Exploration and Development of Methodology for Accessibility Assessments: Based on the Notion of Person-Environment Fit

Slaug, Björn

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Based on the Notion of Person-Environment Fit

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Björn Slaug

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To my parents Barbro and Jörgen,
my wife Marina, my son Michael and my sister Berit

"We shape our buildings and afterwards our buildings shape us".
Winston Churchill

Contents

Thesis at a glance

Exploration and Development of Methodology for Accessibility Assessments Based on the Notion of Person-Environment Fit	
Paper I. Defining Profiles of Functional Limitations in Groups of Older People: How and Why? (Profiles study)	
Aims	To identify combinations of functional limitations for use in simulated analysis, in order to enable predictions of the potentially most severe accessibility problems among groups of older people.
Methods	Utilising data from 1,542 persons aged 75-89 years and applying Configuration Frequency Analysis, we tested which combinations of functional limitations that occurred more or less often than expected. Significant combinations were defined as type profiles and used in simulated accessibility analyses.
Results	Eleven combinations occurred more often and eight less often than expected ($p<0.05$). Simulations with ten type profiles predicted varied patterns of accessibility problems.
Conclusions	The use of type profiles has potential to contribute to the knowledge of combinations of functional limitations among groups of older persons. Variation in predicted accessibility problems for different type profiles helps identifying priorities in societal planning.
Paper II. Towards a Screening Tool for Housing Accessibility Problems: A Reduced Version of the Housing Enabler (Screening study)	
Aims	To identify the core items of the environmental component of the Housing Enabler instrument, that is, the environmental barrier items most important in terms of overall validity to measure accessibility problems.
Methods	In a mixed methods approach, cross-national data and interdisciplinary knowledge was used through an iterative process to identify the core environmental barrier items of the Housing Enabler.
Results	The environmental component of the reduced version comprises 61 items, compared to 188 in the original instrument. The rank correlation between the accessibility scores generated by the original and reduced versions was $r_s \geq .97$ ($p<0.001$).
Conclusions	The reduced Housing Enabler represents a preliminary version of a time efficient and valid screening instrument. It is a powerful tool for research and interventions focusing on housing accessibility problem identification.
Paper III. Unfolding the Phenomenon of Interrater Agreement: A Multicomponant Approach for In-depth Examination was Proposed (Agreement study)	
Aims	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.
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 variation.
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 barrier prevalence and raters' familiarity with using standardized instruments to have the strongest impact on agreement.
Conclusions	Supported by a conceptual analysis, we propose an approach of in-depth examination of agreement variation, as a strategy for increasing the level of inter-rater agreement.
Paper IV. Construction of a Typology for Person-Environment Fit Constellations: Basis for a Scoring Rationale of Accessibility Assessments (Typology study)	
Aims	To construct a typology of person-environment fit constellations, as they are manifested in the Housing Enabler instrument.
Methods	Qualitative classification principles were based on conceptual similarities, and for quantitative analysis of similarities Principal Component Analysis was carried out.
Results	Covered by the Housing Enabler application targeting accessibility of the housing environment, 48 typical person-environment fit constellations were identified.
Conclusions	Extension of a scoring rationale to different environmental arenas will be supported by the typology. In addition, the typology highlights how typical problematic person-environment fit constellations are generated.

List of papers

This thesis is based on the following papers:

I. Slaug, B., Schilling, O., Iwarsson, S., Carlsson, G. (2011). Defining Profiles of Functional Limitations in Groups of Older Persons: How and Why? *Journal of Aging and Health, 23,* (3), 578-604.

II. Carlsson, G., Schilling, O., Slaug, B., Fänge, A., Ståhl, A., Nygren, C., Iwarsson, S. (2009). Toward a Screening Tool for Housing Accessibility Problems: A Reduced Version of the Housing Enabler. *Journal of Applied Gerontology, 28,* (1), 59-80.

III. Slaug, B., Schilling, O., Helle, T., Iwarsson, S., Carlsson, G., Brandt, Å. (2012). Unfolding the Phenomenon of Interrater Agreement: A Multicomponant Approach for In-depth Examination was Proposed. *Journal of Clinical Epidemiology.* In press.

