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*Published in:*

Scandinavian Journal of Occupational Therapy

*DOI:*

[10.1080/11038128.2017.1280078](https://doi.org/10.1080/11038128.2017.1280078)

2018

*Document Version:*

Peer reviewed version (aka post-print)

[Link to publication](#)

*Citation for published version (APA):*

Pettersson, C., Slaug, B., Granbom, M., Kylberg, M., & Iwarsson, S. (2018). Housing accessibility for senior citizens in Sweden: Estimation of the effects of targeted elimination of environmental barriers. *Scandinavian Journal of Occupational Therapy*, 25(6), 407-418. <https://doi.org/10.1080/11038128.2017.1280078>

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5

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# **Housing accessibility for senior citizens in Sweden: Estimation of the effects of targeted elimination of environmental barriers**

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## **ABSTRACT**

**Aim:** To estimate the effects of targeted elimination of environmental barriers (EB) in the ordinary housing stock in Sweden, and to explore the estimated effects on accessibility at a population level in relation to a) residents with different functional profiles, b) different housing types and c) building periods.

**Method:** Data on dwellings from existing Swedish research databases were utilized. EB and accessibility were assessed by means of the Housing Enabler instrument. In simulations of EB removal, five items that correspond to the most common housing adaptations were selected. The simulations were applied to four functional profiles of different complexity.

**Result:** EB known to be commonly removed by housing adaptations exist in large proportions of the existing ordinary housing stock. Estimated targeted elimination of selected barriers would have the largest accessibility effects for the more complex functional profiles. The effects would be consistently larger for one-family houses, and for all types of dwellings built before 1960.

**Conclusions:** The elimination of the EB most commonly addressed by housing adaptations could result in a reduction of the housing accessibility problems that community-living older people are facing. For society to solve the housing situation for the ageing population well-informed and efficient upgrading of ordinary housing is imperative.

**Keywords:** public health, home modification, housing adaptation, occupational therapy, functional limitation

## INTRODUCTION

The home is important for health and independence and is the major arena in which older people maintain control and autonomy in everyday activities [1]. Since older people spend most of their time at home, it is important that the ordinary housing stock is accessible and designed to accommodate and support activity and participation in the ageing population [2-4].

Accessibility is defined as a person-environment relationship [5] and operationalized as a notion of person-environment fit [6]. Thus, accessibility represents the encounter between the individual with his/her functional capacity and the demands of the physical environment and is thereby an important prerequisite for everyday activity. The environmental component of accessibility refers to compliance with national design standards and guidelines and is mainly objective in nature. The personal component can be operationalized as an objective assessment of functional limitations in the individual [7]. Defined in this way, accessibility should be assessed from a professional perspective, preferably with valid and reliable instruments.

Since functional decline and activity limitations often come with age [8], with an ageing population [3] there is a risk for a situation with increasing accessibility problems for senior citizens living in ordinary housing [9, 10, 11]. Given the rapid demographic change towards increasing proportions of older people and people ageing with disabilities [3], society should place accessibility high on the housing provision agenda not only when planning for new housing but also for the existing stock of ordinary housing (i.e., dwellings on the public or private housing market, not including special housing, residential care facilities, etc.). Consequently, but hitherto with insufficient attention in housing provision policies, holistic and

innovative approaches in the field of housing are needed, such as large-scale interventions that strategically targets deficiencies in the existing housing stock [12].

In occupational therapy worldwide, the dominant avenue to support daily activity for older people living in ordinary housing with accessibility problems is to provide multi-faceted home modifications, including advice on adaptations of the built environment as well as provision of assistive technology and related training [13]. Governed by specific legislation focusing on adaptations of the built home environment, at a total cost of SEK 1,039 million in Sweden 73,200 housing adaptations were granted in 2015 [14]. Occupational therapists make recommendations for housing adaptations based on assessment of the transactions between individuals, the characteristics of the physical environment and their daily occupations based on individual needs [15]. Studies in Sweden have demonstrated that housing adaptations increases accessibility [16], improves self-related ability in everyday life [17] as well as the usability of the home [18]. Further, housing adaptations reduces the number of falls [19]. However, occupational therapy expertise on housing adaptations is seldom utilised in the context of housing provision policies or public health.

Regarding research on home modifications internationally there are only a few recent reviews of the scientific literature available. One systematic review focused on the role of physical environmental factors of housing in promoting or inhibiting active living in old age [4]. Based on the 37 publications identified and reviewed, the authors concluded that there is consensus in the literature on the benefits of home modifications on ADL performance of community-dwelling adults. This is in congruence with an earlier literature review of quantitative studies in this research field [20] concluding that there is empirical evidence suggesting that living in housing with less accessibility problems is related to independence in daily life.

