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Lack of research-based standards for accessible housing: problematization and exemplification of consequences.

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Abstract

Objective

To increase the understanding of how definitions of standards for housing design influence the proportion of dwellings not meeting the standards and the proportion of individuals defined as having accessibility problems.

Methods

The sample was old people and their dwellings in three European countries (N=1,150). Frequencies and percentages were reported and empirical distribution functions were used.

Results

Depending on the functional profile and standard in questions, the magnitude of influence of the standards differs in extent. E.g., the existing standard for door openings at the entrance (defined ≥75cm) implied that the proportion of dwellings not meeting it was 11.3% compared to 64.4%, if the standard was set to ≥83cm. The proportion of individuals defined as having accessibility problems for profiles not using of mobility devices was 4-5%, 57% for profiles using them, while 1-3% for the total sample if the standard was set to 90cm.

Conclusion

Research-based standard definitions for housing design are necessary in order to ensure that they actually lead to enhanced accessibility, which is a prerequisite of independence and health for persons with functional limitations.

Keywords: Housing standards, social inclusion, older persons, functional limitations, public health.

Introduction

From a public health perspective, standards addressing accessible housing are crucial for people with functional limitations, as they aim at enabling mobility and the use of the environment as an arena for participation in a broad range of everyday activities. Restricted participation may occur due to barriers in the environment. A state of long-lasting exclusion from meaningful activities, due to circumstances beyond the control of the individual, can lead to health risks (Whiteford 2004). Applying this perspective, accessibility and participation are determinants of health (Christiansen and Townsend 2004). Public health has recognized that well-being and health cannot be separated from the environment, but has largely neglected to consider how some basic human needs relate to health, such as the ability to carry out daily activities (Wilcock 2006). In this study the design of accessible housing, as determined by standards for housing design, is viewed as a public health effort. To the best of our knowledge, empirical research based on this perspective is virtually non-existent.

The formal definition of a *standard* is "a document for common and repeated use, to be used as a rule, guideline or definition" (www.cen.eu). Standards for housing design are compulsory and enacted at national levels, such as the American disability act (ADA) (www.ada.gov) or the Danish building regulation (www.bygningsreglementet2010.dk). According to the Committee for Standardization (CEN), accessibility is gaining more importance as already 10% of the European population (40 million) has functional limitations. Viewed in the light of the growing ageing population, standards have their place next to policy in order to integrate accessibility (www.cen.eu). In some countries, differentiation between the terms *standard* and *norm* is being made, where norm refers to exact measures such as length, while in common language the term *standard* is often used interchangeably. Due to the international use of *standard*, we are using this term, referring to the definition and concrete measurement of the physical built housing design features. It is noteworthy that the results of recent European projects (Helle et al. 2010; Iwarsson et al. 2005), where systematic, cross-national analyses of standards for housing design were accomplished, demonstrated considerable variation as regards the definition of such standards. One example is the standard definition addressing door widths, varying from 77 - 90cm among four Nordic countries (Helle et al. 2010). It is inexpedient and problematic that definitions of the same standards vary among culturally comparable countries, because this variation impacts on the proportion of dwellings society considers to be accessible. This was elucidated also in another recent study evaluating national standards in

relation to wheeled mobility users across the United States, Canada, Britain and Australia (Steinfeld et al. 2010). Since designers make use of standards as an important information source during the process of designing accessible dwellings (Nickpou and Dong 2008), standards play a crucial role for citizens, professionals, and society at large. Accordingly, it is crucial that the knowledge informing standards is valid and moreover reflect inclusion of the intended population (Keates and Clarkson 2004). However, due to existing cross-national variation in standard definitions, it is reasonable to question the knowledge base informing current housing standards and invest in research contributing to enhanced validity in the definition of standards (Steinfeld et al. 2010).

Another problem related to standards is the fact that definitions of the concept of accessibility vary among designers, researchers and user organizations. The lack of a distinct and widely accepted definition is an essential problem in this field of research and practice (Iwarsson et al. 2005; Steinfeld et al. 2010). We use a definition, stating that accessibility is a relative concept, based on the assumption that activity limitations and restricted participation arise from the gap between the functional capacity of an individual or group and the environmental demands. This perspective implies that accessibility comprises a personal component and an environmental component (Iwarsson and Ståhl 2003), with accessibility problems expressed as a person-environment relationship (P-E-fit) (Lawton and Nahemow 1973). In this definition the standards are incorporated in the environmental component. Consequently, accessibility is objective in character as it can be observed and measured (Iwarsson and Ståhl 2003). Accordingly, standards determine whether design features are environmental barriers, potentially generating accessibility problems for persons with functional limitations, or not.

Since the knowledge base appeared to be vague, at the prospect of the current study we performed a comprehensive and systematic literature search. We searched for empirical research published during 1990-2010, resulting in measurable standard definitions with potential to inform housing design, and targeting adults with physical functional limitations. We also contacted 21 leading researchers in the field, and manually inspected the 2008-2010 issues of 22 scientific journals. In all, we screened 2,879 publications and read the full text of 35, and finally identified seven publications. While none of them targeted housing specifically, they pointed out significant sex differences in design requirements (Pacquet, Feathers 2004; Koey, Das 2004; Das, Kozey 1999), and that current standards are not updated and do not support design adequately. It was concluded that since the standards do not reflect the body structure and functional capacity of

the population with disabilities and the use of today's mobility devices, research-based revisions of current standards are required (Steinfeld et al, 2010; D'Souza, Steinfeld et Pacquet, 2009; Steinfeld, Pacquet, Feathers 2004; Ringaert et al. 2001).