IV. Slaug, B., Schilling, O., Iwarsson, S., Carlsson, G. (2012). Construction of a Typology for Person-Environment Fit Constellations: Basis for a Scoring Rationale of Accessibility Assessments. In manuscript.

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List of terminology

Accessibility	The relationship between functional capacity and environmental demands (Iwarsson & Ståhl, 2003).
CFA	Configurational Frequency Analysis (Krauth & Lienert, 1982).
Disability	An umbrella term for impairment, activity limitation and participation restriction in the International Classification of Functioning Disability and Health (ICF; WHO, 2001).
Environmental component	The demands of the physical/built environment making up the environmental component of accessibility (Iwarsson & Ståhl, 2003).
Functional capacity and functional limitation	Functional capacity refers to a person's ability to perform daily activities and functional limitations refer to restrictions in that performance (Jette, 2006).
Functional profile	A specific combination of functional limitations (Paper I).
Functioning	An umbrella term for body function and structure, activity and participation in the ICF (WHO, 2001).

HE	The Housing Enabler instrument (Iwarsson & Slaug 2001; Iwarsson & Slaug, 2010a).
ICF	International Classification of Functioning, Disability and Health (WHO, 2001).
Inter-rater agreement	The degree to which two or more raters achieve identical results under similar assessment conditions (Paper III).
Personal component	The person's functional limitations and dependence on mobility devices making up the personal component of accessibility (Iwarsson & Ståhl, 2003).
Qual, quan	Notation signifying use of qualitative (qual) and quantitative methods (quan). Emphasized method for the overall results indicated with uppercase letters. The use of plus sign, for example QUAN+QUAL, indicates methods were merged, arrow that methods were connected in a sequence, for example QUAN→QUAL, and parenthesis that one method was embedded within the other, for example QUAL(QUAN) (Creswell & Plano Clark, 2007).
Severity score	In the Housing Enabler instrument a score expressing the severity of an accessibility problem, ranging from 0 (no problem) to 4 (impossibility).

Supportive environments for health	Environments that offer people protection from threats to health and enable them to expand their capabilities and develop self reliance in health. Supportive environments encompass where people live, their local community, their home and where they work and play, including people's access to resources for health and opportunities for empowerment (WHO, 1991).
Typology	A multi-dimensional classification based on conceptual similarities (Bailey, 1973).
WHO	World Health Organization.

Introduction

Rationale of the thesis

The impact of the built environment on different aspects of health is often overlooked in recent public health literature (Lawrence, 2010). Nonetheless, when public health emerged as a discipline in its own right during the mid-nineteenth century, the built environment, and in particular the housing conditions, was a major concern in the efforts to promote health in the population. This concern was founded on compelling evidence, showing that deficiencies in housing standard were associated with high rates of morbidity and mortality (Fuller-Thomson et al., 2000; Smith et al., 2001). Improved street cleaning, waste disposal, water supply, sewerage and sanitation proved to be crucial in advancing the health status of the population (Calman, 1998). However, the impact of the built environment is not constrained to poor material and sanitary conditions causing diseases; it concerns other essential aspects of health as well, such as quality of life, general well-being and social inclusion. For these aspects of health, architectural features of the built environment and the social structure of the surrounding environment may be equally important. Thus the built environment impacts on different aspects of health in a complex web of relationships, which in total constitutes a key determinant for health (Shaw, 2004).

With the introduction of the concept of Supportive Environments for Health by the WHO in 1991, the intention was to underscore the role of the environment and to influence public health to focus on the need to ensure that the environment provided adequate opportunities and resources for health (Hagberg, 1996; WHO, 1991). Moreover, it was considered particularly important that the environment is devised in a way that enables people to expand their capabilities and develop self-reliance. In this context the social, political and economical dimensions were especially mentioned. However, a further dimension that was not mentioned but which nevertheless deserves specific attention concerns the degree to which the built environment is designed to be accessible to all citizens, regardless of

functional capacity. That is, the issue of person-environment fit needs to be taken into account (Iwarsson & Slaug 2010a; Steinfeld & Danford 1999). In practical terms that means to what extent features of the built environment are optimized to allow people to move around, to find their way, to activate controls and functions, to reach and manipulate objects, also when the functional capacity of arms and legs is reduced, when sight or hearing is impaired or when mobility devices are needed. To be able to manage and cope with the environment in this basic way is vital for the performance of daily activities, for participation in social life and hence also for expanding capabilities and develop self-reliance (Haak, 2006). Consequently, for the environment to be supportive with respect to accessibility is one of the elements in the complex web of relationships that influences people's health, at individual, group and population levels. To examine these relationships, and to gain knowledge for improvement of the situation, research related to accessibility is called for.

