Housing Accessibility Methodology Targeting Older Poeple - Reliable Assessments and Valid Standards

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Thesis at a glance

Study I. The Nordic Housing Enabler: Inter-rater Reliability in Cross-Nordic Occupational Therapy Practice	
Aim	To develop a content-valid cross-Nordic version of the Housing Enabler and to investigate its inter-rater reliability when used in realistic situations in occupational therapy practice.
Methods	Systematic analysis on harmonization of national standards. The two-panel approach was applied for translation. Twenty raters made 106 pair-wise assessments. Percentage agreement and Kappa statistics were calculated.
Results	Overall good percentage agreement was found. Varying Kappa results demonstrated a need to further explore underlying reasons for this, e.g. prevalence.
Conclusions	The Nordic Housing Enabler was considered sufficiently reliable. There are threats to inter-rater reliability, e.g. rater training which should not be underestimated.
Study II. Unfolding the Phenomenon of Inter-rater Agreement: A Multi-component Approach for In-depth Examination	
Aim	To unfold the concept of inter-rater agreement and explore statistical analyses to identify potential sources of disagreement as predictors of inter-rater agreement variation.
Methods	In addition to common agreement indices, relative shares of agreement variation were calculated. Multilevel regression analysis was carried out, using rater and item characteristics as predictors of agreement variance.
Results	The raters accounted for 6-11% of the agreement variation, the items for 33-39% and the residual for 53-60%. Multilevel regression analysis showed that barrier prevalence and raters' familiarity with using standardized instruments had the strongest impact on agreement.
Conclusions	Supported by a conceptual analysis, we propose an approach of in-depth examination of agreement variance, as a strategy for increasing the level of inter-rater agreement.
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Methods	The sample consisted of 1,150 older people and their dwellings. Frequencies and percentages were reported and empirical distribution functions used.
Results	Definitions of standards determine the proportion of dwellings with environmental barriers and the proportion of persons defined as having accessibility problems. The magnitude of influence depends on the functional capacity of the person and the standard in question.
Conclusions	Research-based standard definitions for housing design are necessary to ensure that they actually lead to enhanced accessibility.
Study IV. Validation of Housing Standards Addressing Accessibility – Exploration of an Activity-based Approach	
Aim	To investigate the validity of a set of housing standards addressing accessibility through an activity-based approach. This included the examination of accessibility problem differences among those without mobility devices, those using a rollator and those using a wheelchair, as well as examination of differences in data obtained by observation and self-report.
Methods	Thirty participants performed an activity in a kitchen designed according to current housing standards. Frequencies of accessibility problems were reported and statistical tests performed to investigate accessibility problem differences among the participants and differences in data obtained by observation and data obtained by self-report.
Results	The overall validity of the standards was poor and some standards were not defined to support accessibility. Those using a wheelchair had most problems and those without mobility device had fewest problems. New knowledge was generated on the basis of observation, while the self-report did not provide additional knowledge.
Conclusions	The study supports the need for a revision of housing standards particularly to benefit those using a wheelchair or a rollator. Observation appears to be a valid method to assess accessibility. Accessibility occurs on the basis of interaction between person, environment, mobility device and activity. Hence, an activity-based approach is a feasible approach to the investigation of the validity of housing standard definitions.

Definitions

Accessibility	The relationship between a person's functional limitations and an environment's demands (Iwarsson and Ståhl, 2003). The concept is based on the notion of person-environment fit (Lawton and Nahemow, 1973).
Activity	In occupational therapy literature the terms *activity*, *task* and *occupation* have different meanings but are sometimes used interchangeably (Fisher, 2009). Even though the terms differ in fundamental ways, *activity* is used in the present thesis for simplification purposes to avoid confusion (Clark, 2002). It refers to a general and culturally common, shared perception of a category of action (Ikiugu, 2012) and the execution of a task or action by a person (WHO, 2001).
Disability	An umbrella term in the International Classification of Functioning, Disability and Health (ICF) for impairment, activity limitations and restricted participation. It refers to difficulties in performing daily activities and tasks in all life arenas. Disability arises due to the complex relationships between the health condition and contextual factors (personal and environmental) of a person (WHO, 2001).
Dwelling	The specific residential physical building unit: house, apartment or row house.
Environmental barrier	An environmental feature that is not designed according to the standard requirements (Iwarsson and Slaug, 2010).
Functional limitation	Restricted capacity to perform basic general actions that are part of many merged activities (Nagi, 1991; Verbrugge and Jette, 1994; Iwarsson and Slaug, 2010).

Healthy aging	A biopsychosocial process involving multiple contributing factors. In this thesis, the term refers to maximal delay of disability (Bengtson et al., 2009).
Housing	An overall term for accommodation.
Inter-rater agreement	The degree to which two or more raters achieve identical results under similar assessment conditions (Slaug et al., 2012).
Mobility devices	In the present thesis, mobility devices are limited to rollators, manual wheelchairs and electric motor-driven wheelchairs.
Nordic Housing Enabler	A Nordic version of the original Swedish Housing Enabler instrument (Iwarsson and Slaug, 2000). The environmental component of the Nordic HE (Iwarsson and Slaug, 2008) is based on consensus standards among four Nordic countries (Denmark, Finland, Iceland and Sweden).
Older people	In this thesis ≥ 60 years.
Participation	The involvement in a life situation (WHO, 2001) as well as the dynamic interaction of person and environment when participating in everyday activities (Hemmingsson and Jonsson, 2005).
Person-environment fit	The balancing of environmental press related to the competencies of the person (Lawton and Nahemow, 1973).
Reliability	The consistency of a measure. A measure is said to have a high reliability if it produces similar results under consistent conditions (Crocker and Algina, 2008).
(Housing) Standard	A technical document for common and repeated use, to be used as a rule, guideline or definition (www.cen.eu). In some countries, a distinction is made between the terms *standard* and *norm*, where norm refers to exact measures such as length and weight, while in common English language

	standard is used interchangeably with the term *norm*.
Standard definition	The specification of the standard that directs the environmental design, like for instance door width 85cm, or two handrails required.
Validity	In psychometrics, validity refers to whether an instrument measures what it intends to measure (Fayers and Machin, 2000). *Validity of housing standard definitions* refers to a more general usage of the term, that denotes if the standard definition is well-founded and corresponds accurately to the real world (Encyclopaedia Britannica Online, 2007). Thus, the validity of housing standards means that the standards are defined to allow people with functional limitations to have access to housing design features in order to be able to interact with the environment.

List of Publications

This thesis is based on the following papers:

I. Helle T., Nygren C., Slaug B., Brandt Å., Pikkarainen A., Hansen A-G., Pétersdórttir E. and Iwarsson S. (2010). The Nordic housing enabler: inter-rater reliability in cross-Nordic occupational therapy practice. *Scandinavian Journal of Occupational Therapy*. 17:258-266.

II. Slaug B., Schilling O., Helle T., Iwarsson S., Carlsson G. and Brandt Å. (2012). Unfolding the phenomenon of inter-rater agreement: a multicomponent analytic approach for in-depth examination was proposed. *Journal of Clinical Epidemiology.* 65:1016-1025.

III. Helle T., Brandt Å., Slaug B. and Iwarsson S. (2011). Lack of research-based standards for accessible housing: problematization and exemplification of consequences. *International Journal of Public Health.* 56:635-644.

IV. Helle T., Iwarsson S. and Brandt Å. (2012). Validation of housing standards addressing accessibility – exploration of an activity-based approach. *In manuscript.*

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Introduction

Setting the scene

The growing ageing population gives rise to a variety of societal challenges of which one of them is to ensure appropriate housing accessibility for older people. Since functional limitations and dependence on mobility devices increase with age (Crews and Zavotka, 2006), older people are particularly dependent on the environmental design (Scheidt and Windley, 2003). The housing environment is a crucial arena for participation in a broad range of everyday activities because older people spend most of the daytime at home (Heyl, 2005). Alleviation of housing accessibility barriers is therefore an important prerequisite for staying active, participatory, independent and for being well in old age.

With the announcement of Supportive Environments for Health by the WHO in 1991, the international society has long acknowledged the importance of accessibility. Recent years have seen a growing recognition of the importance of accessibility to the built environment, including the housing. Interest in accessibility issues has grown internationally, politically, professionally and is also on the agenda of several user organizations (WHO and the World Bank, 2011). The growing interest is reflected, among others, in a rising number of standards and guidelines that have been developed during the past few decades to improve accessibility. Even so, serious accessibility deficits remain (Nygren et al., 2007; Wahl et al., 2009). One of the latest sweeping initiatives to improve accessibility to the built environment is that it has now become a human right. According to the United Nations' (UN) *Convention for the Rights of People with Disabilities* (2006) on the fundamental issue of accessibility (Article 9), countries are required to identify and eliminate obstacles and barriers to the built environment to ensure accessibility for all so that persons with disabilities can access their environment, are able to live independently, are included in the community and can choose where to live (Article 19). Moreover, people with functional limitations are now entitled to take legal action in those countries that have signed the convention of these countries fail to abide by the UN convention. Therefore, there is a call for a concerted specialized and interdisciplinary effort to achieve the international

society's ambition of social inclusion and accessibility for all. Sound methodology is needed to ensure that accessibility policies are, indeed, met and have the intended effects whether they address human rights, health or well-being among older people. Unfortunately, the methods currently used to ensure housing accessibility often build on tacit knowledge and acquired practical experience. The standards for housing design addressing accessibility play an important role in this respect. The standards are intended to accommodate the needs of people with functional limitations (Preiser and Ostroff, 2001); yet, the knowledge underlying the housing standards appears to be vague (Steinfeld et al. 2010). Hence, there is a need for research that nurtures the advancement of housing accessibility. With the current demographic development in mind, the need has become more pertinent for a stronger focus on the issue of housing accessibility and for a methodology that duly targets individual and societal accessibility requirements. The ultimate goal of the present thesis is to explore two aspects of housing accessibility namely reliable assessments and valid housing standards targeting older people.

Context of the thesis

This doctoral thesis was conducted at the Centre of Ageing and Supportive Environments (CASE) and the Department of Health Sciences, Faculty of Medicine, Lund University. CASE is an interdisciplinary research centre bridging medical, engineering and social sciences. Its focus is on supportive environments for older persons with respect to mobility, activity and health (for further information: www.med.lu.se/case).

The present thesis project ran in parallel with another methodological thesis project at CASE that also targeted accessibility: *"Exploration and Development of Methodology for Accessibility Assessments – Based on the Notion of Person-Environment Fit."* This project was conducted by my fellow doctoral student B. Slaug, who completed his thesis in June 2012.

The co-authors of the four papers included in the present thesis have different research interests and competencies that derive from gerontology, traffic and transport planning, psychology, public health and occupational therapy. The authors' different research traditions, perspectives, conceptual as well as methodological considerations came into play and contributed to the conclusions drawn in this thesis. Although the four studies all benefitted from the interdisciplinary research setting at CASE, the prevalent disciplinary perspective that guided the present thesis was that of occupational therapy

with its particular focus on people's ability to perform everyday activities (Townsend and Polatajko, 2007) departing from the environment.

The present thesis is based on data from the "Nordic Housing Enabler (HE) project," which constitutes the first study of the thesis, and from the "ENABLE-AGE project" (Iwarsson et al., 2007). In addition, a stand-alone study was conducted in Denmark. In all, data from six European countries were utilized (Denmark, Finland, Germany, Iceland, Latvia, and Sweden). Although the present thesis is placed in a European context for exemplification purposes, its topicality is even more global.

Thesis development and my role in the studies

The thesis comprises four studies presented in separate papers: the Nordic HE study (I), the agreement study (II), the extrapolation of standards study (III) and the activity-based approach study (IV). The thesis also includes a narrative literature review on peer-reviewed original research with a potential to inform research-based standard definitions. This review was performed in relation to study III and is described in the background section of the thesis (for a thorough description of the review, see appendix I).

The ideas behind the studies II-IV originate from experiences, challenges and results gained from the development of a cross-Nordic content-valid version of the HE instrument in study I. The thesis consists of two parts in terms of contents. Part I: reliable assessments (studies I and II) - examination of the reliability of the content-valid Nordic version of the HE, including an approach for in-depth analysis of inter-rater agreement with a view to improving assessment instrument reliability. Part II: valid standards (studies III and IV) - examinations of the consequences of standard definitions and of the validity of these definitions. For a thesis overview, see

Table III page 37.

In the Nordic HE study (I), I served as the executive coordinator of the overall project as well as the national coordinator of the Danish part of the project. I was actively involved in all processes of the project. Moreover, I was responsible for the translation process of the Nordic version of the instrument into Danish, and the subsequent production of the Danish HE book.

In the Nordic HE study (I), the inter-rater agreement was jeopardized, not necessarily due to the instrument itself, but due to the complex rating situation.

In the agreement study (II), it was therefore decided to take up the challenge of exploring the phenomenon of inter-rater agreement and how to statistically account for this. I was actively involved in that process. Yet, my position in the study with respect to the statistical methodology applied was that of the third author. (This study is also part of B. Slaug's PhD thesis (2012)).

The Nordic HE study (I) involved a cross-Nordic analysis of national housing standard definitions addressing accessibility. This analysis called my attention to the lack of documentation of the knowledge that informs standard definitions. As part of the extrapolation of standards study (III) a systematic narrative literature review (Green, Johnson and Adams, 2006; Fink 2005) was therefore performed to examine the state-of-the-art of current research that may inform research-based housing standard definitions addressing accessibility. In this study, I performed the literature review and the study.

The extrapolation of standards study (III) served as a catalyst for the last study, the activity-based approach study (IV). Study IV empirically examined the validity of a set of housing standard definitions addressing accessibility by means of a new approach that involved activity. In this study, I was the project leader and completed the study with a high degree of independence in all steps of the research process.

Background

The following section presents the rationale and, the theoretical and conceptual background of the present thesis and offers a review of extant literature in the field. The section presents an overview of housing accessibility in a European context of older people. Special emphasis is given to housing accessibility methodology in general and the reliability of accessibility assessments and the validity of the housing standard definitions addressing accessibility in particular.

Older people with functional limitations

The concept of functional limitations

The target population of this thesis is older people with functional limitations who do not depend/depend on mobility devices such as rollators (walkers) and wheelchairs. The definition of the concept of functional limitations derives from Nagi's Disablement Model (1991). In this thesis, functional limitation refers to a restricted capacity to perform basic general actions that are part of many merged activities (Nagi, 1991; Verbrugge and Jette, 1994; Iwarsson and Slaug, 2010). According to the International Classification of Functioning, Disability and Health (ICF) (WHO, 2001), the term *health condition* refers e.g. to consequences of ageing or injury. *Functioning and disability* are umbrella terms applied to describe health problems in relation to impairment in three domains: *body functions and structure,* i.e. physiological functions and anatomic parts of the body; *activity limitation,* i.e. the execution of a task or action by a person; and *participation restriction,* i.e. involvement in a life situation. Within the ICF, the term functional limitations can be placed between body functions/body structures and activities and participation (Iwarsson and Slaug, 2010).

Demography and epidemiology

The growing proportion of older people and the rising number of "very old" people most at risk of disability are well documented (Lafortune and Balestat, 2007). Currently, there are some 80 million people with various kinds of disabilities in the European Union (www.euractiv.com). The older population is expected to grow more rapidly than other age groups in Europe. The share of people aged 65 years or over in the entire European population is projected to rise from 17.1% in 2008 to 30.0% in 2060, i.e. from 84.6 million to 151.5 million. The number of people aged 80 years or over is projected to almost triple from 21.8 million in 2008 to 61.4 million in 2060 (Giannakouris, 2008).

It is important to bear in mind that the most persons with functional limitations are older and that rising age is associated with a rise in the frequency, complexity and severity of functional limitations (Crews and Zavotka, 2006). However, it is difficult to find statistics on older Europeans' functional limitations and their dependence on mobility devices, because such prevalence figures are not registered according to a recognized classification within the health-care system in the same way as diseases for example (Alves, Leite and Machado, 2008; Barbotte et al., 2001). Yet, according to the Statistics Sweden (SCB, 2010), which has produced such figures for Sweden, 38% of men and 57% of women at the age of 65-84 years suffered limitations in movement, while 16% of men and 24% of women encountered difficulties in mobility. As far as mobility device use among older people in Sweden (SCB, 2010) is concerned, 50% of those using wheelchairs are ≥80 years, of whom 80% utilize a wheelchair indoors. With regard those using rollators, 95% are ≥65 years old, of whom 2/3 are 80 years or more, while 50% of those using rollators also use rollators indoors. Knowing such figures would be valuable for the provision and planning of accessible dwellings that meets these needs of the older population.