Awareness of demographic circumstances is important for planning and housing provision. By 2050, the older population is expected to grow more rapidly than other age groups in Europe and will reach 22% aged ≥ 60 years in 2050 (http://www.un.org/esa/population/publications/WPA2009/WPA2009_WorkingPaper.pdf). It is critical to bear in mind that the majority of persons with functional limitations is older and that the frequency, complexity and severity of functional limitations increase with age (Crews and Zavotka 2006) . In Sweden, 50% of wheelchair users are ≥ 80 years, of whom 80% utilize a wheelchair indoors. As to rollators, 95% of users in Sweden are ≥ 65 years old, of whom 2/3 are over 80 and 50% use a rollator indoors (Statistics Sweden 2005).Since older people spend most of the day in their home (Heyl et al. 2005), the design of the housing environment is important for maintaining independence and the ability to perform everyday activities (Letts et al. 2003).

The use of epidemiological data on functional capacity in different user groups could serve to increase the knowledge of the extent to which environmental barriers yield accessibility problems and for whom (Keates and Clarkson 2004). One challenge is that existing databases and national censuses do not have sufficiently detailed data on housing design and functional limitations in the population (Slaug et al. 2010). Another challenge is the fact that older people seldom have only one functional limitation. In order to support the provision of accessible housing, definitions of standards should be based on the occurrence of typical combinations of functional limitations in the population. Accordingly, the aims of this study were to increase the understanding of how different standards for accessible housing design influence 1) the proportion of dwellings not meeting the standards, 2) the proportion of individuals defined as having accessibility problems.

Methods

Data for the present study were drawn from the ENABLE-AGE database, comprising data on home and health among single-living, very old persons in ordinary dwellings in five European countries (Iwarsson et al. 2004). Data concerning housing accessibility were collected by means of the Housing Enabler instrument (Iwarsson and Slaug 2001). Due to validity issues concerning the data on environmental barriers, for the present study, we used data from three of the national samples: Germany, Latvia, and Sweden (N=1,150), see Table 1.

Table 1in here

The Housing Enabler instrument consists of two components that are dichotomously assessed (present/absent): 1) a personal component comprising 13 items on functional limitations and two on dependence on mobility devices; 2) an environmental component comprising 188 items on environmental barriers in the dwelling and the immediate outdoor environment, incorporating national standards on housing design. Based on the assessments of the two components, an accessibility score is calculated by means of a matrix comprising predefined severity ratings ranging from 1–4 (1 = lowest, 4 = highest demand), where the individual functional profile defined is juxtaposed with the environmental barriers found present. In this way, the magnitude of accessibility problems in each case is calculated.

Prior to the ENABLE-AGE data collection (Iwarsson et al. 2004), a research version of the Housing Enabler instrument (Iwarsson and Slaug 2001) was developed and tested for inter-rater reliability, indicating moderate to good overall agreement. This process required a systematic analysis of the national standards for housing design of the countries involved (Iwarsson et al. 2005). This methodological endeavor revealed that in 22 of the 188 environmental items, the variation in the national standard definitions was substantial. Therefore, the subsequent data collection included supplementary recordings of exact measurements within predefined measurement intervals each time any of these 22 items was rated as "not present." Data on ten of these items were applicable to study the proportion of dwellings not meeting different standards (see Table 3). Of these, four standards were chosen due to their exemplification value and further used in the investigation of how standards influence the proportion of individuals defined as having accessibility problems (Figures 1–4).

Data analyses

The proportions (%) of dwellings not meeting the standards were calculated. First, for each item the proportions of dwellings in the three national samples and cross-national totals not meeting the existing standards were calculated. Then, based on the mean of the exact measurements recorded for each of the 22 items, two alternative standard definitions were determined. The alternative standards were defined in order to present lower environmental demands. That is, potentially they generate less accessibility problems for persons with functional limitations. Thereafter, the proportions of dwellings not meeting the alternative standards were calculated, to explore how different definitions of the same standards impact on the proportion of dwellings considered being accessible. In cases where measurements were lacking, data were categorized as missing.

In order to explore how the standards influence the proportion of individuals defined as having accessibility problems, four different type profiles of combinations of physical functional limitations among very old persons (Slaug et al. 2010) were analyzed against the four environmental barrier items selected. Type profiles are combinations of up to six functional limitations and mobility device use. For this study we employed the following the four type profiles, as they were relevant in relation to the selected environmental barrier items and substantial in terms of sample size ($n \geq 100$): Mov: *Limitations in movement* (n = 265), Mov/MD: *Limitations in movement and dependence on mobility devices* (n = 100), Mov/UE: *Limitations in movement and upper extremities* (n = 122) and Mov/UE/MD: *Limitations in movement and upper extremities and dependence on mobility devices* (n = 105) (Table 2).

Table 2 in here.

In order to explore and demonstrate how the proportion of individuals defined as having accessibility problems is impacted by the definition of standards, proportions were analyzed for the four different type profiles and displayed by empirical distribution functions (Kirk and Sterne 2003). In Figures 1-4, the Y-axis shows the accumulated proportion of individuals defined as having accessibility problems and the X-axis shows measures in m, cm or mm, referring to the definitions of standards. On the X-axis the definition of standards, according to the ENABLE-AGE research version of the environmental component of the Housing Enabler instrument is marked.