Yet, to design the built environment in order to be accessible also for people with reduced functional capacity, in addition to technical and architectural know-how, there is a need for valid and reliable methods of measuring accessibility. This involves having reasonable theoretical assumptions underlying the methods for the measured outcome. Thus, there is need for methodological, conceptual and statistical exploration in order to gain further insight and knowledge, strengthening the theoretical basis. Moreover, to have benefit for society and ultimately to improve the health status of the population, theory and knowledge must be transferred to applications for practical use. Thus, there is also need for development of sound methodology and useful instruments, appropriate for use not only in scientific research, but in planning procedures and decisions at societal level as well. This thesis will evolve around the theme of exploration and development of such methodology.

Background

Public health research

The ultimate aim of public health is to promote health, prevent diseases and prolong life through the organized efforts of society (see e.g. Nutbeam, 1998). Health promotion refers to the process of enabling people to take control over, and to improve their health, whereas disease prevention concerns measures directed towards prevention of the occurrence of diseases (Nutbeam, 1998). Further, there are three common characteristics qualifying public health research: a public interest, a focus on health determinants, and an objective to improve the public health (Beaglehole et al., 2004). The relationship between features of the built environment and possibilities and opportunities for people to manage and cope with the built environment in terms of accessibility has a broad public interest, but has not been sufficiently studied from a public health perspective (Andersson & Ejlertsson, 2009). A considerable part of the population is limited in their capacity in some way that may imply person-environment fit problems (SNIPH, 2010). In this context, older people are a particularly important group to focus on. The gradual decline in physical capacity (Verbrugge & Jette, 1994) experienced with ageing, is manifested as functional limitations (Nagi, 1991). With an increased life expectancy, a larger proportion of the population can also be expected to live with such conditions as difficulties in moving, in bending and kneeling, in poor balance, reduced ability in handling and gripping, etc. for a longer period of life (Molton & Jensen, 2010).

Prevalence of functional limitations

Functional limitations are certainly found at all ages, but more frequently with increased age. Comprehensive prevalence figures for functional limitations are difficult to find as they are not recorded according to any recognized classification within the health care system, as diseases are (Alves, Leite & Machado, 2008; (Barbotte et al., 2001). However, the administrative agency Statistics Sweden (SCB) regularly investigates a wide range of living conditions in the Swedish population by means of self-administered questionnaires, the Survey of living conditions (in Swedish ULF). Functional limitations are included in these questionnaires that are distributed to a selected sample, intended to be representative for people aged 16-84 in Sweden. In Table 1 figures from the 2010 survey are presented, showing that especially in the oldest segment of the population, functional limitations are common.

Table 1. Prevalence (%) of functional limitations according to Statistics Sweden[a].

	16-29 years		30-44 years		45-64 years		65-84 years	
	Men	Women	Men	Women	Men	Women	Men	Women
Limitations in movement	1	4	4	7	13	20	38	57
Difficulties with mobility	1	2	2	2	7	9	16	24
Severe loss of sight	6	5	5	4	4	4	3	7
Severe loss of hearing	5	6	9	6	11	9	17	14

[a] Self-administered questionnaire (ULF; SCB 2010), N=10,067.

The Swedish National Institute of Public Health (SNIPH) also compiles statistics on functional limitations, partially from Statistics Sweden, but from other sources as well, such as Health care centers and Centers for provision of assistive devices. From the most recent report published in 2010 (SNIPH, 2010), figures for categories of functional limitations in older age groups (65-74 and 75-84 years) can be found. However, it should be noted that information of combinations of

functional limitations are entirely missing in these reports, information that is vital in understanding and analyzing accessibility problems. Data on functional limitations that can be compared with the data from Statistics Sweden and SNIPH is found in the European ENABLE-AGE project (Iwarsson et al., 2007; Oswald et al., 2007), see Table 2.