Housing accessibility

People use different environments as arenas for participation in a broad range of activities. Physical environments can hinder, restrict and/or enable people with functional limitations to lead an independent, active and participatory life (Christiansen and Townsend, 2010). Restricted participation may occur due to barriers in the environment. People with functional limitations are particularly vulnerable to environmental demands (Wahl et al. 2006). Long-lasting exclusion from meaningful activities due to circumstances beyond the control of the person can, moreover, entail risks to health (Whiteford 2000). Stineman et al. (2007) found that accessibility problems in the housing environment

were associated with an increased probability of encountering difficulties in performing everyday activities. They also found that the proportion of older people who experienced housing accessibility problems was increased particularly in those who were dependent on mobility devices. Housing accessibility has also been shown to support older peoples' ability to maintain health (Fänge and Dahlin Ivanoff, 2009) and independence (Wahl et al., 2009). Accessibility to the housing environment and the ability to participate in everyday activities are therefore crucial determinants of health and well-being (Christiansen and Townsend, 2010). Alleviation of any accessibility obstacles in older people's dwellings is central to healthy ageing (Wahl et al., 2009) since older people generally spend most part of the day at home (Heyl et al., 2005), want to have an active and participatory everyday life (Dahlin-Ivanoff et al., 2007; Haak et al., 2007) and wish to remain in their ordinary dwellings as long as possible and to age in place (Pynoos, Caraviello and Cicero, 2009; Ball, Perkins, Whittngton et al., 2004). Even so, housing accessibility is usually rarely addressed in public health literature (Slaug, 2012). Although public health has recognized that well-being and health cannot be separated from the environment, the discipline has largely neglected to consider how some basic human needs relate to health, such as the ability to carry out everyday activities (Wilcock, 2006) within the housing environment.

In general, accessibility research usually places greater emphasis on the requirements of the population using a wheelchair than on populations using other mobility devices (Thapar et al, 2004). However, those using a rollator cconstitute a larger proportion of the older segments of the population than those using a wheelchair (SCB, 2010; Kaye et al., 2000). Accessibility problems should therefore be investigated for different sub-groups to learn how housing design accommodates the total group of older people. To the best of my knowledge, exploration of accessibility problems in different population remains largely non-existing.

The concept of accessibility

Accessibility, a well-known and regularly used concept, is central to this thesis. Although widely used, it is not a uniform concept with a commonly accepted definition (Iwarsson and Ståhl, 2003). Definitions vary among researchers, architects, health care professionals, standardization organizations and user organizations. In colloquial language, accessibility means *"approachable, at hand, attainable, available, close, convenient, and handy and within reach"* (Oxford Popular Dictionary and Thesaurus, 2010). When it comes to accessibility definitions targeting the physical housing environment, the definition most often used in research implies compliance with official

housing standards addressing accessibility (Preiser and Ostroff, 2001; Steinfeld and Danford, 1999). According to this definition, accessibility focuses explicitly on the environment, and should be assessed dichotomously by observing whether or not housing design features fulfill the requirements stated in the standards. Most housing accessibility research has therefore focused on the environment at the frequent expense of the interaction between the person and the environment. However, according to Iwarsson and Ståhl (2003), accessibility is a relational concept that involves an environmental component, still to be defined in compliance with the standards, as well as a personal component. Their definition is based on an ecological model of ageing published by Lawton and Nahemow (1973). In this model, the person is defined in terms of a set of competencies (i.e. functional limitations) and the environment in terms of press (i.e. environmental demands). It is assumed that activity limitations and restricted participation arise in the presence of a gap between the person with his/her functional limitations and the demands of the environmental arena in question. Accessibility problems may accordingly be expressed as a person–environment relationship (Iwarsson and Ståhl, 2003), which Lawton and Nahemow (1973) denoted a person-environment fit. Adding the docility hypothesis (Lawton and Simon, 1968) to the ecological model of ageing, it may be argued that persons with more functional limitations (i.e. lower competence) are more vulnerable to environmental demands than those with fewer functional limitations (i.e. higher capacity). The premise of this argument is that a balance between the person's functional limitations and the environmental demands can be gained by altering either the one or the other or both. In this thesis, the concept of accessibility denotes a person-environment relationship where functional limitations and environmental demands are juxtaposed (Iwarsson and Ståhl, 2003; Iwarsson and Slaug, 2010).

Limitations of the concept of accessibility

The prevailing research definition of accessibility suffers from a number of limitations. First of all, it is just label that may be affixed to a situation in which a given environment is designed in compliance with the existing standards. This invites a problem in the sense that research that aims to generate knowledge on accessibility faces the challenge of defining what accessibility is and how environmental design features (e.g. door width or threshold height) accommodates or hinders accessibility. Accessibility definitions do not imply that the environmental design actually meets the requirements in terms of activity performance. This has also been problematized by Thapar et al. (2004) who explored if it was possible to

replace accessibility with a concept that they denoted "functional access." This approach was based on assessments of people interacting with particular environmental design features in a public building as a means to perform a set of defined activities. In line with their suggestion, it may be argued that it is necessary to explore alternative definitions that involve person-environment fit, i.e. the person's ability to perform an activity within a certain environment. Some will argue that such approaches per definition imply that the concept under study will be usability. While usability is a concept related to accessibility (Fänge and Iwarsson, 2003), it is, indeed, different, for instance because it involves additional dimensions, such as satisfaction (www.ISO.org), acceptability and learnability (Jordan, 2001). In order to operationalize accessibility to capture functional requirements with respect to the ability to perform activity, but remains based on the notion of person-environment fit, this thesis drew inspiration from definitions of usability provided by the International Organization for Standardization (ISO) (www.iso.org) and Jordan (2001). According to the ISO (www.iso.org), usability is a measure of the effectiveness (degree of task completion), efficiency (amount of effort spent) and satisfaction (degree of freedom from discomfort and positive attitudes towards the use of the environment) with which specified users can achieve specified goals. According to Jordan (2001), satisfaction is the only aspect of usability that may be considered subjective in character, because it addresses aspects such as learnability, acceptability, understandability, adaptability, attractiveness, operability and pleasure. This is in contrast to effectiveness and efficiency, which may be considered objective in character (Jordan, 2001). Thus, in order to contribute to a knowledge development that can serve the scholarly ambitions to revisit and refine current definitions of accessibility, one way is to explore the applicability of accessibility defined as the effectiveness (extent of activity completion) and efficiency (amount of effort spend to complete the activity) with which a person is able to interact with the environment. That is, studying components of activity performance such as forcing a threshold, entering a room, moving around in the room, reaching for objects in wall cupboards, etc. could increase our understanding of the concept of accessibility. Important to note is that the focus remains on a "pure" person-environment fit and that aspects such as aesthetics, preferences, satisfaction, acceptability, etc. are not considered in the present thesis.

Another consequence of the prevailing definition of accessibility (i.e. compliance with the standards) is that it has mainly resorted to observation to investigate accessibility. Current general methodological recommendations argue that both observation and self-reported data provide distinct but complementary information on the phenomenon under study (Bean et al.,

2011). In order to fully capture and understand a given phenomenon, a combination of both methods (i.e. observation and self-report) is therefore recommended (Wæhrens, 2010). To obtain new knowledge about accessibility, it is important to search for that particular knowledge which deepens our understanding of the concept. Especially critical would be, for example, to reveal whether some aspects of accessibility (e.g. reach or space requirements) should be assessed by one method rather than by another, or by a combination of methods. Yet, when it comes to research into accessibility, the comparative advantages of available methods remains to be established (Thapar et al., 2004).

Housing standards addressing accessibility

The formal definition of a *standard* is a "technical document for common and repeated usage, to be used as a rule, guideline or definition" (www.cen.eu). In some countries, a distinction is made between the terms *standard* and *norm*, where norm refers to exact measures such as length and weight. In English, the term *standard* is used interchangeably with *norm*. In order to overcome this potential confusion and because the international use favors *standard*, it was decided to use this term in the present thesis. Housing standards cover a variety of aspects such as safety, energy and accessibility. However, in this thesis, only the housing standards addressing accessibility are addressed. *Standard definition* refers to the concrete specification that directs the design of housing features, for instance a door width of 85cm and a threshold height of 25mm. It is critical to note that housing standard definitions are usually specified in terms of minimum requirements, which refer to the minimum levels of accessibility considered to be acceptable. In practice, however, satisfying the minimum requirements is often perceived as tantamount to the provision of fully accessible solutions, but unrestrained accessibility is rarely achieved in practice by simply meeting minimum requirements (Frandsen et al., 1012).

Housing standards are exclusively subject to national legislated in conformity with the national building law. This implies that different legal systems operate different sets of rules (WHO and the World Bank, 2011). Even if building regulation such as the Danish (www.BR10.dk) and the Swedish (www.boverket.se) quite similarly state that buildings should be accessible and usable for everybody, the number of standard definitions to direct the construction of accessible dwellings is few. However, the number of guidelines supporting an accessible housing design is a great many, but since they are not mandated by the building law, they are rarely followed (Frandsen et al., 2012). Responsibility for the development of housing standards and

standardization procedures lies with national standard bodies such as the Swedish Standards Institute (SIS) (www.sis.se), the German Institute for Standardization (DIN) (www.din.de) and the Latvian Standards (LVS) (www.lvs.le). Yet, the national authorities decide if a standard should be elevated to form part of the building law but by default, a standard is not necessarily legislatively mandated.

Housing standards addressing accessibility play a crucial role to people with functional limitations, to professionals, and thus, to society at large. The standards serve to accommodate persons with functional limitations (Preiser and Ostroff, 2001). More specifically, they are intended to enable mobility and the use of the environment as a means to perform activities. Building constructors and architects use the standards as a management tool to specify the design of the environment (Nickpour and Dong, 2009). Ensuring valid housing standard definitions is therefore of paramount importance to accessibility. Validity is here used in the more general linguistic sense of the term, i.e. not in its more specific statistical sense. It designates the degree to which the knowledge used to inform standard definitions is well-funded and corresponds with the real world (Encyclopaedia Britannica Online, 2007); hence, the extent to which standards are defined to allow people with functional limitations and dependence on mobility devices to access the housing environment and in so doing perform activities. However, it is not clearly state what kind of knowledge informs each of the standard definitions presented in the respective building regulations such as e.g. the Danish regulation (www.BR.10.dk). According to Preiser and Ostroff (2001), the knowledge underlying the standards is for the most part based on professional experience, anecdotal evidence or, at best, research based on small study samples. Apparently, the knowledge informing the standard definitions is not determined on a solid grounding. This is further supported by the fact that substantial differences for the same design feature were found when comparing housing standard definitions across European countries (see Table I).

Table I. Examples of the differences in housing standard definitions for the same design features across six European countries.

Standard definition						
Design feature	Sweden[1]	Finland[1]	Denmark[1]	Iceland[1]	Latvia[2]	Germany[2]
Outdoor seating places every	25m	50m	100m	25m	25m	-
Level difference by refuse room/bin	25mm	25mm	0mm	20mm	25mm	-
Refuse bin/ letterbox above the ground	80-100cm	110-130cm	80-120cm	80-120cm	90-120cm	85cm
Door width	80cm	85cm	77cm	90cm	90cm	80cm
Balcony/sitting outdoor place	140cm	240cm	130cm	160cm	150cm	150cm
Gaps in the floor	5m	5m	-	-	5m	-
Steep transitions	1:12	1:12,5	1:12	1:15	1:12	
Space in front of white goods	120cm	120cm	110cm	150cm	120cm	120cm
Level difference in the shower	0mm	20mm	15-20mm	0mm	25mm	-

[1]From the Nordic HE project (Helle et al., 2010).
[2]From the ENABLE-AGE project (Iwarsson et al., 2007).

Similar results were found in a recent study evaluating national standards in relation to those using a wheelchair and those using a scooter across the USA, Canada, Britain and Australia (Steinfeld et al., 2010). This study emphasized that current standard definitions were outdated. It was concluded that there is a need for sound methodology and a robust definition of the concept of accessibility. Based on this, it is reasonable to question the validity of housing standard definitions that specify the design of accessible dwellings, and to underscore the need for research that contributes to the advancement of this field of research.

Literature review – information of the housing standards

Since the knowledge base on housing standards founded on research seemed to be vague, a systematic narrative literature review (Green, Johnson and Adams, 2006; Fink, 2005) was performed. The review aimed at revealing the state-of-the-art of research with a potential to inform housing standards addressing accessibility. The search targeted empirical publications published during 1990-2010 addressing the design of accessible, ordinary dwellings for adult persons with physical functional limitations and a dependence on mobility devices. A critical inclusion criterion was that the research should result in measures defined in exact metrics. The search identified 2,879 publications, of which the full text of 35 publications was read. Seven

publications were included, separating the studies according to two categories. One category (A) addressed (industrial) workstation design and sex differences, and the other category (B) concerned comparison of standards (see Table II). While none of the publications specifically targeted housing environments, they all identified significant sex differences in design requirements (Paquet and Feathers 2004; Kozey and Das 2004; Das and Kozey 1999). Moreover, they found that current standards were outdated and did not adequately support design. Therefore, they concluded that research-based revisions of current standards was required (Steinfeld et al. 2004, 2010; D'Souza et al. 2009; Ringeart et al. 2001) (For details of the review, see Appendix I). Hence, research that seeks to explore the consequence of the lack of valid research-based standard definitions as well as research that nurtures the methodological advancement to target the validity of housing standard definitions seems to be relevant to this field of research.

Table II. Description and overview of the data extraction and analysis of the seven publications included in the literature review.

Publication	Extraction of data					Pooled synthesis
Category A: Workstation design and sex difference	Aim	Sample	Method	Result	Conclusion	Theme
1) Das, Kozey (1999)	Determination of anthropometric measures for male/ female wheelchair users for work-station design	42 men/20 women. Wheelchair users (same sample in study 3).	16 dimensions were measured. Slide film taken.	Measurements of seat pan of males were significantly higher than females.	Seated able-bodies anthropometric measurements are not suitable for this population. .	Seat dimension
2) Pacquet, Feathers (2004)	Investigation of anthropometric differences among sex and type of wheelchair. Work station and design of living.	121 manual or powered wheelchair users.	Electromechanical probe. Registration of 3D locations of 36 body and wheel-chair landmarks.	Significant differences between men/ women and manual/ powered wheelchair concerning heights, widths and depths.	Need of improving the understanding of anthropometry of wheelchair users.	Seat dimension
3) Kozey, Das (2004)	Determination of normal and maximum reach area among sex and wheelchair users. Industrial work station.	42 men. 20 women. Wheelchair users.	Computerized potentiometric system for anthropometric measures.	Reach ranged from 4-17 mm normal reach and 12-39 mm for the maximum reach with significant differences	Normal and maximum reach of wheelchair users was much smaller than measures for non-wheelchair users.	Reach

				among women and men.		
Category B: Comparison of standards	Aim	Sample	Method	Result	Conclusion	Theme
4) Steinfeld, Pacquet, Feathers (2004)	Determination of how much space needs to be provided for access to seating areas.	178 persons.W heel chair and scooter users (this sample was one of the included samples in study 6).	Electromechanical probe. Registration of 3D locations of 36 body and wheel-chair landmarks.	Distribution of width / lengths differs by type of wheel chair. Propelled chairs require most space.	It is necessary to exceed current requirements of standards. Floor space should be increased to 830mm to accommodate 95% of the sample. Floor space length should be increased to 1400mm.	Space requirements
5) D'Souza, Steinfeld, Pacquet (2009)	Determination of maximum reach of wheelchair users.	257 wheel-chair and scooter users.	3D information on body and wheelchair size/ shape. Digitized set of body/ wheelchair landmarks in 3D with an electrome-chanical probe.	Extended reach tasks are best at 800-1200 mm above the floor for forward/ lateral reach. With existing standards only 61% of the sample can perform reach.	Reach ranges specified in current accessibility standards in the US inadequately support design.	Reach
6) Steinfeld, Maisel, Feathers, D'Souza (2010)	Identification of needs for improvements of standards.	Wheelchair users. Sample size was not reported (only references to different studies).	Comparative analysis of standards from four countries were reviewed and compared with recent research.	Values in current standards for seat height should be increased by 250mm. Floor space should be increased by 2500mm.	Standards need to be updated. Research methods must be improved and documented thoroughly. Finding other sampling approaches to reduce sample size is needed.	Seat dimension and space requirements
7)Ringeart, Rapson, Qiu, Cooper, Schwedyk (2001)	Exploration of changes to be made to pertinent standards for powered wheelchair/ scooter users.	35 powered wheelchair /15 scooter users.	Simulated test environments and motion detector camera plus rulers for anthropometric measures.	Persons with disabilities cannot reach as high/low as indicated by standards. Turning diameter has to be increa-sed with twice the amount of the prescrip-tion of standards.	Standards do not currently consider the dimensional requirements of power mobility users. There is a need to increase many common user areas in the built environment.	Reach and space requirements