Figures 1–4 allowed for two interpretations. That is, by visual graph inspection of the Y-axis, performed by the first author (TH) and subsequently validated by the third author (BS), it was possible to estimate the accumulated proportion of individuals defined as having accessibility problems for each of the type profiles. Next, inspection of the X-axis allowed for identification of critical cut-off points for determining the definition of a standard. Calculations were made in SPSS version 17.0.

Results

Different definitions of standards impact on the proportion of dwellings not meeting them, for several of the environmental barriers studied to a marked extent (Table 3). In our material this impact was most distinct for the standard for *door openings* at the entrance. The total proportion of dwellings not meeting the existing standard was 11.3%. If replacing this standard with an alternative definition representing the least environmental demand and hence the least potential accessibility problems, the redefinition of this standard from ≥ 75 cm to ≥ 83 cm, resulted in that the total proportion of dwellings not meeting this alternative standard increased to 64.6% (Table 3). Compared to the standard for *door openings* in other parts of the dwelling, the increase in the proportion of dwellings not meeting the alternative standard was not as distinct. The existing standard for *door openings* for entrance doors gave rise to less potential accessibility problems (11.3%) compared to doors to the balcony/terraces (37.2%) and indoors (67.7%). Moreover, when the existing standard for *door opening* indoors was replaced with the alternative standard representing the least environmental demand, the total proportion of dwellings not meeting this standard increased to 89.3%.

Replacing the standard for *passenger loading zones* with alternative standard definitions also gave rise to a noteworthy impact on the proportion of dwellings with potential accessibility problems. Applying the alternative standard definition representing the least environmental demand led to an increase by a factor of four for the total sample (from 10.4% to 41.9%), but for Sweden a factor of seven (from 5% to 35.8%).

For some of the existing standards there was a marked variation among countries see e.g. *parking spaces far from the entrance* or *stairs/thresholds/difference in level between rooms/floors* (Table 3).

Table 3 in here.

The four curves show that the proportion of individuals defined as having accessibility problems depends on the type profile and the standard in question (Figures 1–4).

Concerning the distance from *parking spaces* to the entrance (Figure 1), the curves demonstrated that the proportion of individuals defined as having accessibility problems was quite similar for the four type profiles. The existing standard at 50 m implied a proportion of 9-18% of the sample defined as having accessibility problems for all four type profiles, compared to 5% or less if the standard definition was altered to 25 m and 25-34% if the standard was set at >50 m. No critical cut-off could be defined for this standard, but the closer to a distance of 25 m, the lower the proportion of individuals defined as having accessibility problems.

When it came to the standard addressing *door openings* at entrances (Figure 2), the curves show that for the existing standard at ≥ 75 cm, the proportion of individuals within the type profiles not including the use of mobility devices defined as having accessibility problems was 4-5% compared to 57% within the type profiles including the use of mobility devices. If this standard was defined to ≥ 90 cm, only 1–3% of the total sample was defined to have accessibility problems. The curves of the two type profiles including the use of mobility devices decreased dramatically along with lowering the environmental demand concerning door width.

As regards *handrails placed too high* (Figure 3), the curves show that the existing standard at 80 cm height resulted in the lowest proportion of individuals defined as having accessibility problems for all type profiles. The proportion of individuals defined as having accessibility problems increased most markedly when the standard was defined to 90-100 cm.

The standard concerning *stairs/thresholds/difference in level between rooms/floor spaces* (Figure 4) demonstrated that the proportion of individuals defined as having accessibility problems applying the existing standard was 40-51% for the two type profiles including the use of mobility devices, compared to 12-20% for the two without. The critical cut-off point was at a 20 mm for the type profiles including the use of mobility devices, but at 15 mm only 3-7 % of the total sample was defined as having accessibility problems.

Figures 1-4 in here.

Table 4 summarizes to which extent the existing standards impact on the proportion of individuals defined as having accessibility problems, compared to the alternative definitions representing the least environmental demands.

Table 4 in here.

Discussion

To the best of our knowledge, the results of the current study are quite unique in that they provide new insights into the role of definition of standards for housing design. The main contribution is the innovative exploration of how standards influence accessibility for persons with different combinations of physical functional limitations and use of mobility devices typical for very old people, and the examination of how standards impact on the proportion of dwellings considered as accessible. As clearly demonstrated by the results, the definitions of standards determines the proportion of dwellings with environmental barriers and the proportion of individuals defined as having accessibility problems. Depending on the functional type profile and standard in question, the magnitude of influence of the standards differs in extent. According to the extrapolations of accessibility problems (Figures 1-4), type profiles including the use of mobility devices are more sensitive to the housing design. That is, accessibility problems for the individuals represented by these type profiles decrease with standard definitions representing less environmental demand, which is in line with anthropometric research (Pacquet and Feathers 2004). Moreover, for some standards the alternative definitions representing less environmental demands has a marked impact on the proportion of dwellings that do not meet these alternative standards. Thus, from a planning perspective these explorations indicate the importance of determining standards on a qualified decision base, as the definition of standards has implications for the proportion of individuals that potentially have accessibility problems and the proportion of dwellings that society considers as accessible.

Another important contribution is the methodology employed, allowing for specific reading of the consequences of redefining the environmental demand of the standard definitions and hence, the investigation of which groups of persons that will be in- or excluded by the definition of standards (Keates and Clarkson 2004). Our findings support current conclusions stressing the necessity to apply

research results to policy and standard development (Steinfeld et al 2010) in order to ensure that the standards actually lead to enhanced accessibility for the intended population.