Referring to some of the studies included in these reviews [4, 20], specific housing design features and environmental barriers such as lack of grab bars in bathroom and kitchen hindered safe and independent performance in ADL [21]. Lighting adaptation in these housing sections resulted in significant effects on ADL for people with visual impairment [22]. In another study [23], the authors reported that standard and personalized home modifications such as ramps, automatic doors, elevator/lift, and modifications in kitchen and bathroom were associated with less decline in ADL. Further, grab bars were the most prevalent safety features in shower/bathtub [24]. Another study reported that participants who got an intervention including home modifications and training in their use, instruction in problem-solving strategies, energy conservation, safe performance, fall recovery techniques and balance and muscle strength training had less difficulty than controls in ADL, with the largest reductions in bathing and toileting [25]. These studies contribute with knowledge of consequences and effects of housing adaptations at the individual level, but to date the potential impact of systematic approaches aiming for improved housing accessibility at population level is unknown. Moreover, as stated by Ahrentzen and Tural [4] the evidence base is not very strong due to methodological limitations. For example, sophisticated measurement scales are not used and there is selection bias and a large number of cross-sectional analyses. Therefore, more research is needed based on detailed measurements of environmental factors.

Turning to studies on home and health dynamics among older community-living people in different age groups and countries [see e.g., 26-28], results show that objective housing aspects are related to independence in daily activities as well as symptoms of ill-health. According to estimates based on the situation in the U. S. [29], a newly built single-family detached unit will have at least one resident with disability during its expected lifetime. Accordingly, there

certainly is a need for accessible housing [30], and research on aspects such as accessibility features essential for people with disabilities are important for planning and public policy.

The expert knowledge of occupational therapists based on their experiences gained from individual housing adaptation cases should be valuable also on an aggregated level [31] but is yet rarely used to inform housing provision at the societal level. While attempts have been made to engage occupational therapists in knowledge transfer from housing adaptations to housing provision in general [31], when it comes to the potential of utilizing such avenues for targeted efforts to increase accessibility in the ordinary housing stock research is virtually non-existing. Could knowledge on how accessibility problems are generated be used to inform housing provision at the societal level? Accordingly, adopting a public health perspective on housing accessibility to accommodate the needs of the ageing population [11], the aim of this study was to estimate the effects of targeted elimination of environmental barriers in the ordinary housing stock in Sweden. The specific aims were to explore the estimated effects of such targeted elimination in terms of accessibility at a population level in relation to a) older residents with different functional profiles, b) different types of dwellings and c) housing built during different time periods.

## **MATERIALS AND METHODS**

### **Project Context**

For this cross-sectional study we utilized data from two existing databases used in research on home, health and disability during the process of ageing. The Swedish baseline database

(collected in 2002-2003) of the ENABLE-AGE (E-A) project [32] comprises data on 397 dwellings in the ordinary housing stock in urban areas in the southern part of the country. The target population consisted of very old community-residing, single-living people in three mostly urban municipalities in southern Sweden (Halmstad, Helsingborg and Lund). The E-A participants were randomly drawn from the national public population register, stratified by age (80–84; 85–89 years) and sex (25% men) (mean age = 85 years). The baseline database (collected in 2012-2013) of the Home & Health in Parkinson's disease (HHPD) project [33] comprises data on 255 dwellings in the ordinary housing stock in Skåne County, Sweden. For the HHPD the target population was people diagnosed with Parkinson's disease (PD) since >1 year. Using patient records the 255 participants (mean age = 70 years, range 45-93 years) were recruited via the neurology departments at three hospitals in Skåne County. For both projects, comprehensive data were collected by trained project assistants (reg. occupational therapists) with a combination of interview and observation, using study-specific questions and well-established assessment instruments and rating scales at home visits. For details, see [33-34].

The Swedish part of the E-A was approved by the local Ethics Committee at Lund University (LU 324, 2002). The HHPD was approved by the regional Ethical Board in Lund, Sweden (2012/558).

### **Sample of dwellings**

For the present study, only data on housing from the two databases were used (for some dwellings, data were missing on building year why we excluded these from the analyses and the final pooled sample consisted of data on 609 dwellings (N=370 from the E-A; N=239 from the HHPD), whereof 416 apartments in multi-dwelling blocks and 193 one-family houses. We



complemented the database with information on building year, retrieved from the Swedish National Board of Housing, Building and Planning. The housing stock in Sweden was stable during the time frame of the study and the rate of new housing construction was comparatively low [35]. Since the mean number of years living in the same dwelling was high in both samples the 10-year period between the data collection points was considered a minor issue.

Within the time frame of this study in Sweden 1,926 million people were 65 years or older. Out of those 1,759 million was living in the ordinary housing stock, approximately 809,000 in multi-dwelling blocks and 950,000 in one-family houses [36]. With regard to building period we applied the categorisation used in a recent governmental report [9], based on whether the dwelling was built before, during or after the 1960-1970-ies implementation of a national program of massive multi-dwelling block construction. Considering that the participants in the largest dataset used were randomly drawn from the national population register and that the distribution between building periods and type of dwelling in our datasets largely reflects the distribution of the housing stock in Sweden as a whole [35], the data used were considered nationally representative. Based on these assumptions, the Swedish population 65 years or older would be distributed according to Table 1.