Table 2. Comparison of prevalence (%) of functional limitations according to Swedish National Institute of Public Health[a] (SNIPH) and ENABLE-AGE[b] (EA).

	65-74 years		75-84 years			
	Men	Women	Men		Women	
	SNIPH	SNIPH	SNIPH	EA	SNIPH	EA
Limitations in movement[c]	25	33	60	69	80	81
Dependence on mobility devices	5	8	14	22	19	26
Limitations in upper extremity	10	25	25	25	40	35
Loss of sight	5	7	12	12	16	18
Loss of hearing[d]	38	22	49	17	33	11
Difficulties interpreting information	*Not available*	*Not available*	*Not available*	7	*Not available*	10

[a] Sweden, statistics from 2006-2008.
[b] Subset of the ENABLE-AGE sample used in Paper I, N=1,028 (persons >84 years not included).
[c] In SNIPH age groups for Limitations in movement are 65-69 and 80-84, respectively.
[d] In SNIPH sample Loss of hearing includes those using hearing aid.

The ENABLE-AGE project comprises a rich source of data from five European countries. The figures for the categories of functional limitations are strikingly similar when comparing prevalence reported by SNIPH with the ENABLE-AGE sample, with the exception of loss of hearing. Evidently, these prevalence figures indicate that older people are particularly important to focus on. Moreover, older people are the fastest growing group of the population in developed countries. By the year 2030 it has been estimated that every fourth person will be 65 years or older (OECD, 2001). This poses considerable challenges to society, where one crucial field concerns planning and designing the built environment in order to be accessible, regardless of functional capacity (Molton & Jensen, 2010).

Supportive environments for health

The concept of Supportive environments for health has its origin in the third International Conference on Health Promotion, Sundsvall, Sweden, where a policy document was adopted (WHO, 1991). However, there is also scientific evidence establishing the built environment as a key health determinant (Blandin De Chalain & Stephenson, 2009; Clarke & George 2005; Northridge, Sclar & Biswas, 2003). The built environment impacts on health in a wide range of aspects, from the direct physical/material aspects that may include damp, cold, heat, mold etc, over design/architectural aspects that may include design of entrances, stairs, handrails, door-openers, lifts etc. to indirect aspects that may include social status, sense of security, home feeling etc (Bonnefoy et al., 2003; Oswald et al., 2003). Health conditions related to these aspects are just as wide-ranging, from respiratory and gastrointestinal problems, to fall accidents and restrictions in desired activities to social isolation and depression (Finlayson & Petersen, 2010). The built environment can thus be potentially harmful both on an individual and as well as a societal level (Shaw, 2004).

However, as the often quoted WHO definition of health emphasizes, health does not only concern prevention of diseases and other harmful health conditions, it also concerns the promotion of well-being: “Health is a state of complete physical, mental and social well-being, and not merely the absence of disease and infirmity” (WHO, 1946). Hence, for health promotion and public health efforts, it is of vital importance to create physical environments supportive of health (Andersson & Ejlertsson, 2009; Hagberg, 1996). The aspect of the built environment focused on

in this thesis, the degree to which it is accessible, has been shown to be associated with health conditions such as perceived functional independence, quality of life and sense of well-being (see e.g. Oswald et al, 2007). Access to the built environment and to societal resources and utilities, without being dependent on the aid of others, promotes the sense of participation in society among groups otherwise restrained in this respect. Moreover, a housing environment supporting independent living may be the determining factor for older, frail individuals which enable them to stay in ordinary housing. Outdoor environments that facilitate and encourage walking behavior can be supportive for maintaining physical status and thus overall health (Borst et al., 2008; Rantakokko et al., 2009). To sustain desired activities such as getting to shops, to public and cultural facilities, or moving around for recreational purposes, also when functional limitations arise with ageing, is essential for general well-being and quality of life. In order to design the environment not to obstruct or hinder such desired activities, knowledge on how person-environment fit problems are generated is needed.