Seen in the light of the magnitude of influence that standard definitions have on housing design and accessibility problems, it is potential public health problem if the standards do not enable mobility and participation. Based on the results of our initial literature review, we conclude that the expertise and understanding informing the standards, suffers from *knowledge instability* (Persson and Sahlin 2008). That is, there is a lack of research supporting the definition of standards, which may also explain why standards for housing design vary among countries and over time (Helle et al. 2010; Iwarsson et al. 2005). Considering the number of persons living with functional limitations and the increasing ageing population, research contributing to development of standards leading to the design of accessible environments is important to accommodate the well being and health (Wilcock 2006).

Moreover, it is interesting to note that in the literature review, although limited to studies on physical functional limitations among adults, the seven publications included only targeted wheeled mobility users (Steinfeld et al. 2010; D'Souza et al. 2009; Paquet and Feathers 2004; Kozey and Das 2004; Steinfeld, Paquet and Feathers 2004; Ringaert et al. 2001; Das and Kozey 1999). Viewed in the light of the fact that there is a much larger proportion of e.g. rollator users in the older population (U.S. Department of Commerce 2002; Kaye et al. 2000), there is a research gap as related to the development of standards. Maybe researchers prioritize wheelchair users since this group is considered to have the largest implication on housing design. Nevertheless, persons using other mobility devices may encounter different kinds of accessibility problems, deserving explicit attention. In fact, since only 15 persons in our large study sample used a wheelchair compared to 380 persons using other types of mobility devices (about the half were rollator users), we now know that mobility device users in general make large demands on the housing design, which to the best of our knowledge was hitherto unknown. According to Kozey and Das (2004), also when it comes to the number of sub-groups within the wheelchair user population, more knowledge is needed in order to be able to design environments that match the requirements of these individuals. In other words, there is a need to generate more knowledge on person-environment fit interactions in order to ensure access for as many as possible (Keates and Clarkson 2004).

From a public health perspective the development of valid standards will benefit health promotion and prevention ill health for persons with functional limitations (Wilcock 2006). Accordingly, it is problematic if assumptions and convictions rather than empirical investigations will continue to inform the definitions of standards. Research has shown that that very old people want to have an active everyday life and participate in society (Dahlin-Ivanoff et al. 2007: Haak et al. 2007) and that those living in accessible housing perceive their dwellings as more meaningful and useful in relation to carrying out daily activities (Oswald et al. 2007). Therefore, considerations of such aspects of housing have implications for healthy ageing in place. Although public health acknowledges environments as being imperative to health (Andersson and Ejlertsson 2009) research targeting the relationship of housing design and health are seldom addressed. In this respect, the development of standards leading to the design of home environments supporting activity and participation is important.

Still, it should be noted that there are critical viewpoints concerning standards for housing design, stressing that the understanding of housing design according to ergonomic standards and criteria of technical efficiency alone is too one-sided a perception (Imrie 2006). According to the proponents of this perspective, standards are deterministic and reflect a reductionist perspective (Burns 2004). While we do acknowledge the relevance of this criticism, we nevertheless argue that valid standards are imperative in order to provide designers with such specifications as a management tool. Ambitions to conduct research on standards addressing accessibility instead of universal design, could also be questioned, as universal design is gaining increasing international interest among researchers, user organizations, professionals and politicians. The prerequisite of universal design is an existing knowledge base guiding designers in designing for as many as possible, but given that the knowledge base within the field of housing design still is very limited, standards are important to guide the design process. However, since accessibility is an objective concept, it does not reflect how persons with functional limitations actually perceive the interaction with the environment. Since other studies based on the ENABLE-AGE data has shown that there are complex relations ships between objective and perceived housing (Nygren et al. 2007), future research should also incorporate user perceptions and needs.

One of the strengths of this study is the large empirical data material, based on extensive data collection with very old, single-living Europeans with great variation in housing type, of whom only 155 of the total sample (N=1,150) reported having had housing adaptations. The analysis involving four type profiles of combinations of typical physical functional limitations (Slaug et al. 2010) is a novel and promising approach for future research as older persons and persons with disability often have several and different functional limitations in combinations (Kaye et al. 2000). Still, the type profiles represent a first exploratory step of using a methodology novel to this area, and further research is required in order to strengthen their validity, which must be considered when interpreting the results. It should also be kept in mind that although the material is based on real observations, the results presented are theoretical constructions. That is, as long as the standards incorporated in the data collection instrument used have unknown validity, we cannot know if the results reflects the reality. However, the extrapolations and graphical illustrations indicate tendencies on a qualified basis since they are based on a large data material, a well-defined concept of accessibility and a data collection instrument tested for validity and reliability (Iwarsson and Slaug 2001). Since the data were collected for other purposes, the material available was limited, whereas we might have chosen to study standards for other design features if that had been an option.

To conclude, this study represents a critical stance on how housing standards are defined. Magnitudes of accessibility problems to a great extent depend on how standards are defined, and that the determination of standards is of great importance to the proportion of dwellings that society considers accessible. Seen in the light of the crucial role that of standards for housing design play to society at large, the study stresses the need of research contributing to the development of research-based standard definitions for accessible housing design in order to promotion health and prevent ill health for persons with functional limitations.

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Table 1. Sample characteristics of 1,150 single-living, very old persons in ordinary dwellings in three European samples – in the study: Lack of research-based standards for accessible housing: problematization and exemplifications of consequences, Sweden (2011).