*Table 1 in here*

### **Data collection instrument: Housing Enabler**

#### *Environmental barriers*

Environmental barriers were assessed by means of the environmental component of the Housing Enabler (HE) [37], using the version available at the time for the respective data collection (in the subsequent data analyses, the differences between versions were

systematically dealt with). The HE is an internationally acknowledged, reliable and valid instrument available in several languages [7]. The validity of the HE has been successively optimised during twenty years of research. Sufficient inter-rater reliability has been demonstrated in several studies, in Sweden and other countries [38-40].

In the HE environmental barriers are defined by current standards and guidelines for housing design, observed and registered as present/not present by trained raters who have acquired their expertise and knowledge through special training courses. For the present study we used a reduced list of 60 environmental barriers (27 indoors, 13 at entrances and 20 in the close exterior surroundings) representing the core barriers in terms of detecting accessibility problems [41-42]. The HE also includes a personal (P) component for assessments (interview and observation) of presence (yes) /absence (no) of functional limitations and dependence on mobility devices (14 items, displayed in Fig. 1). The magnitude of accessibility problems in a case is calculated by combining the E and P components using a scoring matrix (see Fig. 1).

*Figure 1 in here*

For the estimation of effects that could be achieved by a targeted elimination of environmental barriers, we chose a set of environmental barriers commonly addressed by housing adaptations in Sweden. In the national reports on housing adaptation, statistical data on the type of housing adaptations granted is based partly on the responses provided by municipalities in an annual housing market survey and partly on data collected from a number of municipalities through a few small-scale studies [43]. According to the most recent national report on housing adaptation [43] the most common measures concerned thresholds, installation of grab bars, installation of

ramps, and adaption of hygiene areas, corresponding to five environmental barriers in the HE [41]:

- Steps/thresholds/differences in level between rooms/floor spaces indoors in general
- No grab bar at shower/bath and/or toilet in hygiene area
- Stairs the only route (no lift/ramp) at entrances
- Shower stall with kerb/level difference
- Bathtub instead of shower space

As a basis for the forthcoming estimation of effects in terms of accessibility, we examined the occurrence of these five environmental barriers in our sample of dwellings, considering type of dwelling as well as building period.

### *Functional profiles*

In order to arrive at results at population level rather than on group level we did not use any person-related data collected with the individuals (i.e., very old people, people with PD) actually living in the 609 dwellings. Instead, to exemplify how accessibility problems vary depending on the residents' functional capacity, we employed four previously identified [44] researched-based functional profiles of different complexity. For the construction of functional profiles, datasets comprising HE data on the presence/absence of functional limitations (including use of mobility devices, as a signification of more severe mobility limitations) were utilized. For details on this methodological step, see Appendix in a recent study from the same project [44]. The profiling methodology makes use of Configuration Frequency Analysis (CFA), which is a statistical test identifying which combinations—in our case, of functional limitations—that exist significantly more or less frequently than expected in a data material [45]. Starting out from such analyses, the four functional profiles were identified [9] and employed

in the present study. One of the datasets utilized in the procedure to identify the functional profiles was the E-A, and the four profiles covered in total 44% of the participants (profile 1: 19%, profile 2: 11%, profile 3: 11%, profile 4: 3%). The prevalence of functional limitations in this dataset is fairly consistent with national data available [46]. That is, the four functional profiles represent large groups of older people having a common combination of functional limitations rather than specific groups according to age or diagnose (see Table 2).

*Table 2 in here*

## **Data Analyses**

### *Accessibility problem score*

Based on the notion of person-environment fit [6], the HE takes into account that functional limitations constitute an important component of accessibility problems [37]. To calculate the magnitude of accessibility problems in a given case, the HE uses a scoring matrix that juxtaposes the functional limitations of a profile with the environmental barriers found present in a dwelling. In each intersection between a functional limitation and an environmental barrier the matrix provides predefined severity ratings (0-4) (0=no problem, 1=potential problem, 2=problem, 3=severe problem, 4=impossibility) which are summed up to a total accessibility problem score representing a quantification of predicted accessibility problems (theoretical score range for the reduced list used in the present study, 0-904) [44]. For an exemplification of the scoring procedure, see Figure 1.

To achieve the aim of this study, that is to estimate the effects of a targeted elimination of environmental barriers, we also calculated a subscore for the five barriers that were selected for removal. That is, for each of the four functional profiles we calculated the accessibility problem

score based on the actual occurrence of environmental barriers in our sample of dwellings, but also for a scenario where whenever any of the five selected environmental barriers was found present it was removed. Thus, the effects of targeted elimination were estimated based on the presence/absence of the environmental barriers in the specific type of dwelling, separately for each functional profile. The largest effect would be achieved if all five barriers were present and thus needed to be removed for the most complex of the four functional profiles. In contrast, if none of the five environmental barriers were present in a dwelling the total effect would always be 0, no matter the complexity of the functional profile.

