedish municipality with urban as well as sparsely populated rural areas was chosen for this study. At the time of data collection, the municipality had 74,400 inhabitants, and the demographic characteristics reflected other parts of the region. Annually around 770 housing adaptations were funded by the local municipality, the majority of them to persons staying in various care facilities at the time of application. In order to capture subjective experiences of problems related to person–environment (P–E) interactions in a valid way, the target population was restricted to persons who had been living at the current address for at least three months before the application for a housing adaptation grant. Excluded were terminally ill clients, clients who spent most of the day in bed/chair, and those with problems understanding written and oral information. Participants were consecutively enrolled over 18 months, and out of the 950 clients receiving housing adaptation grants during the time period, 158 fulfilled the inclusion criteria. The rest of the clients receiving housing adaptation grants in the municipality during the project period were staying at different care facilities at the time of application.

Study sample

Out of the 158 clients fulfilling the inclusion criteria, 17 declined to participate in the study. The major reason given was poor health. In all, 131 clients (83% of the target group; 88 women and 43 men, aged 24–93 years) agreed to participate. Of these, 104 clients participated at T2, and 96 at T3. Of the 35 clients not available for assessment at T3 nine had had their housing adaptations delayed so that more than one month had passed between T1 and the start of the housing adaptation, four were deceased, 18 declined further participation after T1 or T2, one was in hospital, and two were lost to follow up. There were significantly more men among the 35 clients not assessed at T3 compared to the group of 96 clients who were assessed at T3 (Chi-Square test $p = 0.011$). Furthermore, at T1, a significantly higher number of environmental barriers were found among the 96 clients assessed at T3 (Mann-Whitney U test $p < 0.0001$). Characteristics for the samples at T1, T2, and T3 as well as for the clients not assessed at T3 are presented in Table 1.

A wide variety of self-reported diagnoses or health problems were represented. For example, 33 clients were diagnosed with stroke or brain injury, and 32 clients reported neurological diagnoses such as multiple sclerosis, Parkinson's disease, polio, or para/tetraplegia. Heart and respiratory problems were reported by 19 clients; 21 clients reported some kind of rheumatological diagnosis; and 47 clients reported arthrosis in one or several joints. Many clients reported more than one diagnosis or health problem.

The kind of adaptations installed in the dwellings varied considerably, with some installed in a day, while others took several months to complete. The grants often covered adaptations in more than one part of the house. The majority targeted hygiene facilities (73 grants); entrances, including balconies and patios (38 grants); and stairways and internal doors (30 grants). The majority of the adaptations in hygiene facilities involved installation of grab bars at the bathtub/shower, and/or replacing the bathtub with a shower. A few adaptations targeted floor surfaces in bathrooms, etc. With some exceptions, due to the relatively high standard in the houses adapted, many adaptations were not time-consuming, and thus the timespan between grant application and adaptation was fairly short. On the other hand, some adaptations concerned the construction of entirely new hygiene facilities or kitchen areas, or required considerable reconstruction of entrances and outdoor areas. Such adaptations were very complicated and time consuming. Consequently, the timespan between T1 and T2 varied considerably among the cases investigated, 71–238 days ($M = 103$, $Q1–Q3 = 90–110$). During the follow-up period 23 clients (24%) of the 96 assessed at T3 were granted a second housing adaptation.

Procedure

Most data were collected by registered occupational therapists employed by the municipality, on home visits scheduled as part of their ordinary practice in assessing the need for housing adaptation. All assessments at T1 were conducted by occupational therapists ($N = 14$) employed by the municipality while assessments at T2 and T3 were conducted either by them, the project leader (AF), or a project assistant. Initially, in order to obtain valid and reliable data, the occupational therapists underwent study-specific data collection training given by the project leader (AF) and the principal investigator (SI). The Ethics Committee of Lund University, Sweden, approved the study.