Characteristic	German sample n=450 (%)	Latvian sample N=303 (%)	Swedish sample N=397 (%)	Total sample N=1,150 (%)
Age				
75-79	-	197 (65.0)	-	197 (17.2)
80-84	212 (47.1)	106 (35.0)	200 (50.4)	518 (45.0)
85-89	238 (52.9)	-	197 (49.6)	435 (37.8)
Sex				
Men	97 (21.6)	35 (11.6)	101 (25.4)	233 (20.3)
Women	353 (78.4)	268 (88.4)	296 (74.6)	917 (79.7)
Use of mobility device				
Wheelchair	4 (0.9)	2 (0.7)	9 (2.3)	15 (1.3)
Rollator	57 (12.6)	5 (1.7)	116 (29.2)	178 (15.5)
Other	85 (18.9)	69 (22.8)	48 (12.1)	202 (17.6)
Housing type				
Apartment in block of flats	383 (85.1)	269 (88.8)	340 (85.6)	992 (86.3)
One-family housing	67 (14.9)	34 (11.2)	57 (14.4)	158 (13.7)

Table 2. Occurrence of functional limitations and dependence in mobility devices for each of the four type profiles in the database used (N=1,150) in the study: lack of research-based standards for accessible housing: problematization and exemplifications of consequences (2011).

Functional limitation	Mov[a] n=265 (%)	Mov/MD[b] n= 100 (%)	Mov/UE[c] n=122 (%)	Mov/UE/MD[d] n= 105 (%)
Prevalence of poor balance	100 (37.7)	60 (60.0)	56 (45.9)	71 (67.6)
Incoordination	14 (5.3)	12 (12.0)	19 (15.6)	18 (17.1)
Limitations of stamina	148 (55.8)	62 (62.0)	71 (58.2)	80 (76.2)
Difficulties in moving head	20 (7.5)	12 (12.0)	30 (24.6)	34 (32.4)
Difficulty in reaching with arms	0 (0.0)	0 (0.0)	72 (59.0)	72 (68.6)
Difficulty in handling and fingering	0 (0.0)	0 (0.0)	65 (53.3)	71 (67.6)
Loss of upper extremity skills	0 (0.0)	0 (0.0)	13 (10.7)	15 (14.3)
Difficulty in bending, kneeling, etc.	203 (76.6)	90 (90.0)	91 (74.6)	97 (92.4)
Reliance on walking aids	0 (0.0)	99 (99.0)	0 (0.0)	105 (100.0)
Wheelchair user	0 (0.0)	3 (3.0)	0 (0.0)	4 (3.8)

Mov[a] = Limitation in movement, Mov/MD[b] = limitation in movement and dependent in mobility devices, Mov/UE[c] = limitations in movement and upper extremities, Mov/UE/MD[d] = limitations in movement and upper extremities and dependence in mobility devices.

Table 3. The cumulative proportion of dwellings not meeting different definitions of standards used to define environmental barriers in three national samples (N=1,150), starting from the existing standard definitions followed by two alternative ones representing lesser environmental demands – in the study: lack of research-based standards for accessible housing: problematization and exemplification of consequences (2011).

Existing and alternative standard definitions of environmental barriers	German sample n=450	Latvian sample n=303	Swedish sample n=395	Total sample N=1,150
OUTDOOR ENVIRONMENT				
Parking spaces far from the entrance (≥50m)[a]	13.6%[a]	5.0%[a]	21.4%[a]	14.0%[a]
Alternative 1: 40-49m[b]	28.4%[b]	-	34.5%[b]	23.1%[b]
Alternative 2: 25-39m[b]	36.4%[b]	-	41.8%[b]	28.8%[b]
Passenger loading zones far from the entrance (≥100m)[a]	21.1%[a]	1.7%[a]	5.0%[a]	10.4%[a]
Alternative 1: 27-99m[b]	54.2%[b]	-	24.7%[b]	29.8%[b]
Alternative 2: 10-26m[b]	72.2%[b]	-	35.8%[b]	41.9%[b]
Marked handicap parking is lacking or too far from the entrance (≥100m)[a]	88.9%[a]	65.0%[a]	70.0%[a]	76.1%[a]
Alternative 1: 47-99m[b]	-	-	77.3%[b]	78.3%[b]
Alternative 2: 10-46m[b]	-	-	81.6%[b]	81.3%[b]
ENTRANCES				
Narrow door-openings (≤75cm)[a]	7.0%[a]	23.4%[a]	6.8%[a]	11.3%[a]
Alternative 1: 76-82cm[b]	27.8%[b]	40.9%[b]	55.7%[b]	40.9%[b]
Alternative 2: 83-90cm[b]	46.2%[b]	58.1%[b]	90.4%[b]	64.6%[b]
High threshold and/or steps at the entrance (≥25mm) [a]	67.6%[a]	23.4%[a]	77.8%[a]	74.9%[a]
Alternative 1: 22-24mm[b]	-	-	86.1%[b]	78.5%[b]
Alternative 2: 15-21mm[b]	-	-	79.8%[b]	79.3%[b]
Handrails placed too high(≥80cm)[a]	10.0%[a]	52.5%[a]	6.5%[a]	20.0%[a]
Alternative 1: 81-90cm[b]	-	79.2%[b]	34.5%[b]	37.7[b]
Alternative 2: 91-100cm[b]	-	86.5%[b]	64.5%[b]	50.1[b]
Narrow door-openings (balcony/terraces) (≤75cm)[a]	29.8%[a]	26.1%[a]	54.2%[a]	37.2%[a]
Alternative 1: 76-81cm[b]	42.9%[b]	-	76.6%[b]	43.4%[b]