Need for sound methodology

To secure that policies for improved health in the population do have the intended effect, there is a need for sound methodology to measure the outcome. This is also true concerning measures of accessibility. The importance of the built environment being accessible is recognized at political level since long. Policy and legislation have been in place for decades (Regeringens prop. 1999/2000:79; United Nations, 1993), stating that housing, public buildings and public transportation should be accessible for all citizens. Guidelines and standards, particularly during the last 25 years, have been gradually developed and applied in order to further this objective. Nevertheless, serious deficiencies as regards accessibility still remain (Fänge, Iwarsson & Persson, 2002; Nygren et al., 2007; Wahl et al., 2009; Preiser & Ostroff, 2001). This is a multi-faceted problem, and there are many interacting and contributory factors explaining why the built environment still is abundant with features hindering or obstructing accessibility. Even though knowledge on technical solutions how to reduce accessibility problems are substantial, solutions are often made ad-hoc and based on subjective interpretations, instead of on systematic and objective analysis. Thus, there is a need for qualified research in order to give a scientific ground to evaluate whether the measures and

interventions carried out do have the intended effect, i.e. resulting in more accessible environments. The focus of this thesis is to strengthen the scientific ground for measuring accessibility, by exploring and developing an existing methodology for accessibility assessments, based on the notion of person-environment fit

Philosophical principles

Before proceeding with the Conceptual and theoretical context of the exploration and development of methodology for accessibility assessments undertaken in this thesis, there are two guiding philosophical principles that need to be presented. These two principles will shed light on and deepen the understanding of the individual studies of the thesis. The German philosopher Arthur Schopenhauer (1788-1860) in his doctoral dissertation "On the fourfold root of the principle of sufficient reason" (Schopenhauer, 2003) refers to two fundamental philosophical principles, which he claims are implicitly underlying every scientific endeavor, and in fact all pursuit of knowledge. These principles have been formulated by many philosophers in different variations ever since Plato, but perhaps most distinctly Schopenhauer says, by his predecessor Immanuel Kant (1724-1804): "Entia praeter necessitatem non esse multiplicanda", that is, the number of entities must not be increased unnecessarily and: "Entium varietates non temere esse minuendas", that is, the varieties of entities must not be diminished unnecessarily. The first principle thus concerns reduction of complexity and considerations of parsimony while the other concerns explanatory sufficiency. The two principles are not excluding or contradicting each other, but are rather complementing and counter-balancing each other. However, depending on the analysis objective, one of the principles may need to be emphasized. When the reduction of complexity principle is emphasized, the focus is on detecting what is common among phenomena, what is uniting them; when the sufficient variation principle is emphasized the focus is on recognizing differences, what varies between phenomena. The rationale for the two principles can be described in terms of simplicity (reduction of complexity) and explanatory sufficiency (sufficient variation). That is, reduction of complexity aims at facilitating understanding, at shortening the path to the answers for complicated questions, at finding the core or what is most essential. Yet, with the gains of simplicity there is a prize to be paid; when complexity is reduced, it may lead to instances of explanatory inadequacy. The principle of sufficient variation on the other hand, concerns the aim to explain

not only the core, but also the individual deviation from the core. These two philosophical principles will be a secondary theme of the thesis, underpinning the theme of exploration and development.

Conceptual and theoretical context

Accessibility

The most fundamental prerequisite for a method to be scientifically valid is that it is based on well-defined concepts. The key concept for the current thesis is accessibility. In its everyday use accessibility focuses on characteristics of the environment and is synonymous with "approachable, at hand, attainable, available, close, convenient, and handy and within reach (Oxford Popular Dictionary and Thesaurus, 2010). As applied in this thesis, the concept has a more specific definition that extends the meaning to cover the interaction of a person with his environment. From a scientific point of view, it is much more fruitful to regard accessibility as a relative concept, expressing the relationship between the capacity of the individual and the demands of the environment (Lewin, 1951). Thus, the concept of accessibility comprises of two components of equal importance: a personal component and an environmental component (Iwarsson & Ståhl, 2003). Further, accessibility is to be understood as an objective and measurable concept. The personal component refers to dimensions objectively observed, and the demands of the environment are defined according to societal norms and legislation (Iwarsson & Slaug, 2010a).