#### *Number of residents and number of dwellings affected*

The estimated numbers of residents and dwellings affected by the targeted barrier elimination were calculated by applying the proportions of people living in multi-dwelling blocks and one-family houses from different building periods in our sample to available population data [35].

#### **Statistical analysis**

Descriptive statistics were used to estimate the effects on accessibility problem scores that would be the result of a targeted elimination of five selected environmental barriers. Differences in occurrence of the five environmental barriers between building periods and types of dwellings were tested by means of Kruskal-Wallis' test. P-values < 0.05 were considered statistically significant unless Bonferroni correction was applied. Three post-hoc pairwise tests were carried out for each group difference found. For these tests a corrected significance level was set to  $0.05/3=0.0166$ . All analyses were carried out using SAS version 9.3 (SAS Institute Inc., Cary, NC USA).

## RESULTS

### **Occurrence of environmental barriers often removed by housing adaptations in the sample of dwellings**

Out of the five environmental barriers targeted for elimination, “stairs the only route (no lift/ramp) at entrances” and “bathtub instead of shower space” occurred significantly less frequent in multi-dwellings and one-family houses built during 1960-1979 as well as 1980 and later. “Steps/thresholds/differences in level between rooms/floor spaces indoors in general” were significantly less common in newer multi-dwellings than older. Occurrence of “shower stall with kerb/level difference” also changed during the different building periods in multi-dwellings but not consistently decreasing. The occurrence of “no grab bar at shower/bath and/or toilet in hygiene area” did not change significantly during the different building periods, neither in multi-dwellings nor in one-family houses. For details, see Table 3.

*Table 3 in here*

### **Estimated effects on accessibility by targeted elimination of five environmental barriers often removed by housing adaptation**

The results displayed in Tables 4 and 5 show that targeted elimination of environmental barriers in multi-dwelling blocks and one-family houses, respectively, has the largest effects on the reduction of the accessibility problems scores for the more complex functional profiles 3 and 4. In terms of relative reduction however, the effects are more apparent for the less complex functional profiles 1 and 2. For example, the effect of removing the five environmental barriers in the oldest buildings for functional profile 1 is a reduction of 13 points in the accessibility problem score (i.e., a relative reduction of 32%), while for functional profile 4, the reduction is 31 points (i.e., a relative reduction of 16%). With regard to type of dwelling, the effects of a

targeted elimination of environmental barriers would be consistently larger for one-family houses compared to multi-dwellings blocks. If restricted to specific building periods, the largest effect of the elimination would be attained for dwellings built before 1960, both with respect to multi-dwellings and one-family houses (see Tables 4 and 5).

*Tables 4 and 5 in here*

### **Estimated effects in terms of older people and dwellings affected in the Swedish population**

Table 6 shows an estimation of how many people aged 65 or older that live in dwellings with any of the five environmental barriers. An elimination targeting one of the five environmental barriers in all multi-dwelling blocks where people aged 65 or older live implies that 27-57% of them would live in dwellings with fewer environmental barriers. The corresponding proportions for one-family houses were 29-82%. Regardless of type of housing, “stairs the only route (no lift/ramp) at entrances” and “bathtub instead of shower space” appeared in close to half (40-49%) of all dwellings where people 65 or older live.

*Table 6 in here*

Table 7 describes the number of dwellings that need to be addressed in order to completely eliminate the five environmental barriers in the total ordinary housing stock (N = 4,307,000) [35]. The results show that 28-54% of multi-dwelling blocks need to be addressed in order to eliminate the five environmental barriers from the total ordinary housing stock in Sweden, with even higher numbers for one-family houses (22-82%) and older dwellings (20-

82%). To replace bathtubs with shower stalls 1,098,045 multi-dwellings and 428,410 one-family houses need to be attended.

*Table 7 in here*

## **DISCUSSION**

As aimed to explore by the present study, the results showcase that targeted elimination of environmental barriers in the ordinary housing stock has a considerable potential to decrease accessibility problems for older people with different complexity of functional limitations. The fact that the ordinary housing stock in Sweden has a high standard in international comparison does not imply that the accessibility is sufficient for the ageing population. Environmental barriers known to commonly be removed financed by individual housing adaptation grants exist in large proportions of the existing multi-dwelling and one-family housing stock. While there are differences between housing types and building periods, the results call for attention from a societal planning and public health perspective.