Alternative 2: 82-90cm[b]	55.6%[b]	-	88.7%[b]	52.9%[b]
INDOOR ENVIRONMENT				
Stairs/thresholds/difference in level between rooms/floor spaces (≥25mm)[a]	24.9%[a]	60.1%[a]	47.4%[a]	41.9%[a]
Alternative 1: 22-24mm[b]	40.4%[b]	67.3%[b]	58.7%[b]	53.8%[b]
Alternative 2: 15-21mm[b]	43.3%[b]	70.6%[b]	76.3%[b]	61.9%[b]
Narrow passages/corridors in relation to fixtures/design of building (≤110m)[a]	58.9%[a]	39.6%[a]	39.8%[a]	47.2%[a]
Alternative 1: 129-160cm[b]	71.6%[b]	61.4%[b]	61.7%[b]	65.5%[b]
Alternative 2: 111-128cm[b]	81.3%[b]	71.6%[b]	82.1%[b]	79.0%[b]
Narrow door-openings (≤75cm)[a]	79.6%[a]	68.3%[a]	53.7%[a]	67.7%[a]
Alternative 1: 76-80cm[b]	84.4%[b]	80.2%[b]	86.1%[b]	83.9%[b]
Alternative 2: 81-90cm[b]	89.3%[b]	81.2%[b]	95.5%[b]	89.3%[b]

[a]Standards incorporated in the environmental component of the ENABLE-AGE research version of the Housing Enabler (Iwarsson and Slaug 2001; Iwarsson et al. 2005).

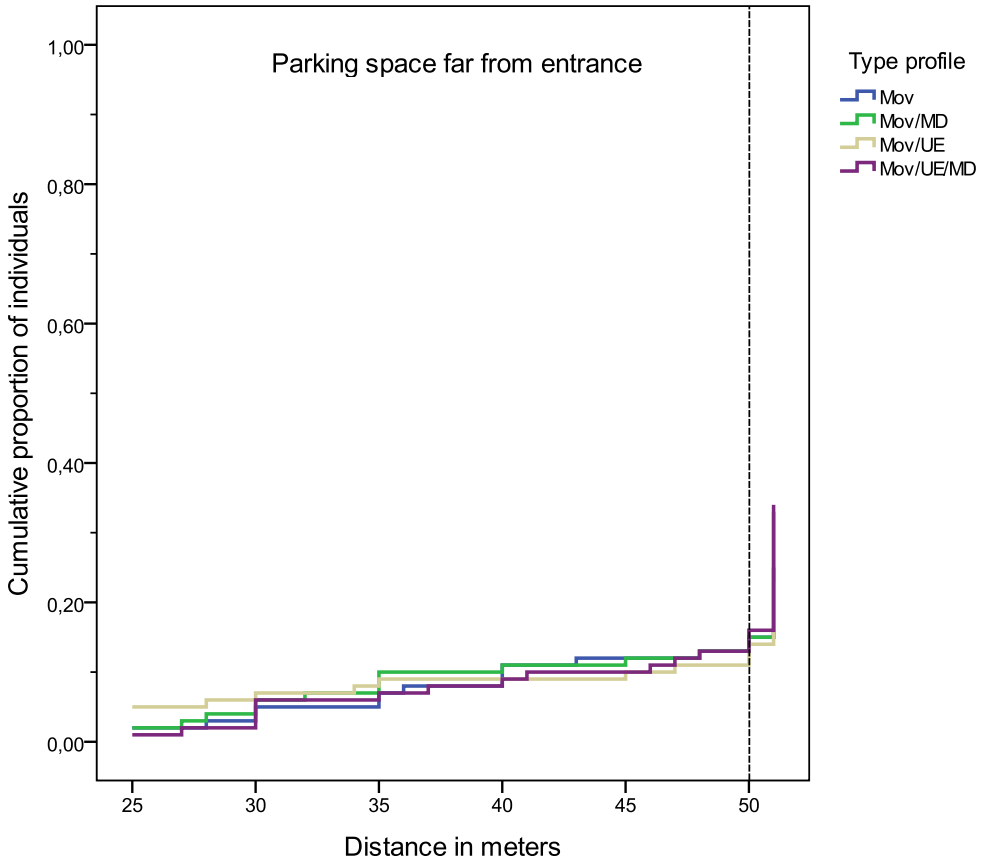
[b]Defined based on the mean of the exact measures recorded.

Note: Data treated as missing if measures were not recorded according to the data collection instructions.

Table 4 summarizes to which extent the existing standards compared to the alternative standard definitions representing the least environmental demands (between brackets) impacts on the proportion of individuals defined as having accessibility problems - in the study: Lack of research-based standards for accessible housing: problematization and exemplification of consequences, Sweden (2011).