TABLE 1. Sample characteristics at T1, T2 and T3, as well as for the clients lost to T3

Characteristic	T1 sample n = 131	T2 sample n = 104	T3 sample n = 96	Clients lost to T3 n = 35
Age (years)				
Median	75	75	75	75
Q1–Q3	66–80	68–80	63–80	67–80
Time living in present dwelling (years)				
Median	15	16.5	15	17
Q1–Q3	5–31	6–31	5–31	6–35
Gender (%)				
Male	67	30	26	51
Female	33	70	74	49
Civil status (%)				
Living alone	45	55	55	54
Cohabiting	55	45	45	46
Type of dwelling (%)				
One-family house	53	50	50	37
Block of flats	47	50	50	63
Formal/informal help in the home (%)				
No help	43	21	24	31
Help	57	79	76	69

Instruments

The Housing Enabler

Accessibility problems were examined using the Housing Enabler (Iwarsson and Slaug, 2001; Iwarsson and Isacsson, 1996; Iwarsson, 1999). The instrument provides information in the following areas.

1. Assessment of functional limitations and dependence on mobility devices (personal component): A combination of interview and observation is used to assess the presence or absence of functional limitations (13 items) and dependence on mobility devices (2 items).
2. Assessment of physical environmental barriers (environmental component): A detailed observation assesses environmental barriers in the home and the immediate outdoor environment (188 items) as present or absent. Just below 70% of the items are defined according to official Swedish norms and guidelines, while the remainder are assessed based on professional experience. The housing environment is divided into four sections: outdoor environment (33 items), entrances (49 items), indoor environment (100 items), and communication (6 items). For each environmental barrier item, the instrument comprises predefined severity ratings (a score of 1–4) quantifying the severity of the problem in each specific case (Steinfeld et al., 1979).

Thus, the magnitude of objective, norm-based accessibility problems in housing caused by a particular combination of functional limitations and environmental barriers can be quantified. The sum of all the points yields a score of the magnitude of accessibility problems anticipated. In cases where no functional limitations or dependence on mobility devices are present, the score is always zero. In cases where the person has functional limitations and/or is dependent on mobility devices, higher scores mean more accessibility problems. The instrument makes it possible to predict which environmental details cause the greatest accessibility problems for a specific client or for groups of people, i.e. weighted environmental barriers. A computerized tool for more efficient data analysis is available (Slaug and Iwarsson, 2001). Content validity and inter-rater reliability have been established for functional limitations and mobility devices, $\bar{\kappa} = 0.87$, as well as for environmental barriers, $\bar{\kappa} = 0.68$ (Iwarsson and Isacsson, 1996), and explorative analyses supported the construct validity of accessibility (Fänge and Iwarsson, 2003).

The Usability in My Home (UIMH) instrument

In order to collect data on usability in housing, the self-administered UIMH (Fänge, 2002; Fänge and Iwarsson, 1999) was used. The instrument comprises 23 items, of which 16 are rated on a 7-point scale where 1 = the most negative and 7 = the most positive response. The instrument was developed in several steps. Content validity was established by means of an expert panel review, and a test-retest reliability study indicated moderate to very good agreement for each item to be rated, κw =0 .57–0.88 (Fänge and Iwarsson, 1999). For further instrument optimization purposes, in a previous study (Fänge and Iwarsson, 2003) factor analysis comprising the 16 items to be rated resulted in three factors, representing three different aspects of usability: 'Activity aspects', 'Personal and social aspects', and 'Physical environmental aspects', thus supporting its construct validity.

For this study, only the factor 'Physical environmental aspects' was considered relevant, as it explicitly reflects the subjective perspective of the environmental component at target. The factor includes six items (Cronbach's alpha = 0.79) regarding overall usability in housing, as well as in specific housing sections (Fänge and Iwarsson, 2003) reflecting the structure of the Housing Enabler. Given case-specific situations, at most one item is non-applicable and need not be answered. Consequently, the maximum score is 42, and the minimum 5.