The effects of a targeted elimination of environmental barriers would be substantial for people with more complex functional profiles, and in the oldest segment of the ordinary housing stock (tables 4 and 5). Importantly, even those with less complex functional decline face accessibility problems when the environmental barriers targeted are present in their homes. The high proportions of people aged 65 and older that would benefit from the targeted elimination exemplified are striking (table 6). That is, for 80 % of the environmental barriers targeted, in multi-family housing close to 50 % or more of this population would benefit in terms of accessibility. Since half of them live in dwellings built before 1961, the proportion that would



benefit is even higher. The picture is similar for one-family houses but it should be noted that when it comes to thresholds and other differences of level indoors >80 % would benefit (table 6). As to the actual numbers of dwellings that would need to be rebuilt or adapted, they are immense. As estimated by the results, out of the currently 2.3 million multi-dwellings in Sweden >1 million have entrances with steps, without a ramp or an elevator. For one-family houses, the proportion and actual numbers are even higher (table 7). Many dwellings are in need of renovation, and the building sector should be made more aware of accessibility issues and take the opportunity to eliminate these problems when renovation is effectuated.

Even if housing adaptation is an individualized intervention, the present study is a contribution to the development of the comprehensive public health strategies needed to meet the needs of the ageing population. In a public health perspective, guidelines and standards for accessible housing are important since people with functional limitations should be able to move around, perform various everyday activities and be able to participate in society. The fact that use of mobility devices is used as a signification of more severe mobility limitations in the functional profiles deserves comment. Accordingly, the accessibility problems generated for the more complex functional profiles to a considerable extent were induced by this component. It should be noted that the use of rollators is common and increasing [47-48] and such devices can be purchased without a needs assessment and formal provision. Thus, it might be that rollators are being used not only by those with more severe mobility limitations but also for preventive purposes or just as a practical support, for example, for shopping. Since mobility limitations are common in older age, extensive adaptation of the housing stock is needed. With the increasing use of mobility devices, the health promotion capacity and preventative potential of such efforts could be considerable.

As indicated by our results, it can be assumed that the need of housing adaptation would decrease by eliminating the five selected environmental barriers from the housing stock. The largest client group requiring housing adaptation is older people, and it is known that over time, many older people need additional housing adaptation [49-50]. Thus, it is plausible to assume that the elimination of the environmental barriers most commonly addressed by housing adaptation would decrease the societal costs for housing adaptation grants. However, an important future direction would be to examine cost-benefits of this type of targeted elimination. Based on the scientific evidence available [21, 23, 51], also functioning in terms of ADL capacity would be positively affected [17]. Since older people often want to live at home as long as possible [52], this is of importance. In line with earlier studies [50, 53], elimination of environmental barriers could also lead to a decreased use of home care services [54].

According to Ahrentzen & Tural [4], architects, housing providers and policy makers need valid and reliable information on which to construct their plans and policies. Considering the present situation in many countries, society could not possibly meet the housing needs of the growing ageing population with individual housing adaptation or special housing. The building sector could gain from increased collaboration with professionals such as occupational therapists, making use of their specific knowledge of person-environment fit when planning for new housing and renovations. For example, the high occurrence of thresholds between rooms and the lack of grab bars in hygiene areas even in newer dwellings noted in this study are problems that could be avoided. This kind of insight is far from new (see e.g. [55]), but as demonstrated by the result of the present study the progress towards more accessible housing is slow. Our results could be used to reinforce the argumentation that data based on housing adaptations have a potential to inform housing design at the population level. Moreover, the present study provides evidence for more progressive political action regarding housing provision that meets

the needs of the ageing population. Efforts in the building industry and public agencies should target ways to enhance active and healthy ageing, as argued in previous research [4, 30, 51]. To meet the needs of accessible housing every effort to rebuild and upgrade the existing ordinary housing stock must be based on the best possible knowledge, calling for more research in this area [29].

For people in general, it might be difficult to imagine how their situation will change while ageing and how functional decline might affect housing accessibility. There is a need for information on housing issues not only to policy-makers, public and private actors in the building and construction sectors but also to the general public. Since occupational therapists can contribute with important knowledge on how everyday activities are influenced by environmental demands [56], our research contributes to strengthening their role as public health agents.

### **Methodological considerations**

In contrast to most of the data collection tools used for environmental barrier and accessibility inventories, we used a scientifically evaluated and well-established instrument [7, 41], and the analyses rest on valid and reliable data available in high-quality databases. The functional profiles used were based on previous research [44], making it possible to run simulations with functional profiles representing typical manifestations of functional decline in the ageing population. Still, it should be kept in mind that additional methodological studies are needed to further validate the functional profiles used, such as comparing the patterns of combinations across samples representing different populations. Also, it is important to keep in mind that functional profiles based on HE assessments are dominated by physical and perceptual functional limitations. In order to validly include the plethora of cognitive functional limitations

based on today's knowledge on cognitive decline, considerable methodological efforts are required. With the high prevalence of dementia in the ageing population, this is a study limitation that should not go unnoticed.

When it comes to the statistical analyses they were straightforward and of basic descriptive nature. Still, the results presented should be useful since the sample of dwellings is representative of the Swedish ordinary housing stock. Reflecting upon to what extent the results could be generalized to other national contexts, we are well aware of that there are differences in housing design and housing standard across countries. Considering the results of a previous cross-national European study on housing accessibility [57] and recent studies accomplished in the U.S. [29-30], the differences between countries might be smaller than expected.