Current accessibility policy in Europe

The general perception of people with functional limitations has changed over the years from one that saw them as "objects" of charity requiring medical treatment and social protection, to one of "subjects" with rights capable of claiming these rights (UN, 2006). This movement follows from the social models of disability that have led to worldwide legislation striving to protect the rights of people with disabilities in the light of the growing recognition of the environment's influence on people's experience of disability (Ainsworth and de Jonge, 2011). One of the concrete achievements of this movement is the recently adopted European Disability Strategy for 2010-20 involving a European Accessibility Act implemented in late 2012 (www.euractiv.com). The act aims at establishing consensus standards within European member countries to secure accessibility as concerns products, services and public buildings. However, one may wonder, why the housing environment was not addressed specifically. The Accessibility Act is intended to improve accessibility and facilitate the social integration of persons with disabilities, including older people, and ensure their mobility across the member states. The Act reflects two important developments in Europe. First, the growing size of the ageing population implies an increase in the demand for accessible goods and services. Second, the ratification of the UN Convention on the Rights of Persons with Disabilities by the European Union (EU) and its member states imposes clear obligations on the member states to improve accessibility to the built environment. In this new framework, the EU Commission must make sure that the needs of people with disabilities are taken into account during the development and implementation of all EU policies and legislation. This is the first comprehensive human rights treaty in this field, and the Commission sees the new legislation as a key element of the European Disability Strategy (www.euractiv.com). This kind of European policy has definitely potential to promote accessibility. However, although accessibility to the built environment has been on the international agenda for decades, the process of designing accessible environments for all has been slow, variable and ineffective across Europe. The question is therefore, whether this new European Accessibility Act will, indeed, make any real difference. Unfortunately, the Act does not specify *how* to achieve the goals and *what* kind of measures to take. Yet, the use of sound methodology is an important prerequisite.

Housing adaptation

When the environmental demands exceed the functional limitations of persons, housing adaptations represent commonly provided services. The purpose of housing adaptation is to reduce the environmental demands of the dwelling (Fänge, 2004). Housing adaptations therefore often involve removal of physical environmental barriers, for instance elimination of thresholds, provision of ramps and widening of door openings (Boverket, 2003). This kind of compensatory strategies have proved to be important community-based services for older people to increase their independence and ability to perform everyday activities (Petersson et al., 2008), improve usability (Fänge and Iwarsson, 2005) and reduce the number of falls in the dwelling (Wahl et al., 2009). Different European countries have different regulative frameworks for providing and financing housing adaptations (Fänge, 2004). In Latvia, for instance, housing adaptations must be privately funded (Tomsone et al., 2003), whereas in Germany they can be granted privately by the landlord or via different kinds of insurances (Naumann et al., 2003). In Denmark and Sweden, housing adaptation services are regulated by law. In both countries, national law states that persons with functional limitations who experience problems in their everyday lives have the right to receive grants to allow the necessary housing adaptations (www.serviceloven.dk [in Danish]; Svensk författnings-samling [in Swedish], 1992:1574).

Different approaches can be used to identify housing accessibility problems. One approach is to perform an assessment using standardized instruments. To assess here refers to the act of assessing a phenomenon and the amount of that phenomenon assessed (www. thefreedictionary.com). Such instruments must possess psychometric properties relevant to the population in question to ensure correct interpretation of the results of the assessment. There are relatively few standardized assessment instruments specifically targeting the physical housing environment that have undergone psychometric tests (Ainsworth and de Jonge, 2011). These instruments either address the specific conditions of older people with particular diagnoses, like dementia or Alzheimer's disease such as the Home Environmental Assessments Protocol (HEAP) (Gitlin et al., 2001) and the Task management Strategy Index (TMSI) (Gitlin et al., 2002). Alternatively, the instruments address safety and falls, like e.g. the Home Falls and Accidents Screening Tool (HOME FAST) (Mackinzie, Byles and Higginbotham, 2000) and the SAFER-HOME version 2 (Chiu and Oliver, 2006). Another instrument that could be used in this context is the Comprehensive Assessment and Solutions Process for Aging Residents (CASPAR) (Sanford et al., 2002). This instrument is a consumer-directed assessment instrument enabling an older person, family or non-specialist

therapist to identify problems in undertaking activities in the dwelling (Ainsworth and de Jonge, 2011). However, there is a paucity of assessment instruments specifically designed to identify and analyze accessibility problems in the physical environment of ordinary dwellings (Wahl et al., 2009). This paucity prevails although housing adaptations are commonly provided services, e.g. by occupational therapists, and although housing adaptations often address accessibility problems as mentioned above. Given that health-care providers are facing increasing demands to apply research-based methodology (Conway, 2008; Kielhofner, 2008), the lack of standardized instruments is a problem for the provision of best practice, for the documentation of the effect of housing interventions and for the provision of effective and efficient societal solutions.

The Housing Enabler

To the best of my knowledge, the HE is the only assessment instrument that allows systematic analysis of housing accessibility with known reliability and validity (Iwarsson and Slaug, 2010). The HE is administered in three steps. Step 1) is an assessment of the personal component like functional limitations and dependence on mobility device use in a person or a group. Fifteen items are dichotomously assessed by means of a combination of interview and observation. Step 2) is an assessment of the environmental component, i.e. physical environmental barriers in the dwelling and the immediate outdoor environment. A total of 188 items are dichotomously assessed by observing if the environment is designed in compliance with housing standard definitions addressing accessibility. Step 3) is an analysis quantifying the magnitude of accessibility problems identified in the dwelling caused by the particular combinations of functional limitations and physical environmental barriers found. Quantification is achieved by calculation of the predefined severity points at the intersection between functional limitations and environmental barriers in the scoring system. The higher the score, the more accessibility problems. The total score is always 0 if the person/group has no functional limitations and/or is not dependent on mobility devices.

In a community-based rehabilitation context at the individual level, the HE can be utilized as a standardized checklist for identification of potential housing accessibility problems. The HE should be applied in combination with other instruments used for housing adaptation and for evaluation of such services (Fänge and Iwarsson, 2007). In a public health and planning context at the societal level, the HE instrument can be used, for instance to map typical functional limitations in particular groups of clients, typically environmental barriers in particular kinds of housing (Iwarsson and Slaug, 2010). The results

obtained in this way generate a basis for effective accessibility solutions in the form of provision of accessible housing that meets the population's requirements (Iwarsson and Slaug, 2010).

Research on the HE has shown that the instrument is suitable in different national contexts (Iwarsson, Nygren and Slaug, 2005). So far, the instrument is available in Swedish (2010), English, German, Hungarian, Latvian and Russian (2000). By tradition and owing to their shared fundamental values, the Nordic countries have largely the same housing and accessibility policies (Nordic Council of Ministers, 2003; 2004). Pooling Nordic resources into a joined project aiming at developing a content-valid and reliable cross-Nordic version of the instrument would make it possible for more professionals in more countries to have access to a standardized instrument with the advantages that follows from this.

Methodological considerations

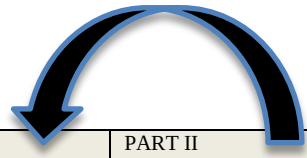
Knowing the reliability and validity of assessment instruments used in clinical practice and research in relation to the population targeted, is important for making correct interpretations of data. Reliability denotes the overall consistency of a measure. A measure is said to have a high reliability, if it produces similar results under consistent conditions (Crocker and Algina, 2008). Validity, in its statistical sense, refers to the ability of the instrument to measure what it is intended to measure, and that it is applicable for its intended purpose (Fayers and Machin, 2000). The use of assessment instruments targeting persons' functioning, health and well-being etc. always involves a variety of challenges. Assessments that also include the environment and furthermore measure compliance with the housing standard definitions are even more challenged. The HE instrument (Iwarsson and Slaug, 2010) has been tested for aspects of reliability (Iwarsson, Nygren and Slaug, 2005; Iwarsson & Isacsson, 1996) and validity (Fänge and Iwarsson, 2003; Iwarsson and Slaug, 2000). Both have been found to be satisfactory. Yet, further methodological studies are needed to demonstrate that the HE actually measures what it claims to measure and that HE assessments are consistent across raters and occasions (Slaug, 2012). Moreover, the translation of any instrument into additional languages always requires assessment of reliability and validity within the new context (Streiner and Norman, 2008).

Instrument reliability is often examined by analyzing the level of agreement between assessments obtained by one or several pairs of raters who apply the same instrument under the same conditions. Techniques for examining

reliability of assessment instruments are well established (see. e.g. Hripcsak and Heitjan, 2002; Streiner and Norman, 2008). However, although it is commonly accepted that the level of agreement is an indicator of reliability, it is, nevertheless, insufficient for determining the reliability of the use of the assessment instrument for several reasons; first, because studies are highly sample-dependent (Streiner and Norman, 2008; Fayers and Machin, 2000); second, because the discriminatory power of items that rarely or often occur is impaired (Hohler, 2000); third, items may be mixed with respect to administration differences (Schwartz and Rapkin, 2004). For instance, some items may be defined in metrics, which requires a measure with a measuring tool. Others may require observation of perceptual traits; and yet others may depend on the raters' evaluative judgments. Finally, although the conditions of the assessment situation are intended and assumed to be similar, two situations are, in practice, never completely identical. In any inter-rater agreement study, some disagreement will always occur. Approaches allowing identification and explanation of potential sources of disagreement by several raters will therefore inevitably vastly improve the reliability of any assessment instrument.

The process of validation is an on-going endeavor (Streiner and Norman, 2008), never an established property of any assessment instrument. Since the HE was constructed (Iwarsson and Isacsson, 1996), information about all kind of limitations, inconsistencies, weaknesses, etc., has been systematically gathered to strengthen the validity of the second revised version of the HE (Iwarsson and Slaug, 2010). The predefined severity points (0-4) of the scale predicting the degree of potential accessibility problems were initially established on the basis of expert discussions (Steinfeld et al., 1979). During the years, they have been re-evaluated and adjusted based on information systematically collected on the HE by occupational therapists and other health care professionals, university teachers, researchers and lay persons (Slaug, 2012). The severity points are indicative in the sense that they have face and content validity, but they have not been empirically validated. Another aspect of the validity of the HE which is important to consider is the validity of the housing standard definitions addressing accessibility, because they form a crucial part of the environmental component of the instrument. It may be argued that the HE items enjoy content validity as long as the environmental barrier items are defined in compliance with the housing standard definitions. However, since the knowledge informing these standards seems to have poor validity, the validity of the HE items themselves is equally poor (see the literature review page 23; Steinfeld et al., 2010; Blanck et al., 2010; Preiser and Ostroff, 2001; Ringeart et al., 2001). Thus, any improvement of the

validity of housing standard definitions addressing accessibility will also strengthen the overall validity of the environmental component of the HE.



	PART I ASSESSMENT	PART II STANDARDS
Validity	Nordic HE study I: The development and test of a content-valid cross-Nordic version of the HE	**Extrapolation of standards study III:** Exploration of the consequences of the lack of valid housing standard definitions addressing accessibility **Activity-based approach study IV:** The investigation of the validity of a set of housing standards addressing accessibility through an activity-based approach.
Reliability	**Nordic HE study I:** The investigation of inter-rater reliability of the Nordic HE when used in realistic situations **Agreement study II:** Unfold the concept of inter-rater agreement and exploration of statistical analyses to identify potential sources of disagreement - ultimately improving assessment reliability	Activity-based approach study IV: Inter-rater reliability of the study specific observation scheme.

Figure 1. This Figure displays how reliability and validity are part of each of the four thesis studies. Part I primarily focuses on the reliability of assessment. Part II primarily focuses on the validity of housing standards. The arrow illustrates that the validity of housing standard definitions influences the content validity of housing accessibility assessments defined in accordance with the housing standards, like e.g. the HE instrument.

It is generally accepted that validity addresses the nature of reality, how well-founded knowledge is and how accurately it corresponds to the real world. Validity is therefore an epistemological issue concerned with the nature and scope of knowledge, questioning what knowledge is, how it is acquired, and to which extent it is relevant for a given subject or entity (Encyclopaedia Britannica Online, 2007). In the context of housing standards addressing accessibility, it is therefore relevant to ask *what kind of knowledge informs the housing standard definitions? And how this knowledge was generated?* When answering these questions on the basis of the knowledge identified in the

literature review it is evident that the knowledge solely addressed single aspects of accessibility, such as reach, space or heights. The knowledge focused on adults using a wheelchair/scooter, sex differences or body position in relation to e.g. reach. The knowledge was generated in study lab-like simulated test environments detached from the realistic contextual situations and most of the studies targeted work station design. Furthermore, the methods used to generate the knowledge were of a technical character, for instance electromechanical probes, registration of 3D body locations and wheelchair landmarks and computerized systems (Das and Kozey, 1999; Pacquet and Feathers, 2004; Kozey and Das, 2004; Steinfeld, Pacquet and Feathers, 2004; D'Souza, Steinfeld and Pacquet, 2009; Stenfeld et al., 2010; Ringeart et al., 2001). Apparently, the knowledge generated on this basis is well-founded and corresponds accurately to the real world (Encyclopaedia Britannica Online, 2007). The "real world" in which the housing standards are intended to ensure accessibility, appears to be somewhat more dynamic and the housing environment somewhat different from the artificial study settings used in the studies included in the literature review. Hence, there is a need for a somewhat different methodology to ensure housing standards that truly support accessibility and accommodate the needs of older people.

The ability to perform everyday activities

The overarching reasoning that has guided this thesis rests on an occupational therapy premise that sees activity as an inherent basic human need. Assuming that humans are active beings, activity is considered to promote health and is a prerequisite for well-being and quality of life (Townsend and Polatajko, 2007). People perform a variety of everyday activities that are meaningful to them (Kielhofner, 2008). The environment is the context within which these activities are performed at home, at work or in school, during leisure time and as citizens in society (Borg et al., 2007; Christiansen, Baum and Bass-Haugen, 2005). There are different ways of understanding person-environment relationships with regard to older people's ability to perform everyday activities. In this thesis, the theoretical framework comprises models derived from environmental gerontology and an ecological model of ageing (Lawton and Nahemow, 1973), the docility hypothesis (Lawton and Simon 1968) and occupational therapy using the Person-Environment-Occupation model (Law et al., 1996). The competence-environmental press framework is perhaps the most frequently applied theoretical framework in studies on older people and the environment (Scheidt and Windley, 2003). The model explains how behavior, which in this thesis is equated with the execution of a task or an

activity, which evolves on the basis of the interaction between a person and the environment. The person is regarded as possessing a set of competencies: cognitive, physical and psychosocial; whereas the environment is perceived as representing demands. The degree of person-environment fit depends on the behavioral success. According to the docility hypothesis (Lawton and Simon, 1968), persons with low competencies are more vulnerable to the design of the environment and its demands than those with higher competencies. Following this line of this reasoning, persons with functional limitations like for instance reduced mobility may experience problems in forcing thresholds and climbing the stairs due to environmental demands that exceed their competencies. Successful behavior can either be achieved by increasing personal competencies or by reducing the environmental demands or both. This reasoning is in line with the one of the Person-Environment-Occupation (PEO) Model (Law et al., 1996). Whereas the competence-environmental press framework (Lawton and Nahemow, 1973; Lawton and Simon, 1968) focuses on behavior, the PEO model (Law et al., 1996) explicitly focuses on activity performance. The PEO model illustrates that the better the fit is between person, environment and activity, the better is the activity performance. According to the PEO model, activity performance will change, whenever any aspect within the person, the environment or the activity changes. The person is viewed as undertaking a set of life roles that change over time and that the person constantly interacts with the environment. Attributes that define the person will impact on the way the person interacts with the environment and will impact the way activities are performed. The environment is broadly defined and covers physical, social, cultural, institutional and socioeconomic dimensions. Activities are viewed as a necessary function of living. They embrace everything the person does and are considered to meet his/her needs for self-maintenance, expression and fulfillment according to his/her roles and the environment. In this thesis, this combination of frameworks was chosen to gain knowledge about the person-environment fit in relation to the person's ability to perform everyday activities. The thesis explicitly focuses on the design of the physical, built housing environment and on accessibility. However, none of these models explain which specific factors affect the ability to perform everyday activities and they offer no clear definitions of central aspects of the activity performance such as accessibility. The environment must therefore be broken down in smaller units to specify relevant concrete design features (Christiansen, Baum and Bass-Haugen, 2005) and to investigate the extent to which these design features impact on persons' functional limitations and cause accessibility problems.