Data analysis

First, changes between T1 and T3 were investigated. Second, in order to investigate in more detail at which stage of the housing adaptation process the demonstrated changes occurred, separate pair-wise analyses of data from T1 to T2, and from T2 to T3 were performed.

The Sign Test (Altman, 1991) was used to calculate changes in overall accessibility and physical environmental aspects of usability, as well as in the sum of environmental barriers, and sum of functional limitations/dependence on mobility devices. Changes in separate functional limitations/dependence on mobility devices, as well as separate environmental barriers were analysed by means of McNemar's test (Altman, 1991), and in addition, descriptive statistics were used to depict changes in dependence on mobility devices over time. Due to internal dropouts in the environmental barriers section of the Housing Enabler, analyses of changes in overall accessibility as well as environmental barriers were calculated for 100 participants between T1 and T2, for 92 participants between T1 and T3, and for 88 participants between T2 and T3. All other data were calculated for 131 participants at T1, 104 at T2, and 96 at T3. Results were considered significant at $p < 0\ .05$.

The Housing Enabler software (Slaug and Iwarsson, 2001) was used to calculate accessibility scores, while all other data were analysed by means of the SPSS, version 11.0.1 (SPSS, 2001).

Results

Significant improvements or declines along the housing adaptation process were demonstrated in all variables targeted in this study. For an overview of descriptive data on the variables studied from T1, T2, and T3, see Table 2.

Housing accessibility

At T1, all clients had accessibility problems, although the magnitude of the problems differed considerably between clients. There was a significant improvement in housing accessibility between T1 and T2 ($p < 0.0001$), but in no other phases of the housing adaptation process.

Personal component of accessibility

On all assessment occasions, all clients had at least one functional limitation or were dependent on a mobility device. A significantly higher prevalence of functional limitations and dependence on mobility devices was demonstrated at T2 compared to T1 ($p = 0.015$), but no other statistically significant changes were demonstrated further along in the housing adaptation process. No statistically significant changes were demonstrated in single items.

Functional limitations

Most prevalent at T1 were difficulties in bending and kneeling (78%) and poor balance (61%). See Table 3 for prevalence rates at T1, T2, and T3, as well as for the clients lost to T3.

TABLE 2. Descriptive statistics on housing accessibility, functional limitations, environmental barriers, and physical environmental aspects of usability at T1, T2, and T3

	T1			T2			T3		
	Md	Range	Q1–Q3	Md	Range	Q1–Q3	Md	Range	Q1-Q3
Accessibility score[a,c]	187	13–390	107–250	179	13–394	111–236	177	3–394	108–231
No of functional limitations[d]	4	1–9	3–6	4	1–9	3–6	4	1–9	3–6
No of environmental barriers[a,c]	99	25–170	72–121	53	30–84	45–62	51	27–87	42–55
Score of physical environmental aspects of usability[b,d]	31	0–42	24–36	35	7–42	29–39	35	7–42	30–40

[a]According to the Housing Enabler (Iwarsson, 1999; Iwarsson and Slaug, 2001); [b]According to the Usability in My Home, UIMH (Fänge, 2002; Fänge and Iwarsson, 1999); [c]T1: n = 127, T2: n = 100, T3: n = 92; [d]T1: n = 131, T2: n = 104, T3: n = 96

Dependence on mobility devices

At T1, 74% of participants were reliant on walking aids for their mobility indoors or outdoors. Even if no significant changes were demonstrated, rates of dependence on mobility devices changed over time. Of the 96 clients assessed at T3, who were dependent or independent at T1, 81 used the same type of mobility device or were still independent at T3. The remaining 15 clients changed their mobility device use between T1 and T3: three became independent of any mobility device, three became dependent on a device, three were using a wheelchair instead of a walking aid, one used both a walking aid and a wheelchair and five changed their use of mobility device in some other way. For more detailed description on the prevalence of dependence on mobility devices, see Table 3.