As to the simulation technique used, such approaches are more familiar in public health research [see e.g., 58-59]. Using simulation techniques in an occupational therapy context is rare, but with the present study we demonstrate the potential of such approaches to nurture the development of occupational therapy research. However, since the use of simulations at best could be used for estimations, research using RCT designs is warranted to evaluate the actual effects of the elimination of environmental barriers on housing accessibility.

### **Conclusions and implications**

The results of the present study indicate that the elimination of the environmental barriers most commonly addressed by individual housing adaptation could result in a considerable reduction of the housing accessibility problems that community-living older people are facing. Given the extent of these problems there are limited possibilities for society to solve the housing situation

for the ageing population without well-informed and efficient upgrading of the existing housing stock. Research based on valid and reliable methodology for housing accessibility assessments and occupational therapy expertise can be used to inform housing policy and housing industry practices as they target the needs of the ageing population.

### **Conflict of interest**

The Housing Enabler instrument is a commercial product sold by Veten & Skapen HB and Slaug Enabling Development, with Iwarsson and Slaug as copyright holders and owners. The remaining authors have no conflicting interests. The authors alone are responsible for the content and writing of the paper.

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## TABLES

**Table 1.** Distribution of the Swedish population 65 years or older living in ordinary housing, on type of dwelling and building period (N = 1,759,000) <sup>a</sup>.

	Building period, years						Total	
	-1960		1961-1980		1981-			
Type of housing	n (column; row %)		n (column; row %)		n (column; row %)		n (column; row %)	
Multi-dwelling block	396 410	(55;49)	299 330	(46;37)	113 260	(29;14)	809 000	(46;100)
One-family house	323 000	(45;34)	351 500	(54;37)	275 500	(71;29)	950 000	(54;100)
All dwellings	719 410	(100;41)	650 830	(100;37)	388 760	(100;22)	1 759 000	(100;100)

<sup>a</sup> According to Statistics Sweden 2014, the total population aged 65 or older was 1,926,300. Accordingly, 167,300 were living in special housing [35].

**Table 2.** Description of functional profiles representing older people with functional limitations of different complexity <sup>a</sup>.

Functional profile (ranked according to increasing complexity)	Functional limitations included
1. Limitations in movement	<i>At least one of...</i> <ul style="list-style-type: none"> <li>- poor balance</li> <li>- incoordination</li> <li>- limitations of stamina</li> <li>- difficulty in moving head</li> <li>- reduced spine and/or lower extremity function</li> </ul>
2. Limitations in movement + limitations in upper extremity	<i>In addition to above, at least one of...</i> <ul style="list-style-type: none"> <li>- loss of upper extremity function</li> <li>- reduced fine motor skills</li> <li>- loss of upper extremity function</li> </ul>
3. Limitations in movement + limitations in upper extremity + dependence on walking aids	<i>In addition to above, at least one of...</i> <ul style="list-style-type: none"> <li>- dependence on walking aids</li> <li>- dependence of wheelchair</li> </ul>
4. Limitations in movement + limitations in upper extremity + dependence on walking aids + visual impairment	<i>In addition to above, one of...</i> <ul style="list-style-type: none"> <li>- visual impairment</li> <li>- blindness</li> </ul>

<sup>a</sup> [9, 11, 44]

**Table 3.** Differences in occurrence in 609 <sup>a</sup> dwellings from different building periods of five environmental barriers frequently at target for housing adaptations in Sweden <sup>b</sup>.

Environmental barrier	Multi-dwelling blocks (n=416)				One-family house (n=193)			
	Before 1960 <sup>c</sup> (n=141) (%)	1960-1979 (n=153) (%)	1980- (n=122) (%)	P-value	Before1960 <sup>c</sup> (n=95) (%)	1960-1979 (n=72) (%)	1980- (n=26) (%)	P-value
Stairs the only route (no lift/ramp) at entrances	66	39	13	<b>&lt;0.001</b> <sup>1,2,3</sup>	80	58	46	<b>&lt;0.001</b> <sup>1,3</sup>
Steps/thresholds/differences in level between rooms	65	56	29	<b>&lt;0.001</b> <sup>2,3</sup>	82	83	81	0.932
No grab bar at shower/bath and/or toilet in hygiene area	52	44	55	0.143	79	86	81	0.628
Bathtub instead of shower space	55	48	30	<b>&lt;0.001</b> <sup>2,3</sup>	25	28	4	<b>0.037</b> <sup>2,3</sup>
Shower stall with kerb/ level difference	20	35	32	<b>0.010</b> <sup>1</sup>	56	42	35	<b>0.049</b>

<sup>a</sup> Data from two Swedish research databases. <sup>b</sup> Thresholds, installation of grab bars, installation of ramps, and adaption of hygiene areas [14]. <sup>c</sup> Building period, year.