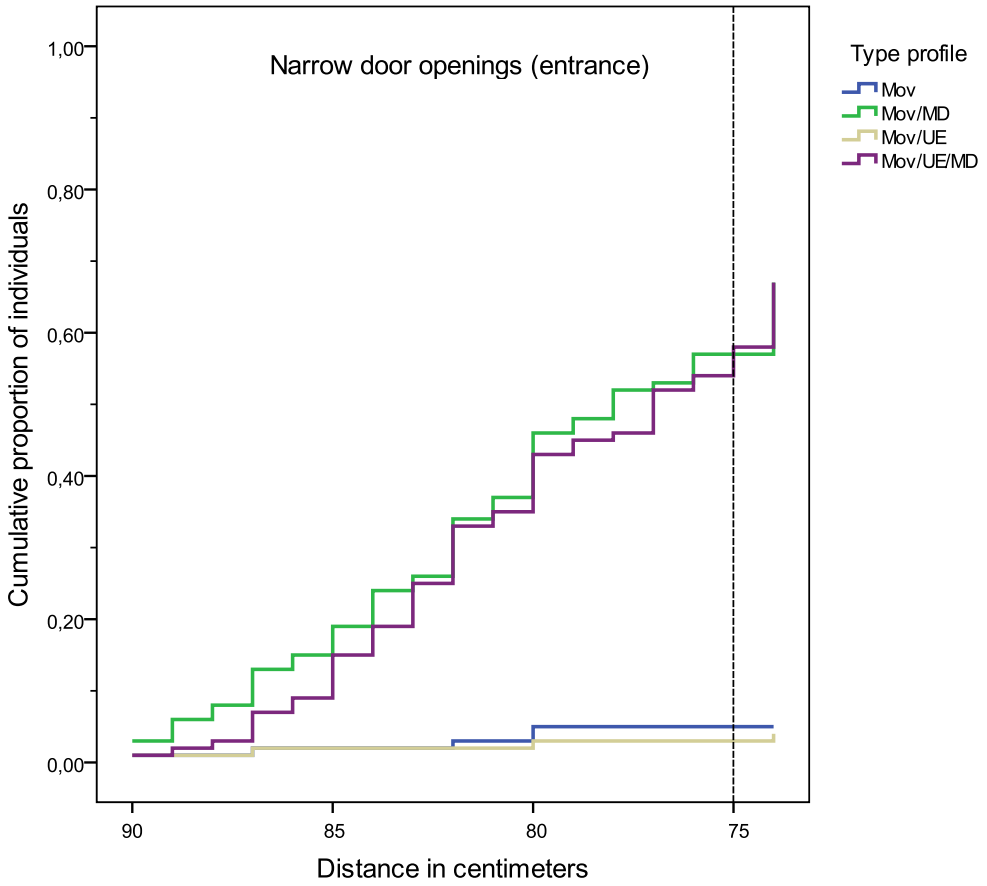
	Type profile			
	Mov[a]	Mov/MD[b]	Mov/UE[c]	Mov/UE/MD[d]
Environmental barrier				
	%	%	%	%
Parking space far from entrance	10 (25)	18 (33)	9 (23)	18 (34)
Narrow door openings (entrance)	0 (5)	10 (67)	1 (4)	9 (67)
Handrails placed to high	16 (31)	17 (48)	20 (37)	16 (44)
Stairs/thresholds/difference in level between rooms/floors	12 (24)	40 (63)	20 (39)	51 (68)

Mov[a] = Limitation in movement, Mov/MD[b] = limitation in movement and dependent in mobility devices, Mov/UE[c] = limitations in movement and upper extremities, Mov/UE/MD[d] = limitations in movement and upper extremities and dependence in mobility devices.



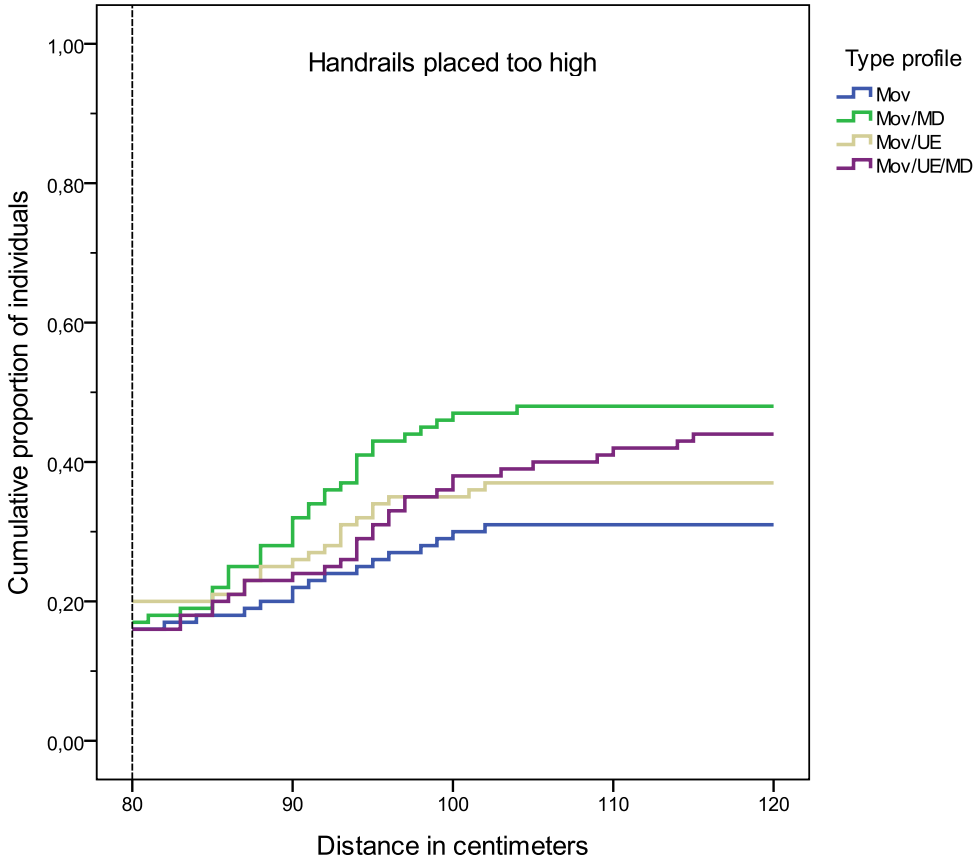
Mov = Limitation in movement, Mov/MD = limitation in movement and dependent in mobility devices, Mov/UE = limitations in movement and upper extremities, Mov/UE/MD = limitations in movement and upper extremities and dependence in mobility devices.