Summing up

Older people constitute a segment of the population that has most functional limitations and uses more mobility devices than other age groups. The majority of older people want to age in place, stay active and independent without help from others in their dwellings. Since older people spend most of their time at home, the dwelling is an important environmental arena for participation and performance of everyday activities. Barriers in the environment can contribute to limiting achievements of everyday activities and restricting participation. Since older people with functional limitations and dependence on mobility devices are particularly sensitive to environmental demands, housing accessibility is therefore an important prerequisite to healthy ageing and well-being in old age.

To create accessible housing environments, it is critical that professionals are provided with valid and reliable assessment instruments with which to identify accessibility problems in the dwelling before planning appropriate housing interventions. Moreover, housing standards addressing accessibility must be valid in the sense that their definitions should truly support accessibility and accommodate the need of older people. Yet, there is a paucity of valid and reliable assessment instruments targeting housing accessibility and recommendations for in-depth analysis of factors potentially impacting reliability. As concerns the validity of the housing standard definitions addressing accessibility, research with a potential to inform the standards is sparse, the standards are outdated and vary across countries. Thus, we may question the validity of current standards and stress the need for research that contributes to an improvement of the housing standard definitions addressing accessibility.

Study aims

This thesis contains four methodological studies that utilize data from six European countries. The thesis focuses on two aspects of housing accessibility, namely the reliability of assessments and the validity of standards. Its overarching aim is to develop and explore methods that may improve housing accessibility assessments. A second general aim is to examine the consequences of current housing standard definitions addressing accessibility and to contribute to the advancement of housing standards that truly support accessibility and accommodate older people with functional limitations who depend on mobility devices.

The specific aims were:

- To develop a content-valid cross-Nordic version of the Housing Enabler and to investigate its inter-rater reliability in realistic situations in occupational therapy practice (Study I).
- To unfold the phenomenon of inter-rater agreement conceptually and statistically to identify potential sources of variation in agreement data and to explore how they can be statistically accounted for (Study II).
- To increase the understanding of how different housing standard definitions addressing accessibility influence the proportion of dwellings not meeting the standard definitions and the proportion of persons defined as having accessibility problems (Study III).
- To investigate the validity of a set of housing standards addressing accessibility through an activity-based approach (Study IV).
- To examine differences in accessibility problems between older people not using mobility devices, those using a rollator and those using a wheelchair, as well as differences in data obtained by observation and self-reporting (Study IV).

Materials and methods

The thesis was accomplished using conceptual, methodological, empirical and statistical exploration as well as extrapolation. Data on older people with different functional limitations not using or using different mobility devices who live in different types of ordinary dwellings in six European countries were utilized. Statistical analysis as well as analysis and approaches of a more qualitative character were employed and mixed in each of the four studies.

In this section, a description of the materials of the Nordic HE and the ENABLE-AGE projects as well as the activity-ENABLE-AGE projects as well as the activity-based approach study (IV) will be described. The data sets for the four be described. The data sets for the four thesis studies were derived from these projects and study. Next follows a projects and study. Next follows a description of the methods used in each of the four studies. For a thesis overview the four studies. For a thesis overview with respect to the characteristics of the studies, see studies, see

Table III.

Table III Overview of the thesis.

CHARACTERISTICS OF THE STUDIES							
		Study	Focus	Dataset utilized	Sample	Instrumentation	Data analysis
RELIABLE	ASSESSMENTS	The Nordic HE study (I)	Inter-rater reliability of the translated and content-valid version of the Nordic HE	The Nordic HE[1] database	106 cases[3]	The Nordic HE instrument[5]	Kappa, percentage agreement
		The agreement study (II)	The phenomenon of inter-rater agreement	The Nordic HE[1] and the ENABLE-AGE[2] database	1,880[4] observations 1,150 cases	The Nordic HE instrument[5] The HE instrument[6]	Kappa, percentage agreement, relative shares of agreement, multilevel regression analysis
VALID	STANDARDS	The extrapolation of standards study (III)	The influence of different standard definitions on accessibility	The ENABLE-AGE[2] database	1,150 cases	The HE instrument[6] and additional measures	Empirical distribution functions
		The approach study (IV)	The validity of housing standard definitions	A stand-alone data collection	30 persons	A study specific observation scheme, a study specific questionnaire for interview, observation notes and participant comments, functional ability scales[7]	Descriptive statistics, Mann Whitney U Test, sign Test, classical content analysis to analyze and categorize observation notes and participant comments

[1]The Nordic Housing Enabler project (Helle et al., 2010).
[2]Three countries included (Germany, Latvia and Sweden) from the ENABLE-AGE project (Iwarsson et al, 2007).
[3]Ten rater pairs assessed 8-14 cases each contributing to a total of 106 cases.
[4]Observations in a raters x items matrix generated from a sample where 10 rater pairs assessed a 188 items checklist in 8-14 different cases each constituting a total of 106 cases.
[5]The Nordic HE instrument (Iwarsson and Slaug, 2008).
[6]The HE instrument (Iwarsson and Slaug, 2010)
[7]Functional ability scales (Avlund and Schultz-Larsen, 1991).

Materials

The Nordic HE project

The Nordic HE and the agreement studies (I and II) were based on data from this project. Yet, only data collected by the Nordic HE environmental component as well as rater characteristics were employed in the agreement study (II).

The Nordic HE project was a collaboration between Denmark, Finland, Iceland and Sweden. Despite repeated efforts, we did not succeed in engaging a Norwegian partner. The main project objective was the development of a cross-Nordic content-valid version of the HE instrument, tested for inter-rater reliability, available in Danish, Finish, Icelandic and Swedish. The Nordic HE instrument was the only data collection instrument used in this project.

Sampling for the inter-rater reliability study

A two-step sampling strategy using identical principles was applied in the four Nordic countries. First, 20 occupational therapists were recruited as raters (data collectors) among participants in national HE courses. Raters were coupled in pairs. Together they identified their sample from client lists at their workplace consisting of 10–15 voluntary adults with functional limitations and/or dependence on mobility devices, living in ordinary, different types of dwellings. For a description of the sample characteristics, see Table V, page 41.

Each rater pair assessed 8–14 persons and their housing (a case), which resulted in a total sample of 106 cases (Table IV). Each case comprised unique dwellings and persons in terms of pairwise dichotomous assessments of presence/absence of 15 functional limitations and/or dependence on mobility devices and 188 environmental barriers in the physical housing, as defined by the HE instrument (Iwarsson and Slaug, 2010).

Table IV. Rater pairs and HE assessments performed in the Nordic HE project (N=106)[1].

	Country				Cross-Nordic
	Denmark	Finland	Iceland	Sweden	Total sample
Number of rater pairs	4	4	1	1	10
Number of cases	40	38	14	14	106

[1]The Nordic HE project (Helle et al., 2010).

At the outset of the study, there were different prerequisites among the raters. In Sweden, the raters had up to three years of experience in using the HE instrument and possessed previous experiences from participation in a research project in which they used the HE instrument. In contrast, the Finnish and Danish raters completed the HE course six to nine months prior to the data collection. They had no previous experience in using the HE, and only a few of the raters were used to employing standardized instruments. In Iceland, the raters were the same persons involved in the translation and the development of the content-valid version of the environmental component of the Nordic HE. All raters had completed a four-day course following the same format, conducted by the same course leaders.

Procedures

Data collection was performed at home visits over a two-month period. The sample was assessed independently by each of the two raters of a rater pair within one week. Immediately after the home visits the raters entered their data into the HE 1.0 software (Iwarsson and Slaug, 2010).

The ENABLE-AGE project

The extrapolation of standards study (III) was based on data from this project. Moreover, in the agreement study (II) data on the environmental component of the of the HE were used to provide a non-sample-dependent estimate of environmental barrier item prevalence assumed to reflect a common prevalence of environmental barrier items in ordinary dwellings.

The European ENABLE-AGE project involved Germany, Hungary, Latvia, Sweden and the United Kingdom. It comprised three major studies: the ENABLE-AGE survey study, the ENABLE-AGE in-depth study and the ENABLE-AGE update review. The main project objective was to examine subjective and objective aspects of housing and their impact on health in very old age, while health was understood mainly in terms of autonomy, participation and well-being (Iwarsson, Wahl and Nygren, 2004). Details of the project have been published elsewhere (see e.g. Iwarsson et al., 2007; Oswald et al., 2007). A battery of standardized instruments as well as project-specific questionnaires was administered during the data collection. Yet, for this thesis, only data on sample characteristics and HE data from the ENABLE-AGE survey study were used. Due to validity issues concerning the data on the environmental barriers, only data from three of the national samples were utilized (Germany, Latvia and Sweden).

Sampling

Samples from Germany and Sweden were drawn at random from national population registers, while Latvia used convenience sampling from social service districts and pensioners' organizations to identify the sample. The same sampling criteria were used in each country: single-living persons, living in ordinary different types of housing. Fifty percent had to be 80-84 years old, while the other 50% had to be 85-89 years of age. Each age group had to have a proportion of 75% women and 25% men. However, due to a shorter life expectancy in Latvia, the sample consisted of persons aged 75-84 years, whereas samples from the other countries consisted of persons aged 80-89 years. The total sample was N= 1,150 persons (Germany, n=450; Latvia, n= 303; Sweden, n=397) and their dwellings. For sample characteristic, see Table V, page 41.

In the ENABLE-AGE survey study, it was necessary to record exact measurements of 22 environmental design features due to substantial variation among the national housing standard definitions addressing accessibility in 22 of the 188 HE environmental barrier items. Each time any of these 22 items were rated as "not present," the data collection therefore included exact measurement of the respective environmental design features on the location. The data collectors were instructed to record these measurements within predefined measurement intervals relevant for each of these 22 items. To give examples, for the item *parking space far from entrance*, the data collectors were instructed to record the actual distance within an interval of 25-50m; for the item *narrow door openings at entrances*, the data collectors were instructed to record measures of door openings within 75-90cm. Measures outside the predefined interval were not recorded. In the extrapolation of standards study (III), only data in terms of exact measurements on ten of the 22 items were used to study the proportion of dwellings not meeting different standard definitions.

Procedures

Data were collected at home visits during the late summer and fall.

The activity-based approach study

This study was not part of a project, but a stand-alone study. It was conducted in a kitchen facility at the University College Northern Denmark. The main objective was to investigate the validity of a set of housing standard definitions addressing accessibility.

Sampling

Municipality health professionals identified potential participants, which was complemented by snowballing sampling among participants (DePoy and Gitlin, 2011). The following criteria were applied: persons 60 years of age or older; living in ordinary dwellings; used to preparing lunch, coffee and clean at least twice a week; having primarily physical functional limitations. The target sample was 30 participants sampled into three groups according to their mobility device use: those not using a mobility device (n=10), those using a rollator (n=10) and those using a manual or powered wheelchair (n=10). For sample characteristic see Table V.

Table V. Sample characteristics of the studies I-IV.

Sample characteristics	The Nordic HE[1] (studies I and II) N=106	The ENABLE-AGE[2] (studies II and III) N=1,150	The activity-based approach study (IV) N=30
Age			
Mean (SD)	-	83.4 (3.8)	74.97 (9.11)
Sex, n (%)			
Men	-	233 (20.3)	9 (30)
Women	-	917 (79.7)	21 (70)
Use of mobility device, n (%)			
Wheelchair	60 (56.6)	15 (1.3)	10 (33.33)
Rollator	41 (38.7)	178 (15.5)	10 (33.33)
Other	24 (22.6)	202 (17.6)	0
No use of mobility device	14 (13.2)	767 (66,7)	10 (33.33)
Housing type, n (%)			
Apartments	79 (74.5)	992 (86.3)	28 (93)
One-family housing	27 (25.5)	158 (13.7)	2 (7)

[1]The Nordic HE project (Helle et al., 2010).
[2]The ENABLE-AGE project (Iwarsson et al., 2007), three countries included: Germany, Latvia and Sweden.

Instrumentation

Data on accessibility problems were collected by means of the functional ability scales (Avlund and Schultz-Larsen, 1991), a study-specific structured observation scheme and a study-specific structured interview questionnaire developed based on textbooks on psychometrics, observation schemes, questionnaire methodology and traditional usability tests (see e.g. Streiner and Norman, 2008; Schaeffer & Pressers, 2003; Jordan, 2001). Besides, the study-specific instruments allowed for observation notes and participant comments that were also used for data collection.

Prior to data collection, the observation scheme and interview questionnaire were piloted, and basic psychometric properties such as face and content validity (Crocker and Algina, 2008) were investigated. To improve the face

and content validity of the interview questionnaire, cognitive interviews (Willis, 2005) were performed. The observation scheme was piloted to examine inter-rater reliability (Streiner and Norman, 2008), which demonstrated satisfactory results (k=0.78 for the person using a wheelchair and k=0.86 for the person using a rollator). To further investigate reliability during the subsequent observations (N=30), a research assistant and I performed the data collection independently from each other, which resulted in k=0.80. This is considered to be a very good reliability (Altman, 1999).

Procedures

Individual data collection sessions lasted for about 1.5 hours. First, the personal component of the Nordic HE instrument (Iwarsson and Slaug, 2008) and the functional ability scales of Avlund and Schultz-Larsen (1991) were administered. The participant was then introduced to the kitchen and the standardized activity. The study observation scheme was administered during the activity performance. The questionnaire was administered immediately after activity was completed.

Ethics

This thesis complied in all aspects with the formal national requirements for research on humans. Oral and written consent was obtained from all participants, who were enrolled after giving their informed consent. Participants were assured full confidentiality and were informed that they could withdraw from the study, and that they could withdraw all their data at any stage up to publication of results.

The projects and the studies fulfilled the legal and ethical requirements of the participating countries. In countries requiring formal ethical approval and approval for the storage of electronic data, such procedures were managed under the responsibility of each national project leader. Guidelines for this work were drawn up from the inception of the project and referred to nationally accepted guidelines in each participating country or best practice where such guidelines did not exist nationally. Examples of guidelines to follow were for Sweden the Guidelines of the Swedish Medical Research Council, for Germany the Guidelines of the German Research Foundation and the German Society of Psychology. In Iceland, formal ethical consent was applied for and granted. Finally, approval was obtained from the Danish Data Protection Agency.

Methods

Data quality control

Quality control was accomplished by means of 100% proof reading of the data entry of the Nordic HE project (studies I and II) and the activity-based approach study (IV). Any wrong data entry was corrected according to the rating forms in paper used during data collection. The error rate was below 5%.

For the ENABLE-AGE project, quality control of the data entry was performed by means of 10% proof reading of the data entry. The detected error rate was below 5%.

Translation and content validity of the Nordic HE instrument

The manual and the personal component of the Nordic HE were identical to the original Swedish version of the instrument. The environmental component was a result of the development of a content-valid Nordic HE. The translation was performed in two steps in the four countries with minor variations. First, a professional translator translated the entire instrument, which was reviewed and compared with the original version by a number of occupational therapists and architects in each country until consensus was reached. Second, the manual and the rating forms were translated by means of the so-called two-panel approach (Swaine-Verdier et al., 2004: Whalley, 2004) in which a consensus translation was produced by a panel of a professional translator, professionals familiar with the Swedish language and representatives of the developers of the adapted instrument. This was followed by a review of the first translation by a second panel consisting of monolingual people representing the users of the instrument to increase the acceptability of its wording and to ease completion (McKenna et al., 2010).