The notion of person-environment fit

Based on this definition of accessibility, theoretical models describing the relation between the individual and his environment can be applied. A model often referred to is Lawton and Nahemow's ecological model (1973) also referred to as the competence-press or person-environment fit model. This model has also been used

as the main theoretical foundation in previous research on accessibility (Iwarsson, 1997; Iwarsson & Ståhl, 1999; Steinfeld & Danford, 1999). The model defines the person in terms of a set of competencies, and the environment in terms of its demands, called environmental press. With the addition of the docility hypothesis (Lawton, 1986), it follows from the model that those with lower personal competencies are more vulnerable to environmental press, whereas those with higher competencies can withstand greater environmental press. Thus a balance between the individual's competence and environmental press can be achieved by changing one or the other, or both. A very important implication of this model is that a person's level and range of action can be maintained or improved, even if the functional competence deteriorates, provided that the demands made by the environment are being lowered. Applying this perspective, accessibility can theoretically be achieved for all citizens, regardless of functional capacities, on condition that environmental demands are sufficiently reduced.

The International Classification of Functioning Disability and Health

The International Classification of Functioning Disability and Health (ICF; WHO, 2001) forms part of the World Health Organization's family of international classifications and provide a universal framework and classification system for describing the situation experienced by a person with a health condition that has been globally accepted. The classification originated from practical needs to classify health and health related concepts in other terms than diagnoses. Components defined in the ICF are Body Function and Structures, Activities and Participation, Environmental Factors and Personal Factors. In order to explain the relationships between the components, a model is presented where the interaction of all the included components is displayed. The ICF is useful as a framework for describing and understanding health and health related conditions across disciplines. Underlying the idea of problematic person-environment fit constellations is the assumption that environmental barriers do not generate accessibility problems themselves, but may do so when connected to certain aspects of functioning. For instance, high kerbs may constrain walking, or too high/low seats may constrain sitting, hence generating accessibility problems Thus it is relevant to relate these problematic person-environment fit constellations to the universal framework of ICF.

The Housing Enabler instrument

Among the few methodologies available, intended to provide the tools for systematic and objective assessments and analysis of accessibility, is an instrument based on the Enabler Concept (Steinfeld et al., 1979). First developed by the American architect, professor E. Steinfeld, this concept was used to construct the Housing Enabler (HE) instrument that was specifically designed to assess accessibility problems in housing (Iwarsson & Isacsson, 1996). Even though the methodology as such is not limited for use in any specific environmental arena, up till now it has mainly been applied to the housing environment (Iwarsson et al., 2004; Jensen et al., 2002). Consequently, the methodology has a potential that to a great extent remains to be explored. In order to optimize the methodology for housing accessibility assessments and to expand it to other environmental arenas in a valid and reliable way, further methodological research is needed. This thesis has the ambition to take some decisive steps in that direction.

The HE instrument is based on a three-step assessment and analysis approach. Step 1 (the personal component) concerns functional limitations and dependence on mobility devices in an individual or a group. To assess functional limitations as regards mobility, perception, and dependence on mobility devices, an interview is conducted in combination with observation. The assessment results in a functional profile. Step 2 (the environmental component) is based on observation of the actual environment, in the form of a detailed rating/screening of environmental barriers. The assessment is based on accepted standards and guidelines for items where these exist. Step 3 (the analysis) involves calculating a total score that quantifies the magnitude of accessibility problems in a particular case. The total score predicts the load caused by a particular combination of functional limitations and environmental design, thus giving a measure of the magnitude of accessibility problems - the higher the score, the greater the accessibility problems. The total score is always 0 if the individual or group has no functional limitations/ dependence on mobility devices), regardless of whether there are environmental barriers or not. It is also possible to calculate a ranking order of the environmental barriers that cause the most accessibility problems. Both analytical methods can be applied to either an individual or a defined group.