Figure 1. Curves displaying the cumulative proportion of individuals defined as having accessibility problems in the environmental barrier *parking space far from entrance* analyzed by means of four different type profiles of combinations of physical functional limitations, in three national samples (N=1,150) - in the study: lack of research-based standards for accessible housing: problematization and exemplification of consequences (2011).


Narrow door openings (entrance)
Type profile
Mov
Mov/MD
Mov/UE
Mov/UE/MD
Cumulative proportion of individuals
1,00
0,80
0,60
0,40
0,20
0,00
90
85
80
75
Distance in centimeters

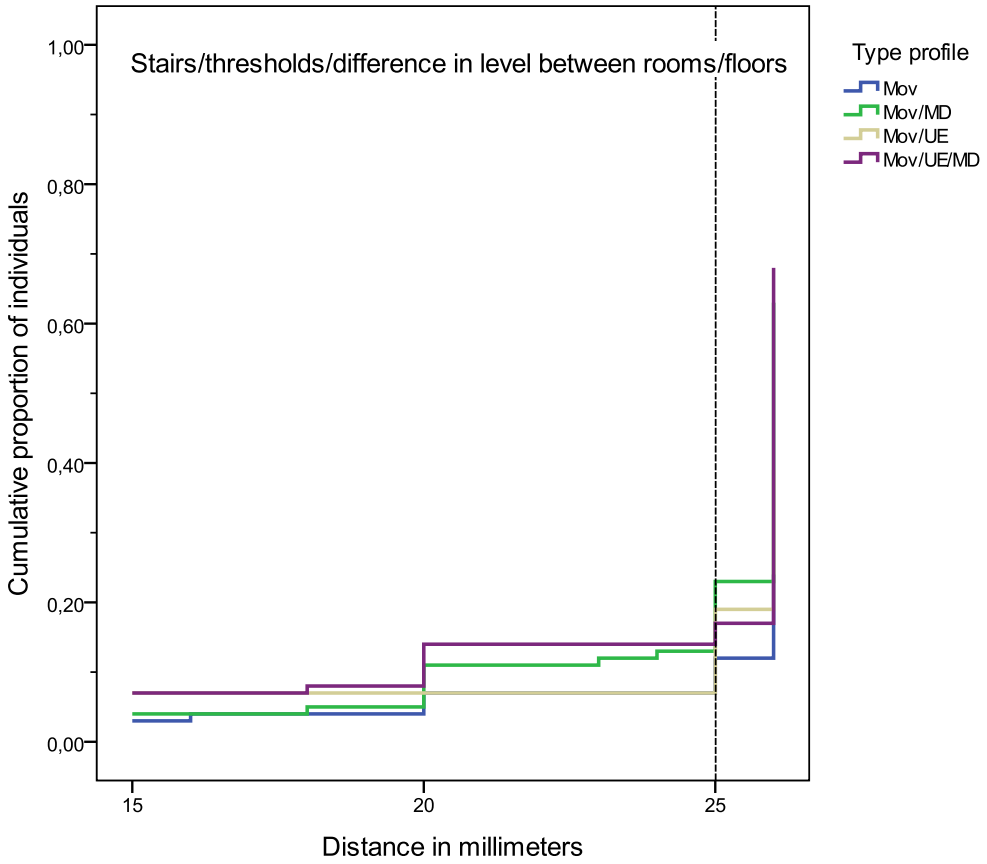
Mov = Limitation in movement, Mov/MD = limitation in movement and dependent in mobility devices, Mov/UE = limitations in movement and upper extremities, Mov/UE/MD = limitations in movement and upper extremities and dependence in mobility devices.

Figure 2. Curves displaying the cumulative proportion of individuals defined as having accessibility problems in the environmental barrier *narrow door openings (entrances)* analyzed by means of four different type profiles of combinations of physical functional limitations, in three national samples (N=1,150) - in the study: lack of research-based standards for accessible housing: problematization and exemplification of consequences (2011).



Mov = Limitation in movement, Mov/MD = limitation in movement and dependent in mobility devices, Mov/UE = limitations in movement and upper extremities, Mov/UE/MD = limitations in movement and upper extremities and dependence in mobility devices.

Figure 3. Curves displaying the cumulative proportion of individuals defined as having accessibility problems in the environmental barrier *handrails placed too high* analyzed by means of four different type profiles of combinations of physical functional limitations, in three national samples (N=1,150) - in the study: lack of research-based standards for accessible housing: problematization and exemplification of consequences (2011).



Mov = Limitation in movement, Mov/MD = limitation in movement and dependent in mobility devices, Mov/UE = limitations in movement and upper extremities, Mov/UE/MD = limitations in movement and upper extremities and dependence in mobility devices.

Figure 4. Curves displaying the cumulative proportion of individuals defined as having accessibility problems in the environmental barrier *stairs/thresholds/difference in level between rooms/floor spaces* analyzed by means of four different type profiles of combinations of

physical functional limitations, in three national samples (N=1,150) - in the study: lack of research-based standards for accessible housing: problematization and exemplification of consequences (2011).