Since housing standard definitions constitute a crucial part of the environmental component of the HE, cross-Nordic harmonization based on a systematic comparison of national housing standard definitions addressing accessibility was required in order to develop a content-valid Nordic HE. Using the approach applied in the ENABLE-AGE project (Iwarsson, Nygren and Slaug, 2005), we systematically compared and analyzed housing standard definitions item by item. This analysis took place over several meetings during a period of eight months. The process involved different constellations of professionals collaborating nationally and cross the Nordic countries. The

development of a cross-Nordic content-valid version of the environmental component of the HE led to a change of 13 of the 188 original environmental barrier items.

Data analysis

The Nordic HE study (I)

Inter-rater reliability and agreement were analyzed by means of percentage agreement and Cohen's Kappa (Cohen, 1960). Percentage agreement and Kappa values were calculated for each rater pair, item by item. Next, the mean percentage agreement and Kappa values of the 10 rater pairs were calculated for each item. Furthermore, the mean percentage agreement and Kappa values for the 15 items in the personal component were calculated, as were the mean percentage agreement and Kappa values for the 188 items in the environmental component. A common definition of good agreement is 80% or more (Iwarsson and Isacsson, 1996). Kappa values were interpreted according to Altman's guidelines (1999); values < 0.20 = poor agreement, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = good, and 0.81–1.00 = very good agreement.

The agreement study (II)

The underlying basis for the agreement study was a conceptual analysis of the phenomenon of *inter-rater agreement.* Deriving from the tradition of analytical philosophy (e.g. Hospers, 1997), the concept was disassembled to examine and comprehend what it was composed of. The conceptual analysis was supported by reviewing the literature, by discussions among authors and by pure reasoning (Slaug, 2012).

To fit the design of the agreement study, the data were restructured in a raters x items matrix. For each rater pair and item constellation, the cell frequencies were computed by cross-tabulating the pairwise assessments of presence/absence of the environmental barrier items. The resulting data set comprised 1,880 observations (10 rater pairs x 188 items).

The statistical analysis took place in two steps. First, we outlined so-called *shares of agreement variation formulae*, with the purpose of separating into relative shares the contribution of the variation in the agreement data deriving from the raters, the items and the residuals. Hence, the the total sum of squares (SST) of the agreement values could be decomposed into the sums of squares resulting from rater pair variation (SSR), resulting from item variation (SSI), and the residual sum of squares (SSres). Next, to reveal the magnitude of

influence on disagreement deriving from each of the components, multilevel regression analysis was used (Hox, 2002).

The extrapolation of standards study (III)

Based on the means of the exact measurements recorded for each of the ten selected HE environmental barrier items, two alternative housing standard definitions were created. The two alternative standard definitions represented lower environmental demands compared with existing standard definitions. Then, the proportions of dwellings not meeting each of the two new alternative standard definitions were calculated to examine how different standard definitions for the same design feature influenced the proportion of dwellings considered to be accessible. Analyses were conducted in the three national samples as well as in cross-national totals.

Four of the ten selected HE environmental barrier items were chosen owing to their exemplification value. They were subsequently used in the investigation of how different standard definitions influenced the proportion of persons defined as having accessibility problems. The four items were: *parking space far from entrance; narrow door openings; handrails placed too high;* and *stairs/thresholds/difference in level between rooms/floors.* For the exploration of how the standards influenced the proportion of persons defined as having accessibility problems, four different type profiles of combinations of physical functional limitations among old people were analyzed against the four HE environmental barrier items just mentioned. Type profiles are combinations of up to six functional limitations, and two of the profiles included the use of a rollator or a wheelchair (Slaug et al. 2010). The proportions were analyzed and displayed by empirical distribution functions (Kirkwood and Sterne 2003). A visual graph inspection of the curves displaying the cumulative proportion of persons defined as having accessibility problems was performed and validated among authors. Important to note is that the analysis involved measures recorded in dwellings belonging to the persons represented in the type profiles. The analyses were thus generated on the basis of the persons who were actually living in each of the particular dwellings where the exact measurements were recorded.

The activity-based approach study (IV)

The kitchen was designed according to the environmental component of the Nordic HE instrument (Iwarsson and Slaug, 2008). The standardized activity (preparation of lunch and coffee and cleaning) was analyzed to identify the series of activities that formed part of this activity (e.g. forcing the threshold, taking objects from the shelves of the wall cupboards and base units). For this purpose, an activity-focused activity analysis was performed (Crepeau et al.,

2009). This approach also served to ensure that the kitchen and the equipment was purposefully arranged according to the study purpose.

Descriptive statistics of the approach study were used to examine the distribution of observational and the self-reported data. The distribution was subsequently graphically displayed. The Mann-Whitney U-test was performed to investigate if there were significant accessibility problem differences between those not using mobility devices, those using a rollator or those using a wheelchair (Kirkwood and Sterne, 2003). The sign test was conducted to investigate if there were significant differences between the observational and the self-reported data (Kirkwood and Sterne, 2003). P-values < 0.05 were considered to be statistically significant. Finally, a classical content analysis technique was used for categorizing and analyzing the content of the observation notes and participant comments. The number of occurrences per category were counted and presented if considered to be substantial (Kohlbacher, 2006), which was defined as observations and/or comments occurring ≥ 8 times.

Results

The main results of the separate four studies are presented together under the following two headlines: “Reliability of housing accessibility assessments” (studies I and II) and, “Validity of housing standard definitions” (studies III and IV).

Reliability of housing accessibility assessments

The main result of the Nordic HE study (I) was the development of a cross-Nordic content-valid version of the HE instrument made available in four Nordic languages. To develop the Nordic version of that instrument, the harmonization of housing standard definitions addressing accessibility resulted in a revision of 13 of the 188 original environmental barrier items. The mean percentage agreement exceeded 80% for both components of the instrument, while the mean Kappa values indicated moderate agreement for the personal component and fair agreement for the environmental component. An item-wise analysis of the percentage agreement of the personal component revealed that 13 of the 15 items in total demonstrated good agreement. A similar analysis of the Kappa results showed that 11 of the items had moderate to very good agreement, while the remaining four items demonstrated fair or poor agreement. For the environmental component, an item-wise analysis of the percentage agreement demonstrated that the agreement exceeded 80% for 128 of 188 items in total, and that it was 70-79% for another 35 items. In terms of Kappa values, the agreement was moderate to very good for 68 items.

The conceptual analysis in the agreement study (II) allowed agreement to be disassembled into three components: raters, items and contexts. The two agreement indices (percentage agreement and Kappa) showed similar patterns in the variation of agreement data when disentangled into relative shares. The raters accounted for 6-11% of the variance, the items for 32-33% and the residual accounted for 57-60%. Statistical significance for both agreement indices was found for: item assessment type, item prevalence estimate and raters’ familiarity with standardized instruments, which appeared to be

substantial predictors of the agreement variation. Raters' housing adaptation experience acted to be a non-statistically significant predictor. Disagreement is likely to decrease if the barriers are assessed by items based on evaluative judgments and if one or both raters are not familiar with the use of standardized instruments (see Table VI).

Table VI. Predictors of agreement variation.

Rater and item characteristic	Agreement index[1]			
	Percentage agreement		Kappa[2]	
	N=1880		N=1402[2]	
	Estimate[4]	P	Estimate[4]	P
Housing adaptation experience (raters)[3]	-0.024	0.444	-0.048	0.529
Familiarity with standardized instruments (raters)[3]	0.107	0.009	0.270	0.007
Barrier assessment type (items):		<0.0001		<0.0001
- evaluable vs. obvious	-0.094	<0.0001	-0.205	<0.0001
- measurable vs. obvious	-0.022	0.060	-0.010	0.717
Barrier prevalence estimate (items)[5]	-0.258	<0.0001	-0.099	0.010
Level-1 R^2	0.16		0.12	

[1]The agreement indices are treated as dependent variables in the model.
[2]Kappa have missing values due to division by zero, i.e. the agreement index is undefinable.
[3]Dichotomized: 0="Only one/none of the raters experienced/familiar", 1="Both raters experienced/familiar."
[4]Estimated regression coefficient (fixed effect).
[5]Barrier prevalence is estimated as the occurrence in the ENABLE-AGE sample.

Validity of housing standard definitions

The results of the extrapolation of standards study (III) clearly demonstrated that different standard definitions for the same design features affected on the proportion of dwellings not meeting the standard definitions, for several of the examined environmental barriers to marked extent. This affect was most distinct for the standard definition for *entrance door openings*. The proportion of dwellings not meeting the current standard definition for *door opening at entrances* (≥75cm) reached 11.3%. If this standard definition was replaced by

an alternative definition (≥83cm) perceived to pose fewer accessibility problems, the overall proportion of dwellings not meeting this alternative standard definition rose to 64.6%. As to the *door openings in the indoor environment*, replacing ≥75cm with the least demanding alternative standard definition (≥81cm) meant that 89.3% of the dwellings would not meet this standard. If the alternative standard definition for *passenger loading zones* was used, the proportion of accessibility problems rose four-fold (i.e. from 10.4 to 41.9%); however, in Sweden it rose seven-fold (from 5 to 35.8%). For some of the current standards, there was much variation among the countries; see *parking spaces far from entrances or stairs/thresholds/difference in level between rooms/floors,* for example (see Table VII).

Table VII. 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 current standard definitions followed by two alternative ones representing lesser environmental demands.

Current 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)[1]	13.6%[1]	5.0%[1]	21.4%[1]	14.0%[1]
Alternative 1: 40-49m[2]	28.4%[2]	-	34.5%[2]	23.1%[2]
Alternative 2: 25-39m[2]	36.4%[2]	-	41.8%[2]	28.8%[2]
Passenger loading zones far from the entrance (≥100m)[1]	10.4%[1]	10.4%[1]	10.4%[1]	10.4%[1]
Alternative 1: 27-99m	54.2%[2]	1.7%[1]		
Alternative 2: 10-26m[2]	72.2%[2]	-	35.8%[2]	41.9%[2]
Marked handicap parking is lacking or too far from the entrance (≥100m)[1]	88.9%[1]	65.0%[1]	70.0%[1]	76.1%[1]
Alternative 1: 47-99m[2]	-	-	77.3%[2]	78.3%[2]
Alternative 2: 10-46m[2]	-	-	81.6%[2]	81.3%[2]
ENTRANCES				
Narrow door-openings (≤75cm)[1]	7.0%[1]	23.4%[1]	6.8%[1]	11.3%[1]
Alternative 1: 76-82cm[2]	27.8%[2]	40.9%[2]	55.7%[2]	40.9%[2]
Alternative 2: 83-90cm[2]	46.2%[2]	58.1%[2]	90.4%[2]	64.6%[2]
High threshold and/or steps at the entrance (≥25mm)[1]	67.6%[1]	23.4%[1]	77.8%[1]	74.9%[1]
Alternative 1: ≤25mm[2]	-	-	86.1%[2]	78.5%[2]
Alternative 2: ≤22mm[2]	-	-	79.8%[2]	79.3%[2]
Handrails placed too high(≥80cm)[1]	10.0%[1]	52.5%[1]	6.5%[1]	20.0%[1]
Alternative 1: 81-90cm[2]	-	79.2%[2]	34.5%[2]	37.7[2]
Alternative 2: 91-100cm[2]	-	86.5%[2]	64.5%[2]	50.1[2]
Narrow door-openings (balcony/terraces) (≤75cm)[1]	29.8%[1]	26.1%[1]	54.2%[1]	37.2%[1]
Alternative 1: 76-81cm[2]	42.9%[2]	-	76.6%[2]	43.4%[2]
Alternative 2: 82-90cm[2]	55.6%[2]	-	88.7%[2]	52.9%[2]
INDOOR ENVIRONMENT				
Stairs/thresholds/difference in level between rooms/floor spaces (≥25mm)[1]	24.9%[1]	60.1%[1]	47.4%[1]	41.9%[1]
Alternative 1: 22-24mm[2]	40.4%[2]	67.3%[2]	58.7%[2]	53.8%[2]
Alternative 2: 15-21mm[2]	43.3%[2]	70.6%[2]	76.3%[2]	61.9%[2]
Narrow passages/corridors in relation to fixtures/design of building (≤110m)[1]	58.9%[1]	39.6%[1]	39.8%[1]	47.2%[1]
Alternative 1: ≤129-160cm[2]	71.6%[2]	61.4%[2]	61.7%[2]	65.5%[2]
Alternative 2: ≤111-128cm[2]	81.3%[2]	71.6%[2]	82.1%[2]	79.0%[2]
Narrow door-openings (≤75cm)[1]	79.6%[1]	68.3%[1]	53.7%[1]	67.7%[1]
Alternative 1: 76-80cm2	84.4%[2]	80.2%[2]	86.1%[2]	83.9%[2]
Alternative 2: 81-90cm[2]	89.3%[2]	81.2%[2]	95.5%[2]	89.3%[2]

[1]Standards incorporated into the environmental component of the ENABLE-AGE research version of the Housing Enabler (Iwarsson and Slaug 2000; Iwarsson et al. 2005).
[2]Defined based on the mean of the exact measurements recorded.
Note: Data treated as missing if measures were not recorded according to the data collection instructions.

The curves demonstrate that the proportion of persons defined as having accessibility problems depends on the type profile and the standard definition in question. For the standard definition for *distance between parking space and entrances*, the proportion of persons defined as having accessibility problems was quite similar for the four type profiles. For the standard for *door openings at entrances* (≥75cm), the proportion of persons within the type profiles not using mobility devices defined as having accessibility problems was 4–5% compared with 57% within the type profiles that used mobility devices. If this standard was redefined to ≥90 cm, only 1–3% of the total sample was defined as having accessibility problems. With regard to *handrails placed too high*, the standard at 80 cm height yielded the lowest proportion of persons defined as having accessibility problems. For the standard concerning *stairs/thresholds/level difference between rooms/floor spaces*, the proportion of persons defined as having accessibility problems was 40–51% for the two type profiles, including the use of mobility devices, compared with 12–20% for the two without. For this standard definition the critical cutoff point was 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.

The results of the activity-based approach study (IV) demonstrated that all groups of participants were facing quite substantial accessibility problems. The design features that caused the most frequent and severe observed and self-reported accessibility problems across the three groups of participants were the *wall cupboards' upper shelves* and the *base units' lower shelves*. The participants without mobility devices had the least frequent and least severe accessibility problems, while those using a wheelchair had the most frequent and most severe problems.

Significant accessibility problem differences between those not using a mobility device and those using a rollator were found for three design features upon observation and for five design features as determined by self-reporting. Significant differences were found in about half of the design features between accessibility problems encountered by participants using a rollator and those using a wheelchair. For all 12 design features except two design features assessed by observation, significant accessibility problems differences were found between participants not using a mobility device and those who used (see Table VIII). Yet, there were no significant accessibility problem differences between the data collected by observation and self-report.

Table VIII. The kitchen features demonstrating statistical significant difference with regard to the accessibility problems among the three groups of participants assessed by observation and self-report (N=30).

Kitchen feature	Not using/using rollator		Using rollator/wheelchair		Wheelchair/not using	
	Observation p-value	Self-reporting p-value	Observation p-value	Self-reporting p-value	Observation p-value	Self-reporting p-value
Thresholds	.000	.000	.040	.629	.000	.002
Door width	.146	.317	.056	.100	.005	.030
Kitchen encounter height	.661	.374	.002	.042	.005	.012
Kitchen encounter depth	.259	.067	.208	.280	.048	.012
Floor space	.317	.012	.845	.313	.002	.001
Floor space turning	.317	.146	.010	.052	.000	.001
Floor space at domestic appliances	.005	.002	.000	.016	.001	.001
Wall cupboards' upper shelves	.191	.488	.478	.690	.000	.000
Wall cupboards' lower shelves	1.00	.549	.011	.011	.001	.019
Base units' upper shelves	.189	.022	.001	.077	.374	.049
Base units' lower shelves	.014	.048	.661	.933	.084	.0229
Legroom beneath kitchen encounter	-	-	.256	.412	-	-
Summary of self-report	-	.067	-	.001	-	.000

P-values ≤ 0.05 were considered to be statistically significant and are marked.

The observation notes showed that the mobility devices were used for transportation purposes, such as for bringing an object from A to B. Moreover, half of those using a rollator sat on their mobility device during the activity. Some participants used the environment to compensate for their functional limitations, e.g. by holding on to the door frame while walking through the door. Besides, only few participants stood in front of the dish washer and the refrigerator; instead, they used these domestic appliances laterally. Participants using mobility devices had to close the door by squeezing their fingers in between the door leaf and the door frame, giving the door a push. The participant comments provided no new knowledge.