Note: Bolded P-values indicate a significant result of the test between the three groups. Post-hoc pair-wise comparisons that were significant after Bonferroni correction are indicated as follows: <sup>1</sup>Before 1960 vs. 1960-1979, <sup>2</sup> Before 1960 vs. 1980-, <sup>3</sup>1960-1979 vs. 1980-.

**Table 4.** Effects on accessibility based on simulation of a targeted elimination of five selected environmental barriers <sup>a</sup> in multi-dwellings blocks in relation to building period and different functional profiles.

Building period, years	Functional	Functional	Functional	Functional
	profile 1	profile 2	profile 3	profile 4
Median (relative reduction, %)				
Before 1960 (n=141)				
Accessibility problem score without targeted barrier elimination	37	57	141	175
Total effect on accessibility problem score, with all five barriers eliminated	-13 (32)	-14 (22)	-25 (16)	-31 (16)
1960-1979 (n=153)				
Accessibility problem score without targeted barrier elimination	32	50	131	165
Total effect on accessibility problem score, with all five barriers eliminated	-5 (17)	-5 (10)	-16 (11)	-20 (11)
1980- (n=122)				
Accessibility problem score without targeted barrier elimination	24	45	108	135
Total effect on accessibility problem score, with all five barriers eliminated	-3 (14)	-3 (7)	-9 (8)	-10 (7)

<sup>a</sup> Corresponding to thresholds, installation of grab bars, installation of ramps, and adaption of hygiene areas [14].

Note: The functional profiles are presented in Table 2. Simulations utilizing housing data from two Swedish research databases, (multi-dwellings, n=416). The five environmental barriers generate more points for accessibility problems the more complex functional profile they are related to. Theoretical min-max values; Profile 1: 0-73, Profile 2: 0-105, Profile 3: 0-265, Profile 4: 0-335.



**Table 5.** Effects on accessibility based on simulation of a targeted elimination of five selected environmental barriers <sup>a</sup> in one-family houses in relation to building period and functional profiles.

	Functional profile 1	Functional profile 2	Functional profile 3	Functional profile 4
Building period, years	Median (relative reduction, %)			
Before 1960 (n=95)				
Accessibility problem score without targeted barrier elimination	38	59	147	187
Total effect on accessibility problem score, with all five barriers eliminated	-16 (35)	-17 (24)	-32 (19)	-39 (18)
1960-1979 (n=72)				
Accessibility problem score without targeted barrier elimination	33	51	132	164
Total effect on accessibility problem score, with all five barriers eliminated	-13 (35)	-14 (23)	-25 (17)	-31 (17)
1980- (n=26)				
Accessibility problem score without targeted barrier elimination	30	51	128	160
Total effect on accessibility problem score, with all five barriers eliminated	-5 (24)	-5 (12)	-16 (13)	-20 (13)

<sup>a</sup> Corresponding to thresholds, installation of grab bars, installation of ramps, and adaption of hygiene areas [14].

Note: The functional profiles are presented in Table 2. Simulations utilizing housing data from two Swedish research databases, (one-family houses, n=193). The five environmental barriers generate more points for accessibility problems the more complex functional profile they are related to. Theoretical min-max values, Profile 1: 0-73, Profile 2: 0-105, Profile 3: 0-265, Profile 4: 0-335.

**Table 6.** Number of individuals in the population 65 years or older living in multi-dwelling blocks or one-family houses, respectively, that would be affected if the five environmental barriers most often eliminated with housing adaptations <sup>a</sup> were targeted, related to building period.

Environmental barrier to be eliminated	Multi-dwelling blocks				One-family houses			
	-1960 <sup>b</sup>	1961-1980	1981-	Total	-1960 <sup>b</sup>	1961-1980	1981-	Total
	n=396,410 <sup>c</sup>	n=299,330	n=113,260	n=809,000	n=323 000 <sup>c</sup>	n=351 500	n=275 500	n=950 000
Environmental barrier to be eliminated	Number of residents affected (%)				Number of residents affected (%)			
Stairs the only route (no lift/ramp) at entrances	261 630 (66)	116 739 (39)	14 724 (13)	393 093 (49)	213 180 (66)	138 890 (39)	35 815 (13)	387 885 (40)
Steps/thresholds/differences in level between rooms/floor spaces (indoors in general)	257 666 (65)	167 625 (56)	32 845 (29)	458 136 (57)	264 860 (82)	291 745 (83)	222 750 (81)	779 355 (82)
No grab bar at shower/bath and/or toilet (hygiene area)	206 133 (52)	131 705 (44)	62 293 (55)	399 501 (49)	167 960 (52)	154 660 (44)	151 525 (55)	474 145 (50)
Bathtub instead of shower space	218 026 (55)	143 678 (48)	33 978 (30)	395 682 (49)	177 650 (55)	168 720 (48)	82 650 (30)	429 020 (45)
Shower stall with kerb/level difference	79 282 (20)	104 766 (35)	36 243 (32)	220 291(27)	64 600 (20)	123 025 (35)	88 160 (32)	275 785 (29)

<sup>a</sup> Thresholds, installation of grab bars, installation of ramps, and adaption of hygiene areas [14].