Environmental component of accessibility

On all assessment occasions, environmental barriers were identified in 100% of the dwellings, with the highest number found at T1. At T1, all hygiene and laundry rooms were equipped with controls and hardware requiring hand function, finger function, and/or turning motions, e.g. water taps. Working surfaces and washbasins too high for use when seated were found in most kitchens (87%) and hygiene rooms (78%), while insufficient legroom underneath working surfaces was found in 84% of the kitchens and hygiene rooms. In nearly all (91%) of the bathrooms mirrors were placed too high for use when seated, and the majority of the apparatus/controls were placed less than 0.7m from the floor (90%). In most of the dwellings, inadequate shelter from

TABLE 3. Prevalence of functional limitations and dependence on mobility devices in the study sample at T1, T2, and T3 as well as for the clients lost to T3

Functional limitation: Dependence on mobility device[a]	Prevalence % T1 sample n = 131	T2 sample n = 104	T3 sample n = 96	Clients lost to T3 n = 35
Difficulty interpreting information	<1	2	<1	0
Severe loss of sight	26	26	23	29
Complete loss of sight	<1	0	0	3
Severe loss of hearing	5	7	6	0
Poor balance	61	61	58	69
Incoordination	15	17	10	23
Limitations of stamina	53	55	58	57
Difficulty in moving head	8	10	14	3
Difficulty in reaching with arms	46	48	50	34
Difficulty in handling and fingering	34	33	40	26
Loss of upper extremity skills	10	13	14	9
Difficulty in bending, kneeling, etc.	78	83	75	83
Extremes of size and weight	<1	1	1	0
Reliance on walking aids	74	73	66	86
Reliance on wheelchair	18	18	17	26

[a]According to the Housing Enabler (Iwarsson and Slaug, 2001)
NB. Many clients had more than one functional limitation/dependence on mobility device

weather in passenger unloading zones (90%), high thresholds and/or steps at the main entrance to the house (80%) or to the balcony/sitting-out place (78%) were found.

The sum of environmental barriers in the dwellings decreased highly significantly between T1 and T3, as well as between T1 and T2 and between T2 and T3 ($p < 0.0001$). At T3 controls and hardware requiring hand function, finger function, and/or turning motion were still found in 100% of dwellings, and work surfaces and sinks were too high for use when seated in most kitchens (83%) and hygiene rooms (82%). In 91% of the hygiene rooms mirrors were still placed too high for use when seated, and in 87% of the dwellings shelter from weather in passenger unloading zones was still lacking. Descriptive statistics on the number of environmental barriers at T1, T2, and T3 are presented in Table 2.

In more detail, in 28 of the 188 environmental barriers assessed there was a significant change in prevalence between T1 and T3. One was found in the outdoor environment, eight at the entrances (elevators and stairs included), 18 in the indoor environment, and one concerned the communication section. For 25 of the 28 environmental barriers the prevalence decreased significantly from T1 to T3, as listed in Table 4. For the remaining three barriers the prevalence increased: automatic opening on side-hung doors at entrances ($p = 0.016$), grab bars inadequately positioned ($p = 0.0040$), and elevated toilet ($p = 0.0060$).

TABLE 4. Environmental barriers showing a decrease in number between T1[a], and T3[b], n = 25