Discussion

This thesis addresses housing accessibility methodology in general and the reliability of assessment and the validity of standards in studies of older people in particular. A main methodological contribution of the present thesis is the development of the content-valid Nordic HE instrument which is deemed sufficiently reliable in Nordic countries, and the recommendations for in-depth examination of inter-rater agreement for the improvement of reliability. A second main contribution of the present thesis is that it explores the consequences of the housing standard definitions in terms of accessibility and provides estimates of the proportion of dwellings considered accessible and the proportion of persons defined as having accessibility problems. Collectively, these results have the potential to influence research, practice and policy in a European and even a global context for the benefit of the health and well-being of older people with functional limitations. Moreover, the results provide new knowledge and invite reflections on central concepts and methodology relevant to psychometrics and research on person-environment fit.

Reliability of housing accessibility assessments

In the Nordic HE study (I), we followed systematic procedures for translation and cross-national harmonization of items on housing standards. This resulted in a content-valid instrument for housing accessibility assessment: the Nordic HE. The findings show that the inter-rater reliability of the Nordic HE is good in terms of percentage agreement and moderate to fair in terms of Kappa values. Since the Nordic HE is a multi-dimensional instrument and the fact that the raters lacked up-dated rater training, we do find the instrument sufficiently reliable for application in Nordic contexts in light of the below discussion of Kappa values and prevalence. However, there are threats to the inter-rater agreement that are rooted not in the instruments itself, but in aspects of the complex assessment situation; and these issues may potentially impact the agreement results.

The fact that only 13 environmental barrier items needed to be revised for the development of the cross-Nordic content-valid version confirms the assumption that the Nordic countries are, indeed, similar with respect to housing standard definitions. Although careful attention was paid to the translation process, small language mistakes were identified during the course of the translation. This demonstrates that translation also constitutes a potential threat to validity and reliability (Streiner and Norman, 2008). In the Nordic HE study (I), a two-panel approach was employed for the translation (Swaine-Verdier et al., 2004; McKenna et al., 2010). This approach has shown advantages over forward and backward translations in terms of linguistic preferences by the target population and by the lay people representing the end user of a given instrument according to Hagell et al., (2010). Although not reported, this is in line with our experiences.

In terms of reliability, the level of agreement in the Nordic HE study (I) was expected to be higher for the personal component than for the environmental component. One reason is that occupational therapists are used to assess persons by observation and interviews, while less used to performing environmental assessments based on standards with clear-cut definitions. Another reason is that since the HE is applicable in different types of dwellings (one family house, row house, blocks of flats etc.), the instrument covers a number of items of which some are likely to only rarely occur while others occur often. That is, if there is little variability among the items assessed, the ability of the instrument to discriminate will rarely be put to test (Gwet, 2012; Guanmin et al., 2009; Sim and Wright, 2005). Already aware of these potential problems at the outset of the Nordic HE study (I), we sought to improve the study design by striving for achieving a balanced prevalence as suggested by Hohler (2000) in order to optimize the conditions for estimating agreement. By means of sampling according to diversity criteria we tried to obtain a data set, where each of the 188 environmental items occurred around 50%. Despite these precautions, we did not succeed in this. Considering this further, it should be emphasized that it is very challenging to sample persons with different functional limitations who are dependent on diverse mobility devices and living in different types of dwellings.

In light of the complexity of the assessment situation identified in the Nordic HE study (I), which potentially affects reliability, the main contribution of the agreement study (II) is that it proposes a multicomponent approach. This approach aims at in-depth examination of inter-rater agreement to identify the most critical sources of disagreement deriving from items, raters and contexts. As demonstrated by the present results on barrier prevalence estimates, item ratings hinge on evaluative judgments, and the rater's relative familiarity with the use of standardized assessment instruments emerged as a significant

predictor on both Kappa and percentage agreement. This analysis could have been even deeper if we had had additional data on other characteristics of the components. In particular, data on contextual characteristics deserve to be explored in future research. The approach applied in the present study is applicable to assessment instruments in general that involve multiple raters and is relevant for instance in relation to instrument development. Future studies serving such purposes are recommended to systematically obtain data on raters, items and contexts. Only with such data at hand may it be possible to identify potential weaknesses threatening the use of reliable instrument in realistic assessment situations. Such in-depth studies would also create the foundation for optimization of item definitions, improvement of rater training and a stronger focus on contextual factors that may influence the assessment situation, and, hence, ultimately improve assessment instrument reliability (Slaug, 2012).

The results of the agreement study (II) further confirm one of the main messages of the previous discussion: that it is easy to agree if items occur rarely or often, because these items will rarely be put to test (Gwet, 2012). Applying the barrier prevalence estimate of the present study, items with a balanced prevalence in the range from 41 to 60% demonstrated the highest Kappa values, which is in line with the results of Hohler (2000). As also demonstrated by the result of the present study, the level of agreement differed between the Kappa values and the percentage agreement, although the shares of variation were more or less comparable. This is hardly surprising in light of the fact that Kappa and percentage agreement measure different traits (Kottner et al., 2011). However, based on these results, we may argue that low Kappa values are not necessarily an indicator of poor reliability or a better agreement index than percentage agreement, although it is often claimed to be so (see e.g. Kielhofner, 2008). At least, the results of the present study lend substance to the impression a similar distribution is revealed when examining the shares of agreement variation by both Kappa and percentage agreement. Still, this needs to be further explored in future research. In this context, it is also relevant to address another aspect of reliability in light of the results of the agreement study (II). In general, reliability is considered to constitute an upper threshold of validity so that the higher the reliability, the higher the utmost achievable validity (Streiner and Norman, 2008). In that regard, it is important to note that item prevalence significantly influenced the agreement variation as demonstrated by the results of the present study. That is, some of the HE items that demonstrated poor Kappa values in the Nordic HE study (I), because they were either rarely or often put to test could indicate poor reliability, as these items may be regarded as items that add no new information (Kottner et al., 2011). However, from a content validity perspective, these items may be

warranted (Cook and Beckman, 2006), as they could be considered to be critical for capturing relevant aspects of accessibility problems (Slaug, 2012). In relation to the interpretation of Nordic HE results, it is thus essential to consider reliability relative to validity with respect to each of the environmental barrier items.

The result of the Nordic HE study (I) allows the investigation of differences and similarities in the Nordic countries as concerns housing accessibility in general or e.g. in occupational therapy practices. With respect to housing interventions, such as housing adaptation or relocation advice, the Nordic HE has the potential to improve best practice and, ultimately, advance and promote accessibility at the Nordic policy level. However, relevant inferences may only be made if such comparison is conducted on an appropriate knowledge basis (Streiner and Norman, 2008). In the agreement study (II), agreement is relative in the sense that it is shaped by three components, raters, items and contexts, which vary between studies. Without knowing which components impact agreement to which extent, any comparison of assessment results across studies is therefore hardly appropriate. However, the approach proposed in the agreement study (II) offers an opportunity to collect data systematically in a way that allows appropriate comparison across countries. Unifying the results of the Nordic HE study (I) with the results of the agreement study (II), we can now present a strategy for how to accomplish cross-national content-valid versions of the HE involving translation and harmonization of housing standard definitions addressing accessibility. We may also present an analytical approach that allows in-depth examination of inter-rater agreement that has the potential to enhance the reliability of assessment instruments and make cross-national comparisons of inter-rater agreement studies possible.

Validity of housing standard definitions

To the best of my knowledge, the results of the extrapolation of standards study (II) and the activity-based approach study (IV) represent novel knowledge. The results provide new insights into accessibility problems encountered by older people with different types and combinations of physical functional limitations and dependence on mobility devices. The results also further the understanding why it is critical that housing standard definitions addressing accessibility are valid. The results of the extrapolation of the standards study (III) demonstrated that a difference of a few cm in some of the standard definitions markedly affected the proportion of dwellings considered

accessible and the proportion of older people defined as having accessibility problems. The fact that the proportion of dwellings that society considers being accessible varies much from country to country is evidence that dwellings actually are designed quite differently with respect to accessibility, at least in the three European countries involved in the present study. Moreover, as shown by the results of the activity-based approach study (IV), if the standards are not validly defined, they may not accommodate older people with functional limitations, even if they are intended to serve this purpose. This is in accordance with Barnes et al. (2012), who found that although the housing environment on the surface seems to be well-designed for accessibility and wheelchair use, the devil lies in the detail, e.g. thresholds, heavy doors and cupboards. Such details may make independent living unrealistic for residents with physical functional limitations.

A striking aspect of the results of the activity-based approach study (IV) is that although the study setting was designed according to current housing standards aimed to ensure accessibility for the study population, the participants did, in fact, encounter many accessibility problems. This is even more striking when adding the results of the literature review and the results of the extrapolation of the standards study (III). That is, although housing accessibility has important implications for older people's lives and although the standard definitions determine the proportion of dwellings considered being accessible, research with a potential to inform standards addressing accessibility remains largely lacking. Paradoxically, this is in contrast to the increasing international focus on accessibility in light of global society's ambition to ensure social inclusion as a basic human right (www.CEN.org; WHO and the World Bank, 2011; UN, 2006). Persson and Sahlin (2008) refer to this as *knowledge instability.* This concept signifies that if the knowledge informing our judgments is based on an instable knowledge basis, the judgments rests on perilous ground, and the judgments may therefore not have the intended effect. Applied to the issue of housing standard validity, the risk is that the standard definitions do not truly accommodate older people with functional limitations. According to the results of the activity-based approach study (IV) this happens to be the case. The present study found that some standards are not defined in a manner that duly enhances accessibility because the definitions do not cater for the way older people with mobility devices actually interact with the environment. One example is the standard for *floor space by the domestic appliances,* positing 130 cm in front of the domestic appliances. This space was not used. Instead, an accessibility problem appeared in terms of lack of legroom beneath or next to the domestic appliances. Based on the results of the present study, our standpoint is that standard definitions not anchored in reality are of poor relevance and hence,

may have poor validity. Moreover, we found that there is a need for additional standards such as space for legroom next to domestic appliances or for enabling door closing. We may therefore suggest a review of the validity of existing standard definitions as well as identification of potentially lacking others. Thus, the findings of the present thesis support the results of Steinfeld et al., (2010), who stressed the need to apply research results to policy and the need for a revision of standard definitions addressing accessibility.

As demonstrated by the results of the extrapolation of standards study (III) and the activity-based approach study (IV), different design features generate distinct accessibility problems to a variable extent depending on the combination of functional limitations and the dependence on mobility devices in question. It is therefore important to examine the validity of the standard definitions in a sample representing the broad spectrum of people whose needs the standards are intended to accommodate (Blanck et al., 2010). However, most studies have investigated accessibility problems in homogeneous samples (see e.g. the literature review, page 23). Kirvesoja et al. (2004) found that 160 cm was an appropriate height for the uppers shelves of the wall cupboards for older people not using mobility devices. This is in line with the results of the activity-based approach study (IV) for those not using mobility devices. This takes us to another important part of the results gained in the extrapolation of standards study (III) and the activity-based approach study (IV), namely the applicability of the methodology used. It is, for example, possible to determine the proportion of persons defined as having accessibility problems for a threshold height standard of either 15mm or 25mm. Moreover, it is possible to define the extent to which this standard definition causes accessibility problems to how many of those using a rollator, or a wheelchair and to those not using mobility devices. This is relevant for the investigation of which groups of people will be included or excluded by the standard definitions (Keates and Clarkson, 2004). In fact, the determination of the standard definitions represents one of the most critical challenges related to the establishment of the validity of housing standard definitions addressing accessibility. The methodology utilized in the present studies may produce knowledge that can validly inform the definitions of housing standards.

We learned from the observations of the activity-based approach study (IV) that accessibility and accessibility problems occur as a result of the interaction between the person (with his/her functional limitations), the mobility device, the environment and the activity. For instance, the kitchen counter and the door frame serve to compensate for functional limitations and thus formed part of the activity by accommodating its performance. This may add to Lawton's argumentation (1989; 1985) that older people with functional limitations adapt to environmental demands. This finding is also in line with the results of

Thapar et al. (2004). They found that both environmental barriers and environmental facilitators are critical for the understanding of what restricts or promotes accessibility. Moreover, in accordance with the findings of Löfqvist et al. (2008), we found that like the environment, the mobility devices also formed part of the activity. For instance, half of those using a rollator sat on their mobility device during the activity. Further, the mobility devices were used for transportation, for example of bringing a cup of coffee from A to B. That is, the situations "forcing the threshold with a cup of coffee" versus "forcing it without any objects" differ substantially, because the coffee topples when the threshold is forced. This demonstrates the importance of including mobility devices in the investigation of accessibility and the value of examining accessibility in realistic environments. It also shows the importance of involving the activity and persons with different functional limitations and dependence on varying mobility devices into the examination of accessibility, as displayed in Figure 2.

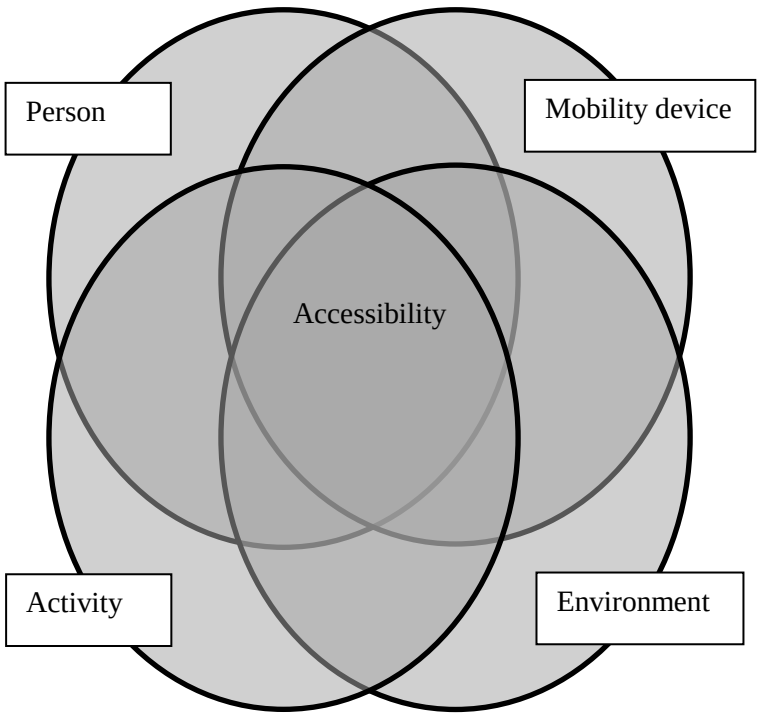


Figure 2. An activity-based approach was used to study accessibility, which was found to involve four components: person, environment, activity, and mobility device.

As demonstrated by the results of the activity-based approach study (IV), the "real world" in which the housing standards are intended to ensure accessibility is much more dynamic than reflected in the knowledge identified in the literature review (Paquet and Feathers 2004; Kozey and Das 2004; Das and Kozey 1999; Steinfeld et al. 2004, 2010; D'Souza et al. 2009; Ringeart et al. 2001). Supported by Kirvesoja et al. (2000), the results of the activity-based approach study (IV) illustrate that knowledge on human body size alone is not sufficient for the design of environments that accommodate older people's needs. It is therefore difficult to apply models of ergonomics and anthropometry with static standardized measures to establish the validity of housing standard definitions addressing accessibility. The experiences gained in the present study show that it may be relevant to apply a theoretical framework, for instance based on dynamic system theory, to approach the complexity and dynamics of the interaction between components constituting accessibility.

Finally, particularly critical is to bear in mind that ensuring the validity of housing standard definitions is an on-going process due to continuous changes in the population of older people with functional limitations, environmental design trends and the general technological development. Ensuring the validity of housing standard definitions is thus an extensive task that would benefit from an international collaboration in line with the recommendations of Steinfeld and al. (2010). To serve this effort, there is a need for a consensus definition of accessibility and a need for sound methodology to inform robust housing standard definitions. With that said, it is important to acknowledge the differences among national housing standard definitions addressing accessibility. Differences across Europe and globally are prominent, for example in wheelchair design, housing design, body size, economic development, types of activities performed in the dwelling and cultural expectations to independence among the population. Research informing the housing standards and housing standards developed in the Western world therefore cannot be blindly applied in other parts of the world. Still, this does not render international standardization collaboration superfluous and the benefits of such collaboration far outweigh the disadvantages according to Steinfeld et al. (2010).