<sup>b</sup> Building period (year).

<sup>c</sup> Number of persons 65 years or older estimated to live in multi-dwellings built during that period [35].

**Table 7.** Number of dwellings that need to be addressed to eliminate the five selected environmental barriers most often eliminated with housing adaptations <sup>a</sup> in the in the total stock of one-family houses and multi-dwellings in Sweden, respectively, and related to building period.

Environmental barrier to be eliminated	Multi-dwelling blocks				One-family houses			
	-1960 <sup>b</sup>	1961-1980	1981-	Total	-1960 <sup>b</sup>	1961-1980	1981-	Total
	n=982 500 <sup>c</sup>	n=874 000	n=460 500	n=2 317 000	n=845 000 <sup>c</sup>	n=714 000	n=431 000	n=1 990 000
Environmental barrier to be eliminated	Number of dwellings affected (%)				Number of dwellings affected (%)			
Stairs the only route (no lift/ramp) at entrances	648 500 (66)	340 860 (39)	59 865 (13)	1 049 225 (45)	676 000 (80)	414 120 (58)	198 260 (46)	1 288 380 (65)
Steps/thresholds/differences in level between rooms/floor spaces (indoors in general)	638 625 (65)	489 440 (56)	133 545 (29)	1 261 610 (54)	692 900 (82)	592 620 (83)	349 110 (81)	1 634 630 (82)
No grab bar at shower/bath and/or toilet (hygiene area)	510 900 (52)	384 560 (44)	253 275 (55)	1 148 735 (50)	667 550 (79)	614 040 (86)	349 110 (81)	1 630 700 (82)
Bathtub instead of shower space	540 375 (55)	419 520 (48)	138 150 (30)	1 098 045 (47)	211 250 (25)	199 920 (28)	17 240 (4)	428 410 (22)
Shower stall with kerb/level difference,	196 500 (20)	305 900 (35)	147 360 (32)	649 760 (28)	473 200 (56)	299 880 (42)	150 850 (35)	923 930 (46)

<sup>a</sup> Thresholds, installation of grab bars, installation of ramps, and adaption of hygiene areas [14].

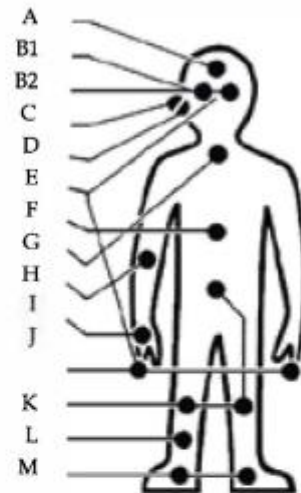
<sup>b</sup> Building period (years).

<sup>c</sup> Number of dwellings built during the defined period [35].

**Example of scoring for functional profile I: Limitations in movement only.**

Functional limitations

- A. Difficulty interpreting information
- B1. Visual impairment
- B2. Blindness
- C. Loss of hearing
- D. Poor balance
- E. Incoordination
- F. Limitations of stamina
- G. Difficulty in moving head
- H. Reduced upper extremity function
- I. Reduced fine motor skill
- J. Loss of upper extremity function
- K. Reduced spine and/or lower extremity function
- L. Dependence on walking aid(s)
- M. Dependence on wheelchair



Mark the observed environmental barriers with a cross. Then circle the scoring points (1–4) found at the intersections between functional limitations etc. and environmental barriers. The total of these scores is a quantification of the magnitude of accessibility problems.

Personal component / functional profile	Yes													RATING			
	A	B1	B2	C	D	E	F	G	H	I	J	K	L		M		
<b>A. Exterior surroundings</b>	X X X X X													X			
<b>General</b>																	
<b>A1. Paths narrower than 1.5 m.</b> <i>A width of 1.0 m is acceptable provided there are 1.5 m turning zones at least every 10 m.</i>	Byggnadskap														3 3	3 3	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Not rated
<b>A2. Irregular/uneven surface.</b> <i>(irregular surfacing, joints, sloping sections, cracks, holes; 5 mm or more).</i>	p. 304														3 1 3	1 3 3	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not rated
<b>A3. Unstable surface (loose gravel, sand, clay, etc).</b> <i>Mark if it causes difficulties e.g. when using a wheelchair or rollator.</i>	p. 305														2 3 3 3 2	1 3 4	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Not rated

**Figure 1.** Example of the generation of accessibility problem score for functional profile 1 by combining functional limitations of the profile with environmental barriers present in a specific dwelling. Reused under the Creative Commons License 4.0 International License. From Granbom M, Iwarsson S, Kylberg M, Pettersson C and Slaug B. A public health perspective to environmental barriers and accessibility problems for senior citizens living in ordinary housing. BMC Public Health. 2016; 16: 1-11.

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