Environmental barrier[c,d]	T1 (%)	T3 (%)	P-value
A7. No tactile cues of abrupt level changes or other hazards	43	30	0.019
B6. Heavy doors without automatic opening	34	20	0.013
B11. Complicated/illogical opening procedure	7	2	0.031
B12. Stairs the only route (no lift/ramp)	57	53	0.016
B16. No handrails at stairs (required on both sides)	39	36	0.039
B19. No tactile cues to stairway in circulation path	48	32	0.001
B46. Narrow door to balcony/sitting out place (clearance less than 85cm)	56	51	0.012
B47. High threshold/level difference/step (more than 25mm) to balcony/sitting out place	78	72	0.031
C1. Stairs/threshold/differences in level between rooms/floor spaces (more than 25mm)	66	53	0.001
C4. Narrow doors (clearance less than 80cm)	71	65	0.012
C5. Slippery walking surface (not hygiene rooms)	17	8	0.021
C16. Very high/very low and/or irregular height of raisers	9	3	0.039
C34. Door swing which impedes accessibility to storage units in kitchen	21	14	0.016
C40. Very small controls in kitchen/laundry room/utility kitchen	14	6	0.004
C50. No place to sit in shower/bath	46	26	< 0.0001
C51. No grab bars at shower/bath and/or toilet seat	68	40	< 0.0001
C73. Toilet with standard height (41cm inc. seat) or lower	66	58	0.006
C78. Toilet roll holder in inaccessible position	50	40	0.013
C81. Bathtub instead of shower stall/space	57	26	< 0.0001
C82. Slippery floor surface in hygiene rooms	17	4	0.001
C84. High force required to activate controls at doors, windows, switches, etc.	40	25	0.004
C86. Use of controls at doors, windows, switches, etc. requires intact fine motor control	49	43	0.004
C90. Complex manoeuvres (more than one operation/movement) and good precision required	35	26	0.031
C98. Inappropriate design of store in separate storage area	43	34	0.035
D1. No telephone with amplified sound	66	56	0.035

[a]n = 127; [b]n = 92; [c]According to the environmental component part of the Housing Enabler (Iwarsson and Slaug, 2001), comprising 188 environmental barrier items; [d]A. Outdoor environment, B. Entrances, C. Indoor environment, D. Communication

Physical environmental aspects of usability

Even if the physical environment was judged to be fairly usable, at T1 nearly all the clients considered their physical housing environment to be less than fully usable, as demonstrated in their subjective evaluations (Table 2). At T3, physical environmental aspects of usability had improved from T1 (p <

0.0001), and since no significant changes were found between T2 and T3, improved usability was the result of changes between T1 and T2 ($p < 0.0001$).

Discussion

This study demonstrated that accessibility improved significantly in the course of the housing adaptation process. The prevalence of functional limitations and dependence on mobility devices increased, and the number of environmental barriers decreased, while physical environmental aspects of usability improved. To the best of our knowledge, this study is the first specifically focusing on longitudinal changes following housing adaptations from the perspective of accessibility and usability. Given the fact that the demonstrated changes occurred at different times, and in different directions along the housing adaptation process, the results highlight the complexity of the housing adaptation process, and pinpoint the need for considering person–environment (P–E) interactions over time, not only the personal and environmental components separately. Moreover, separate attention to objective and subjective aspects of person and environment generates important knowledge for occupational therapy research and practice. In this respect, the methodology used in this study seems promising.

At first glance, and given the objectives of a housing adaptation, it seems reasonable that accessibility improved directly after the initial intervention, and in this respect one of the objectives of a housing adaptation seems to be fulfilled. These results were expected, although they have not until now been empirically demonstrated. More surprisingly, the magnitude of accessibility problems found after housing adaptation in the housing environments assessed for this study was still considerable (Table 2). Since accessibility represents the encounter between personal and environmental components, these results indicate that some of the adaptations undertaken were not specifically tailored to the person's functional capacity, and thus the reduction of environmental barriers was not reflected in improved accessibility. The physical housing environments assessed for this study changed for a variety of other reasons. First, the housing renovations or reconstructions, which were either initiated by the house owner or by the municipality, were not always specifically designed for the individual client. However, they obviously contributed to a reduction of environmental barriers. Second, 24% of the clients' homes were subject to a second housing adaptation during the follow-up period. Third, in order to promote proactive adaptations (Lawton, 1989), client-specific recommendations for other environmental interventions not eligible for a housing adaptation grant, e.g. removal of carpets, were in some cases given.