From a methodological perspective, the knowledge achieved on the validity of current housing standard definitions and the approach used to examine accessibility problems deployed in the activity-based approach study (IV) can serve to increase the overall validity of the HE. First, since housing standard definitions form part of the environmental component of the instrument, the validity of the items therefore depends on the validity of these standards. Therefore, optimal validity cannot be achieved unless the validity of standard

definitions is known. The lack of valid standard definitions may result in misleading results of the HE instrument which could lead to wrong decisions and priorities concerning strategies for housing adaptations or relocation advice. However, it is important to note that the HE instrument is only one among several assessment instruments with which information about housing interventions may be collected (Fänge and Iwarsson, 2007). Moreover, information on housing accessibility problems should consist of data obtained via the use of standardized assessments and data showing the users' perception (Iwarsson and Slaug, 2010). Second, the methodology used could serve to improve the validity of the predefined severity points (0-4) of the HE scale through an empirical examination of the extent to which certain design features generate accessibility problems for persons with particular functional limitations and dependence on mobility devices. Yet, this is would be very resource demanding. Alternatively, computer simulations of type profiles, representing groups characterized by certain combination of typical functional limitations occurring among the population of older people (Slaug et al., 2010) could be used. Taken together with the results presented in Slaug's PhD thesis (2012), the results of the present thesis have the potential to nurture future research on housing accessibility methodology.

Reflections on accessibility

While the ecological model of ageing (Lawton and Nahemow, 1973) and the docility hypothesis (Lawton and Simon, 1968) seem well-suited for defining accessibility (Iwarsson and Ståhl, 2003), they only provide a basic understanding of the nature of person-environment fit. The results of the present research demonstrate that the personal component of the concept represents the major share of the variance in the magnitude of accessibility problems as also demonstrated by others (Slaug et al., 2013). The results of the activity-based approach study (IV) may therefore be taken to indicate that more complex and severe functional limitations actually generate accessibility problems. With that said, it is important to note that the results of the activity-based approach study (IV) demonstrated that those using a rollator reported more functional limitations and problems in mobility as well as PADL than those who used a wheelchair. However, the latter demonstrated the most frequent and most severe accessibility problems. There is accordingly a need to further differentiate between mobility device users and to establish to which extent the accessibility problems encountered are due to the users' physical functional impairments on the one hand and/or to their use of various mobility devices on the other hand.

The PEO model (Law et al., 1996) also seems to aid our understanding of the factors constituting the ability to perform activities. However, the PEO model offers no definition of concepts of importance for activity performance as related to the environment, such as accessibility. That is, even if the ability to perform everyday activities has been much investigated (Kielhofner, 2008), the model does not address which particular environmental design features should be assessed and how. The results of the activity-based approach study (IV) have contributed with further knowledge and clarification on which environmental design features impact accessibility and to which extent and how accessibility is the prerequisite of successful activity performance. One way of reasoning is that accessibility is one dimension or aspect of activity performance that departs from the environment and seeks to explain what enables the ability to perform activities. While accessibility denotes a "pure functional fit" with respect to the ability to perform an activity, activity performance includes more than this, e.g. personal constructs such as motivation, meaningfulness, and preferences, representing a dimension that was not targeted in the activity-based approach study (IV). Therefore, accessibility and activity performance is not the same.

The overlapping nature of accessibility and usability lies at the heart of the complexity of person-environment fit with respect to activity. This is supported by Fänge and Iwarsson (2003), who found that the concepts are related, yet different. In an attempt to further elaborate on the prevailing definition of accessibility, the activity-based approach study (IV) attempted to explore accessibility by maintaining a focus on the person-environment fit with respect to functioning at the expense of other aspects like satisfaction. According to the results of the present study, this definition works well where the aim is to examine accessibility problems as a means to investigate the validity of housing standards. However, the thesis does not solve all the challenges related to the concepts of accessibility and usability with respect to person-environment-activity fit. Still, it has hopefully served to advance this field of research. Evidently, there is a need to further refine the concepts of accessibility and usability to guide data collection and analysis in research on person-environment interactions (Iwarsson and Ståhl, 2003).

As demonstrated by the results of the activity-based approach study (IV), the new knowledge gained on accessibility was generated on the basis of observation. The self-reporting and participant comments provided no new information. This finding runs counter to the prevailing stance of combining different methods, e.g. observation and self-rating scales, to obtain a full picture of the investigated phenomenon (Bean et al., 2011). However, this may also be evidence that the applied definition focused squarely on the person-environment fit relationship as was the intention. Furthermore, older people

may adapt to the environment as argued by Lawton (1975) and may thus not notice accessibility problems obvious to the observers. For instance, only the observers noticed the participants' elevated shoulders while working by the kitchen counter. It is possible that participants would have noticed these problems in a daily, non-experimental setting where these accessibility problems would likely have translated into physical sensations or muscle pain over time. Still, based on our findings, observation seems to be a valid method to assess accessibility.

Reflections on accessibility in relation to the scope of the thesis

Extant research on standards for housing design addressing accessibility has been criticized on a number of counts. Part of the critiques argues that an approach to housing design that focuses on ergonomic standards and technical criteria is too narrow (Imrie, 2006). Proponents of this perspective consider standards as deterministic and argue that they reflect a reductionist perspective (Burns, 2004). Viewed in the light of the growth of social disability models and the growing recognition of the environment's influence on people's experience of disability (Ainsworth and de Jonge, 2011), it is hardly surprising that universal design has evolved and is gaining global attention. This concept could be seen as an approach to design that meets critiques of the standards. Universal design is defined as an approach to design that incorporates products as well as building features that to the greatest extent possible can be used by everyone (Mace, 1985). The goal of universal design is to bring people with functional limitations into mainstream society by ensuring equal opportunities and eliminating discrimination based on disability (Steinfeld and Maisel, 2012). This approach is more a philosophy of social inclusion and a process than a definite result. Conducting research on standards safeguarding accessibility instead of research on universal design could therefore be a subject of critique. Still, although universal design per definition is appealing and its ultimate goal worth striving for, universal design environments cannot be created without extensive knowledge bases clarifying whom and how many will be accommodated by which measures as addressed in the extrapolation of standards study (III). Actually, these kinds of reflections and discussions are largely overlooked in the literature. I agree with the World Disability Report (WHO & the World Bank, 2011) that once the concept of accessibility has become ingrained and more knowledge on accessible solutions has become available, it will be easier to attain universal design. That is, as long as research with a potential to inform research-based standards is as sparse as demonstrated in the present thesis, I claim that the standards are imperative to provide designers with such specifications as a management tool and to ensure

accessibility. As demonstrated by the results of the present thesis, a huge step still needs to be taken before the issue of valid housing standards and universal design may be duly addressed and housing policy and recommendations in general may be improved (Fänge and Dahlin-Ivanoff, 2009). Hence, there is a need for research contributing to the methodological advancement and development of the validity of standard definitions. Any results of empirical research that may pave the way for universally designed environments are valuable.

Study limitations

Although not reported in the Nordic HE study (I), the Icelandic and Swedish raters demonstrated better agreement than the Finnish and Danish raters, who completed their HE course six to nine months prior to the data collection. Since the HE instrument is comprehensive, the raters must continuously strive to maintain their competence (Iwarsson and Slaug, 2010). The lack of updated rater training and instructions in how to collect data for research purposes may have influenced the results of the study, which is considered to constitute a critical limitation of the study.

In the agreement study (II), the sample sizes used in the multilevel regression analysis need to be considered. With only 10 rater pairs, which constitute the level-2 sample size for our multilevel model, conventional sample size recommendations (Hox, 2002), such as the 30/30 rule (i.e., 30 level-2 units, each containing 30 level-1 units at least), were not met. In contrast, the level-1 sample size (N=1,880) much exceeds requirements given in the multilevel modeling literature. Yet, the literature is not unanimous concerning sample sizes. The results of Bell et al. (2010) suggest that with a sample size of 10 for level-2 sample sizes, confidence intervals and type I errors are estimated fairly well and estimates are unbiased (Slaug, 2012). Our design may thus be underpowered with respect to the influence of rater characteristics. Moreover, it would have been desirable to have had data on contextual factors to control for their characteristics such as time and weather condition and the number of persons present in the dwelling during the rating situation. Finally, we cannot be sure, if the residual, which we ascribe to the share of the agreement variation following from the contextual characteristics, does not cover other raters and items characteristics than those controlled for. That is, the explanatory strength of rater and item characteristics can potentially undermine the results. Yet, the main point of the agreement study (IV) was not the results as such, but the provision of a new analytical approach.

The analysis of the extrapolation of standards study (III) involved four different type profiles representing combinations of up to six typical physical functional limitations seen among very old people with different degrees of dependencies on mobility devices (Slaug et al. 2010). The type profiles are a first exploratory step of using a new methodology in this area. That is, to strengthen the validity of the type profiles, more research is required to confirm their legitimacy. However, the type profiles have been compared with aggregated data on older people of similar age from Statistics Sweden (SCB, 2010). These studies show striking similarities in the prevalence of functional limitations (Slaug, 2012). It should also be kept in mind that although the material is based on real observations, the results presented are theoretical constructions. The results have been achieved on the basis of the definition of accessibility applied, but do not necessarily reflect the extent of accessibility problems in reality. Still, the extrapolations and graphical illustrations demonstrating the proportion of persons defined as having accessibility problems are considered to represent qualified indications hereof, since they are based on a large data material and a data collection instrument tested for validity and reliability, namely the HE (Iwarsson and Slaug, 2010). The fact that the data were collected for other purposes limited the amount of available material. It would have been interesting and relevant to examine the same design features for which the standard definitions were examined in the activity-based approach study (IV) to compare theoretical and empirical explorations of the consequences of standards.

The results of the activity-based approach study (IV) should be interpreted with caution for several reasons. Although the study setting was an ordinary, typical and real kitchen, it was a contrived setting created to study single snapshots of a specific situation. The results may have turned out differently if the study had been conducted in the participants' own kitchens. However, for the examination of the validity of standard definitions, it was necessary to use a standardized setting with a certain level of control to be able to compare the results. The observers' impressions and each of the participants' comments on the study setting (systematically collected but not reported) gave us reason to believe that the study setting reflected a "real life" situation. This was so even if the kitchen was unknown to the participants and the situation reported to seem somewhat "artificial" during the first minutes. The target group was limited to older people with physical functional limitations. Accessibility problems among people with other functional limitations across a lifespan should also be investigated before valid standard definitions accommodating the needs of an entire population may be proposed. Since the use of study-specific instruments is a recurring criticism within accessibility research (Steinfeld et al., 2010; Preiser and Ostroff, 2001), efforts were made to test

basic psychometric properties of the study-specific instruments. With the satisfactory inter-rater reliability results and an interview questionnaire that was easily understood and well accepted by the participants, the results are considered sufficiently reliable for the present study objective. It should be noted that the approach for in-depth analytical strategy proposed in the agreement study (II) was not applied in the activity-based approach study (IV). Given the objectives of this study, it would have been an exaggeration. However, the use of study-specific data collection instruments has to be taking into consideration when interpreting the results. Future investigations of the validity of housing standards should deploy data collection instruments with a known validity and reliability. In this respect, it is relevant to employ the strategy for in-depth analysis to improve the overall reliability of such new instruments as proposed in the agreement study (II).

Conclusions

The overall results of the present thesis contribute to the further methodological advancement of housing accessibility. Although the thesis utilized data from six European countries, its results are considered to be applicable in an even broader context where focus is on older people with functional limitations and their dependence on mobility devices. The results may also be help guide professionals as well as the international society at large. New knowledge was generated for the development of cross-nationally applicable assessment instruments targeting housing accessibility, involving translation and harmonization of housing standards and in-depth examination of inter-rater agreement to improve assessment reliability. From an occupational therapy perspective targeting community-based rehabilitation as well as public health and planning, these kinds of results generate the basis for effective accessibility solutions, documentation of housing interventions and best practice. Exploring the consequences of the housing standard definitions addressing accessibility and the validity of the standards, the studies furthered our understanding of the critical aspects of the currently used standards. The findings may therefore serve to improve housing accessibility assessment methodology in general and to further the use of reliable and valid methods and approaches in particular. The following main conclusions may be made:

- The Nordic HE instrument is content-valid and sufficiently reliable for use in practice and research in the Nordic countries.

- Threats to inter-rater agreement are not due to the instrument itself, but to the complex assessment situation.
- The importance of up-dated rater training and familiarity with the use of standardized instruments should not be underestimated.
- An approach for in-depth analysis and examination of inter-rater agreement is proposed to identify the most important sources of disagreement that may jeopardize reliability, and on this basis to refine the instruments, to improve rater training and to increased awareness of the potential impact of various contextual aspects.
- Different environmental design features generate diverse accessibility problems to a variable extent depending on the person's functional limitations and dependence on mobility devices. Therefore, it is important to include people across the broader spectrum of functional limitations using various mobility devices to investigate housing accessibility problems.
- Housing standard definitions impact on the proportion of dwellings that society considers accessible and on the proportion of persons defined as encountering accessibility problems. A difference of a few cm in the standard definitions can make a large difference in these proportions; the validity of the standards is therefore essential.
- An activity-based approach for the investigation of accessibility problems is proposed. This approach may inform housing standards that are defined in ways that truly accommodate older persons with physical functional limitations who depend on mobility devices.
- Accessibility and accessibility problems arise on the basis of the following components: person, environment, mobility device, and activity.
- Observation seems to be a valid method for capturing accessibility while self-reporting of accessibility yielded no new knowledge.
- There is a need for a revision of housing standards addressing accessibility based on research and a critical review of existing standard definitions, which also includes an identification of potentially lacking standards.

Implications, relevance and future research

The overall results of this thesis have implications for the health and well-being of older people with functional limitations who use or do not use mobility devices. The thesis therefore also has implications for health-care professionals, such as occupational therapists, architects, gerontologists and researchers of diverse disciplines interested in housing accessibility methodology. Moreover, since a built environment that is accessible to all is a shared European and global policy effort (www.euractiv.com), even formulated as a human right (UN, 2006), the results of this thesis have societal and political implications for the planning and the provision of accessible dwellings that meet the population's requirements.

The implications of the Nordic HE study (I) are fourfold. The study targets both the cross-Nordic context and each of the national contexts and practices as well as research. At the national levels, the availability of the Nordic HE may support occupational therapists facing increasing demands to use research-based methodology and who need to demonstrate that interventions are efficient and effective (von Zweck, 2004; Kielhofner, 2008). As to the implementation of the HE instrument in community-based occupational therapy, Fänge et al. (2007) found that challenges are related notably to utilization of research-based methodology in practice. They also argued that communication and close cooperation between researchers and occupational therapists is an important prerequisite to the implementation of the HE. That is, there is already an existing knowledge base to build on. The Nordic instrument has the potential to advance and promote accessibility at the Nordic policy level. Since the HE is available in other European languages, it is even possible to make comparisons between additional countries. Ultimately, the HE methodology could be used in relation to the European Accessibility Act (www.euractiv.com) serving to place focus on and secure accessibility as concerns the housing environment.

The second edition of the HE (Iwarsson and Slaug, 2010) will be translated into Danish during the winter 2013. Based on the novel recommendations for inter-rater agreement examination proposed in the agreement study (II), it is relevant to conduct a new inter-rater agreement study of the second edition translated into Danish to examine its reliability. This should involve a data collection that covers particular characteristics of raters, items and contexts potentially influencing agreement, and a design that allow for a multilevel data structure. Ultimately, the proposed analytical approach serves to improve

reliable use of assessment instruments. Therefore, the results of the agreement study (II) as well as the Nordic HE study (I) furthermore have implications for future HE training courses. Up-dated rater training and instructions on how to collect reliable HE data in complex rating situations involving a variety of disturbances potentially impacting on reliability should be underscored.

The results of the extrapolation of standards study (III) and the activity-based approach study (IV) represent a critical stance on the knowledge informing current housing standard definitions addressing accessibility. Although this thesis does not solve the conceptual, theoretical and methodological challenges related to the development of housing standards that truly support accessibility, the results have, however, paved the way for future research on accessibility by its problematizations and exemplifications. Hopefully, these results stress how crucial it is that future standards are developed on the basis of solid knowledge. The thesis will also, hopefully, have made clear that current housing standard definitions should be critically reviewed with respect to their validity in realistic environments in which the standards are intended to accommodating older people. The results of the thesis are therefore highly relevant and have implications for standardization and the development of standards.