From the client's perspective it is not environmental barriers or accessibility per se that are the focus of housing adaptation, but the need and wish to be able to perform activities in the home environment (Golant, 2003), and this perspective is reflected by current Swedish legislation on housing adaptations (SFS, 1992: 1574). Overall in this study, the physical environment was judged to be more usable after housing adaptation, and in this way the intervention was successful in relation to its objectives (Gitlin, 1998; Boverket, 2000). It is however important to note that lack of further improvement between T2 and T3 may be due to 'ceiling effects' in measurement. That is, in spite of problems at T1 indicating a need for housing adaptation, by using different strategies the clients had adapted their way of living to the extent that they judged the physical environment to be very usable even before the intervention. Consequently, further improvements were not reflected in the evaluations. Interestingly, the removal of environmental barriers between T2 and T3 did not affect usability, probably because the adaptations in this phase were not individually tailored. It should however be kept in mind that the Housing Enabler instrument is rather coarse, i.e. the personal component is assessed dichotomously, and subtle changes are not detected by the instrument. In spite of this, such changes may well be reflected in the changes in usability found, thus pinpointing the complexity of the P–E interactions that need to be considered in a housing adaptation process. Furthermore, given the transactional nature of usability, the results indicate the importance of considering the activity component in a housing adaptation process as well, that is, targeting P–E–A transactions is necessary.

From an occupational therapy practice perspective, decisions to effect housing adaptations are often closely linked to the prescription of mobility devices, thus indicating the need to consider both aspects simultaneously. Within the ICF framework (WHO, 2001), mobility devices are seen as part of the context. However, given previous research experiences (Brandt et al., 2003), mobility devices such as wheeled walkers and wheelchairs seem to be an intermediary variable, and in accessibility assessments it is therefore considered more valid to include dependence on mobility devices in the personal component.

The results of this study indicate that the complexity of the housing adaptation process calls for an approach where objective assessments are used alongside subjective evaluations, in order to support practical decision-making (Iwarsson, 2003). The assessment instruments used in this study seem promising, but further empirical research on their usefulness for evaluation purposes is necessary. The strength of the Housing Enabler is that it yields information on the impact of different combinations or profiles of functional limitations and dependence on mobility devices on the magnitude of accessibility. However, in order to arrive at more valid information useful for understanding, e.g. longitudinal changes in usability evaluations, the UIMH instrument could well be complemented with self-ratings of functional limitations, i.e. aspects of the personal component.

This study was limited to clients who were living at home at the time of application, and thus the majority of clients receiving housing adaptation grants were not targeted. In this respect, it is not possible to generalize the results to all housing adaptation clients in the community. However, in order to generate knowledge useful for the development of evaluation strategies, and to investigate the usefulness of the methodology for community-based occupational therapy our approach seemed to be the most relevant first step.

Finally, it is important to note that this study was not intended to evaluate the effects of housing adaptation, but to investigate longitudinal changes in important aspects of the housing adaptation process. The study focused on longitudinal changes from the perspectives of the client, as well as on changes assessed by occupational therapists, but additional information on administrative procedures and economic aspects is imperative for evaluation purposes.

To conclude, the findings highlight the complexity of the housing adaptation process, and the need to consider P–E interactions in order to improve accessibility and usability in housing, not only the different components separately. The findings challenge occupational therapists to implement systematic assessment, intervention and evaluation strategies into practice, and the methodology applied seems useful for systematic data collection within community-based occupational therapy. In this respect, the study contributes to quality development in the field. Further research targeting P–E–A transactions would advance the understanding of the complexity of processes involving environmental interventions, such as housing adaptations, and for further theoretical and methodological development of relevance for occupational therapy practice.

Acknowledgements

We are grateful to the study participants and occupational therapists who collected data for this study. Special thanks to M Davidsson, Reg OT, for assistance in co-ordinating the data collection procedure, and to B Slaug, BA, for help with data computations. Thanks also to V Horstman and J Lanke for statistical advice. The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS), the Swedish Council for Working Life and Social Research (FAS), the Riksbyggen Jubilee Foundation, the Swedish Research Council, and Kristianstad municipality supported the study financially.

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