Finally, the thesis may have implications and relevance for public health. Although public health has recognized that well-being and health cannot be separated from the environment (Andersson and Ejlertsson, 2009), research targeting the relationship of housing accessibility and health is scarce (Slaug, 2012). In fact, public health has largely neglected to consider how some basic human needs relate to health, such as the ability to perform everyday activities in the housing (Wilcock 2006). Hopefully, the results of this thesis have contributed to a nuanced understanding of housing accessibility with respect to public health efforts.

Populærvidenskabelig sammenfatning på dansk

Den aldrende befolkning bliver større, hvilket giver samfundet og de fagprofessionelle en række udfordringer bl.a. med hensyn til udformning af tilgængelige omgivelser. Dette gælder ikke mindst boligen, da ældre mennesker overvejende opholder sig i hjemmet og ønsker at blive boende i egen bolig længst muligt. Menneskets naturlige aldring indebærer bl.a. fysiske funktionsnedsættelser i forskellig grad. Som følge heraf anvender mange ældre mennesker mobilitetshjælpemidler, eksempelvis rollatorer og kørestole. Ældre mennesker med fysiske funktionsnedsættelser, som anvender mobilitetshjælpemidler, har øget sandsynlighed for at få problemer med at udføre hverdagsaktiviteter i hjemmet, fordi boligen ikke er tilstrækkelig tilgængelig. Boligers tilgængelighed har betydning for ældre menneskers mulighed for at bevare deres sundhed og uafhængighed af andres hjælp, hvorfor det er vigtigt at identificere de barrierer i boligen, som giver anledning til tilgængelighedsproblemer.

Til dette formål er der er behov for valide og reliable måleredskaber, hvor validiteten sikrer, at måleredskabet faktisk undersøger det fænomen, som det har til hensigt, mens reliabilitet sikrer, at måleredskabet er stabilitet over flere målinger. Det har dog vist sig, at der er en række faktorer, som påvirker reliabiliteten. Disse faktorer kan eksempelvis være dataindsamlernes (raters) forudsætninger for at lave undersøgelsen eller, at måleredskabets items er formuleret upræcist. Endeligt kan der være faktorer i omgivelserne, der under selve undersøgelsessituationen påvirker undersøgelsens resultat. Derfor er der brug for indgående analyser af, i hvor høj grad sådanne faktorer påvirker måleredskabers reliabilitet. Valide og reliable måleredskaber er en forudsætning for, at de fagprofessionelle kan foretage interventioner, f.eks. rettet mod boligen, på et kvalificeret grundlag. Desværre findes der ikke mange redskaber, der kan bruges til at identificere tilgængelighedsproblemer i boligen, som samtidig er undersøgt for validitet og reliabilitet. Der er dog et måleredskab, nemlig det såkaldte ”Housing Enabler,” som er udviklet i Sverige. De nordiske lande har i store træk sammenlignelige boliger og ens politikker på tilgængelighedsområdet, hvilket er baseret på fælles

fundamentale værdier. Eftersom Housing Enabler allerede er oversat til flere sprog og har vist sig at være brugbar i andre lande, vil udviklingen af et fælles nordisk måleredskab på en gang give mulighed for, at mange fagprofessionelle får adgang til et redskab, der desuden har potentiale til at styrke tilgængeligheden på et samlet nordisk niveau.

Foruden behovet for at undersøge tilgængeligheden i eksisterende boliger, er der endvidere behov for at sikre tilgængelighed i opførelsen af nye boliger. Til sikring af dette, findes der en række standarder for biligdesign, der bl.a. specificerer, hvordan boliger skal udformes, så de lever op til vores krav om tilgængelighed. Arkitekter, bygherrer og andre fagprofessionelle bruger standarderne som et værktøj til at styre efter under opførelse af nye boliger. Det er derfor vigtigt, at den viden, der definerer disse standarder er valid. Herved forstås, at standarderne rent faktisk sikrer boligens tilgængelighed, så mennesker med funktionsnedsættelser har mulighed for eksempelvis at komme ind i boligen, komme omkring i boligen, samt nå deres ting i skabene. Standarddefinitionerne spiller på den måde en afgørende rolle for mennesker med funktionsnedsættelser, de fagprofessionelle og dermed for samfundet som heldhed. Forskning har dog vist, at den viden, der informerer disse standarder, er usikker og mangelfuld, fordi den er fastsat på baggrund af små og få studier, eller fordi den bygger på praksiserfaring og anekdoter. Således er det vigtigt at få større viden om konsekvenserne af mangel på forskningsbaserede standarddefinitioner samt at bidrage til udviklingen af metoder, der er med til at øge standarddefinitionernes validtet. Det overordnede formål med denne afhandling er at udvikle og afprøve metoder og tilgange til at kvalificere reliable og valide undersøgelser af tilgængelighedsproblemer i boligen og bidrage til udviklingen af valide standarddefinitioner for boligdesign, der fremmer tilgængelighed til fordel for ældre mennesker med funktionsnedsættelser. Afhandlingen består af i alt fire studier.

Formålet med det første studie var at udvikle en indholdsmæssig valid nordisk version af måleredskabet ”Housing Enabler” og teste dets reliabilitet, når redskabet anvendes i praksis. Processen med at udvikle og oversætte måleredskabet til dansk, islandsk, finsk og svensk involverede diverse konstellationer af forskellige fagprofessionelle (f.eks. oversættere, ergoterapeuter og arkitekter). Til selve oversættelsen, blev metoden ”the two-panel approach” anvendt. For at undersøge reliabiliteten af den nordiske Housing Enabler, undersøgte vi overensstemmelsen mellem data indsamlet af 20 ergoterapeuter, der parvist i alt undersøgte 106 boliger på tværs af de fire nordiske lande ved hjælp af den nordiske Housing Enabler. Data blev målt med to alment kendte mål, nemlig procentvis overensstemmelse og Kappa statistik. Resultaterne viste, at den nordiske Housing Enabler var tilstrækkelig reliabel til at den fremadrettet kan anvendes i de involverede nordiske lande.

Formålet med det andet studie var at identificere potentielle faktorer, der påvirker overensstemmelsesdata, når flere personer undersøger samme sag under lignende omstændigheder og at undersøge graden af faktorernes bidrag til variationen i overensstemmelsesdata. Det ultimative formål var at udvikle en metode, der kan være med til at forbedre måleredskabers reliabilitet. Med afsæt i en begrebsanalyse af "overensstemmelse," som blev delt op i komponenterne: raters, items og kontekst, analyserede vi variationen i de overensstemmelsesdata, der blev indsamlet i det første studie. Variationen i overensstemmelsesdata blev delt op i relative andele og påvirkningen af specifikke karakteristika hos raters og items blev analyseret. Resultaterne viste at items, der forekommer hyppigt eller sjældent, eller som har en evaluerende karakteristik (f.eks. glatte gulve) samt dataindsamleres (raters) mangel på erfaring med brugen af standardiserede måleredskaber, var signifikante prædiktorer på variation i overensstemmelsesdata. Desværre havde vi ikke de fornødne data til at tage analysen en skridt videre ved også at undersøge, hvordan karakteristika fra komponenten kontekst påvirker variationen. Dette metodestudie resulterede i anbefalinger til, hvordan man med fordel fremover kan designe overensstemmelsesstudier mhp. at identificere de faktorer, der bidrager til variation i overensstemmelsesdata.

Formålet med det tredje studie var at få indsigt i konsekvenserne af manglende forskningsbaserede standarddefinitioner for tilgængeligt boligdesign. Dette blev undersøgt ved at studere, hvordan forskellige standarddefinitioner påvirker andelen af boliger, som anses for at være tilgængelige og andelen af ældre mennesker, som anses for at have tilgængelighedsproblemer. Til dette formål blev data fra et stort Europæisk projekt anvendt (The ENABLE-AGE). Materialet rummede data på 1150 ældre mennesker, deres funktionsnedsættelser, brug af mobilitetshjælpemidler, boligtype og tilgængelighedsbarrierer i boligen målt med Housing Enabler. Resultaterne viste, at få centimeters forskel i standarddefinitionerne, kan have afgørende betydning for andelen af boliger, som anses for at være tilgængelige og andelen af mennesker, som anses for at have tilgængelighedsproblemer. Eftersom standarderne har så stor indflydelse på både boliger og personer med funktionsnedsættelser, viser dette studie nødvendigheden af at basere standarddefinitionerne på et validt grundlag.

Formålet med det fjerde studie var at undersøge validiteten af nuværende standarddefinitioner for tilgængeligt boligdesign gennem en aktivitetsbasseret tilgang. Endvidere var formålet at undersøge, om der er forskel på tilgængelighedsproblemer blandt ældre mennesker med fysiske funktionsnedsættelser, der ikke anvender et mobilitetshjælpemiddel, der anvender rollator og der anvender kørestol og om der er forskel på data, der er indsamlet ved observation sammenlignet med egen-rapportering. Dette blev

undersøgt ved at registrere hyppigheden og graden af tilgængelighedsproblemer, når ældre mennesker interagerer med omgivelserne. Dette studie involverede i alt 30 ældre mennesker (10 uden mobilitetshjælpemidler, 10 med rollator og 10 med kørestol), som lavede frokost og kaffe i et køkken, der var udformet efter nuværende standarddefinitioner for tilgængeligt boligdesign. Mens deltagerne udførte disse hverdagsaktiviteter, blev køkkenet observeret for tilgængelighedsproblemer, hvilket blev efterfulgt at et spørgeskema interview om deltagernes egne oplevelse af tilgængelighedsproblemer. Resultaterne viste, at nuværende standarddefinitioner ikke er valide, idet køkkenet i overraskende grad gav anledning til tilgængelighedsproblemer, ikke mindst hos kørestolsbrugerne. Dette er i tråd med resultater fra andre studier på området. Observation af tilgængelighed i en aktivitetsbasseret tilgang er en god metode til at undersøge standarddefinitioners validitet på, idet man ser interaktionen mellem de komponenter, som vi fandt, der bestemmer graden af tilgængelighed, nemlig: personen, mobilitetshjælpemidlet, omgivelserne og aktiviteten. Derimod tilførte egen-rapportering ikke til ny viden.

Samlet set bidrager denne afhandling til øget viden om nye metoder og tilgange, der har potentiale til at forbedre praksis og forskning indenfor tilgængelighedsområdet, særligt med fokus på boligen. Desuden har afhandlings resultater politisk betydning med hensyn til fastsættelse af standarddefinitioner i en national såvel som global kontekst til fordel for ældre menneskers sundhed, velbefindende og uafhængighed. Resultaterne bidrager endvidere med ny viden, der inviterer til refleksioner over centrale begreber indenfor instrumentudvikling og forskning i tilgængelighed.

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Appendix

The literature review

A systematic, narrative literature review was performed. We searched for empirical publications with a potential to inform research-based housing standards addressing the design of accessible, ordinary dwellings for adult persons with physical functional limitations and mobility device use, published during 1990–2010 in peer-reviewed journals. The publications also included architectural competitions, PhD theses and conference presentations. At the critical inclusion criterion was that the research should result in specific measures defined in metrics. No methodological restrictions were applied and publications in English, German, French and Scandinavian languages were included.

First, given the multidisciplinary character of this research field, with different publication traditions, we contacted 22 leading researchers, resource persons and seven organizations/consultancies specialized in accessibility issues and standards for housing design to have their references. The contacted persons were from the US, Canada, Australia, Japan, Denmark, Sweden, Germany, Ireland, the UK and Latvia.

Second, we performed a search of the CINAHL, PubMed, PsyINFO, socINDEX and ISI databases, using 28 search terms in 81 combinations referring to 1) dwelling (such as; *home, housing, built environment*), 2) accessibility (such as; *universal design, barrier free, ergonomics of living, anthropometry, architectural barriers, human factors, task analysis*), 3) standards (such as; *codes, guidelines, recommendations, norms*) and 4) persons with physical functional limitations (such as; *disability, impairment, mobility device users, ageing*).

Third, we manually inspected the following 21 journals; *Open Housing International, Journal of Architectural and Planning Research, Architectural Design, The Architectural Review, Architecture, Architecture Australia, International Journal of Architectural Research, Architectural Research Quarterly, Building Research and Information, Design Studies, Indoor and Built Environment, Journal of Architectural Engineering, Journal of*

Architecture, Journal of Housing and the Built Environment, Professional Builders, Housing Studies, Disability and Society, Ergonomics, Ergonomics in Design, Applied Ergonomics, and *Local Environments.* Each journal was reviewed three years back. If we found no relevant articles, we discontinued the search. But if we did, we extended the hand search another three years back.

Fourth, we searched two university databases in Sweden; at the comprehensive, eight-faculty Lund University and the specialized Royal Institute of Technology (KTH), Stockholm. Furthermore, we conducted a search in Google Scholar since several architects stated that this was their primary source for literature searches.

Fifth, to enlarge the search we used snowballing search (Depoy and Gitling, 2011) of the references of relevant publications.

After each database search as well as after the hand search in each journal and the search in the university databases, all identified publications were screened based on their titles and abstracts. Publications not meeting the inclusion criteria were excluded. Publications identified by means of personal contacts were screened continually. I performed the screening of the first pool of potential publications. The remaining publications were retrieved in full text and read by me. Any doubt about the relevance of publications was discussed with Brandt (my supervisor). At this step, a number of publications were excluded due to duplication or based on the inclusion and exclusion criteria (Fink, 2005).

I performed the data extraction, encompassing purpose, sample, methods, results and conclusions, which was validated by Brandt and Iwarsson (my supervisors) (Fink, 2005). I then identified themes across the pooled synthesis of the included publications, which was subsequently validated by Brandt and Iwarsson (Green, Johnson and Adams, 2006; Fink 2005). Finally, we agreed on the final sample of seven identified publications as well as themes identified across the pooled synthesis. Data derived from the extraction is displayed in Table II on page 24.

We screened 2,879 publications, read the full text of 35 and included seven publications. All the excluded publications failed to fulfill the critical inclusion criterion. Six of the seven included publications were identified by means of personal contacts. Even though the vast majority of the screened publications were identified by means of the database search (n=2,577), none of these publications were included.

The seven studies were conducted in the US or Canada between 1999 to February 2010. Six publications were experimental and explorative (1-5, 7.),

and aimed at determining anthropometric dimensions for wheeled mobility users. The remaining study aimed at a comparison on recent research on anthropometry from the US, UK, Canada and Australia and current national standard specifications targeting accessibility for wheeled mobility users (6). Sample sizes varied between N=62-257. All publications concerned wheelchair users, including scooter-users in three of them (4, 5, 7). Three publications addressed anthropometric sex differences (1, 2, 3). The analysis of the included publications revealed three themes; *seats dimension* (1, 2, 6), *reach* (3, 5, 7) and *space requirements* (4, 6, 7) (see Table II, page 24).

Based on the synthesis, analysis of results and conclusions drawn from the seven publications, there was a certain pattern among the studies that split the publications into two categories across the themes. As shown in Table II, page 24, category A (1-3) addressed workstation design and sex differences, while category B (4-7) concerned standards, including international comparison and evaluation against current research. Conclusions drawn from category A (1-3) stated significant sex differences in design requirements concerning seat dimensions (1,2) and reach (3), in that men reached longer and required larger/higher seat dimensions. Moreover, there was a need for efforts to improve the understanding and knowledge of the anthropometry of wheel-chair users, especially when it comes to the sub-groups, for whom such anthropometric data characteristics are missing. Conclusions drawn from category B (4-7) addressed that current standard definitions in the US, UK, Australia and Canada are not updated; hence, they do not support design adequately as the standards do not reflect the body structure and functional capacity of the segment of the population with disabilities and the use of today's mobility devices. According to the authors of these publications, there is a need for international consensus regarding the definition of the concept of accessibility, methodology and the research methods used to develop the standards. More specifically, research methods have to be improved and documented more thoroughly. Finally, the authors stated that there is a need to extend this kind of research to the developing countries, where no research so far has been conducted on this topic.

Dissertations in Occupational Therapy,

Faculty of Medicine,

Lund University, Sweden

1. Persson, D. (2001). *Aspects of Meaning in Everyday Occupations and its Relationship to Health-related Factors.* ISBN 91-974281-0-8.

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10. Haak, M. (2006). *Participation and Independence in Old Age Aspects of Home and Neighbourhood Environments.* ISBN 91-85559-56-3.

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15. Gunnarsson, B. (2008). *The Tree Theme Method –An Occupational therapy Intervention Applied in Outpatient Psychiatric Care.* ISBN 978-91-86059-73-6

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