Though the HE instrument has been tested for content and construct validity at different phases of the instrument development (Fänge & Iwarsson, 2003; Iwarsson & Slaug 2010), validity testing is an ongoing process that is never completed. The instrument's initial scoring system was based on knowledge acquired by many years of experience in working with questions concerning relevant aspects of accessibility and by both lengthy and thorough discussions with different experts and client representatives (Steinfeld et al., 1979). Over the years thereafter, knowledge generated from research studies, from use within education and from professional use in practice, has been systematically collected, providing evidence for improvements and revisions of the instrument. The level of inter-rater agreement, as presented in several publications, has indicated that with proper instructions and training, reliable use of the instrument can be achieved (Helle et al., 2010; Iwarsson & Isacsson, 1996; Iwarsson, Nygren & Slaug, 2005). However, some results have also underlined that more research on cross-national harmonization of housing norms/guidelines is needed. The instrument is being used by occupational therapists, in education and in research as well as in municipality practices. On community level it can be used for building up databases useful for housing planning and provision (Fänge et al, 2007). However, even though a complex and extensive instrument is necessary for detailed and valid accessibility assessments, practitioners often consider that checking for a total of almost 200 environmental barriers is very time consuming, as it may take up to one hour to accomplish. In addition, to make housing provision for specific user groups more efficient, there is a need for research-based screening tools. Furthermore, the instrument is limited to assessing accessibility problems in housing, while accessibility problems in other environmental arenas, particularly public environments, have come increasingly in focus in research as well as in political and public debate. During the work with this thesis a new version of the HE instrument was launched (Iwarsson & Slaug, 2010a). In paper IV, the new version was used whereas in paper I-III the original version was used. The new version has 161 environmental barrier items, compared to 188 in the original. In the new version one functional limitation item has also been removed, leaving 14 items instead of 15.

Methodological considerations

Accessibility at individual and group level

Applying a public health perspective, to be able to validly capture accessibility problems on a societal level, a methodology useful for group- rather than individual-based approaches is needed. In that perspective it is well known that not only prevalence of co-morbidity increases with age, but also dysfunction in body systems and limitations in physical performance (Karlamangla et al., 2007). Coexistence of several such conditions complicates health care related assessments, decisions and preventive measures. This is also true with respect to accessibility; considering them in isolation may compromise validity. Thus it is essential to increase the knowledge about the occurrence of combinations of functional limitations (Guralnik & Ferrucci, 2003; Nagi, 1991) in different target groups, as currently knowledge of such combinations is scarce. Of particular importance for societal planning is the older segment of the population, as we know that older people often have more than just one functional limitation. Are there combinations of functional limitations that are more or less common than others? Can specific patterns be identified? Are there combinations that give rise to distinguished sets of priorities, in terms of the environmental barriers causing the most severe problems of accessibility? By identifying certain relevant combinations of functional limitations, could it be possible to use computer simulation techniques in order to predict accessibility problems for different groups of people in different environmental scenarios? These are questions that deserve to be further explored and that may call for methods, novel to this research area and to public health research at large.

Screening of accessibility problems

Another important aspect of the environmental component of the HE accessibility assessment is the very high level of detail. In situations where specific information is sought, practitioners often consider that the extensive checklist that the HE includes is very time consuming. Also, in research data collection instruments should be time efficient, yet valid. Thus, a reduced and valid version of the HE instrument would be of great value. In addition, such a reduced version would have the potential to be used for screening purposes. Screening of single dwellings within blocks of flats may be a cost-effective way to survey large scale accessibility problems. Moreover, within public health there is an established tradition to use screening as a health promoting strategy, by early detection of signs of diseases (Raffle & Muir Gray, 2007). To transfer this strategy to features of the environment related to accessibility problems would be a novel approach that deserves to be explored.

Validity and reliability

There is also a strong need for further methodological studies in order to strengthen the evidence both that the HE measures what it intends to, i.e. accessibility problems, and that measurements by the HE are reproducible by different raters at different occasions. These two dimensions are known as validity and reliability (e.g. Norman & Streiner, 2008). Assessments of individuals functioning, health, etc. always imply a variety of challenges, and for assessments involving the environment as well, the challenges are even greater. The most basic and fundamental requirement may also be the most the challenging, namely to certify that the instrument actually captures the phenomena it intends to, and that it does so in a scientifically meaningful way. This is the process of validation, and it is not something that is achieved once and for all, but rather a long-term process of accumulating evidence (Fayers & Machin, 2000). Since the initial construction of the HE in 1996 (Iwarsson & Isacsson, 1996), information on all kinds of limitations, weaknesses, inconsistencies, etc. have been systematically collected. The informants have been practicing occupational therapists and other health care staff, persons with a technical or architectural background, university teachers, PhD students, researchers from different disciplines as well as lay persons that have been involved in undergraduate and graduate teaching, courses for

practitioners, popular science lecture or scientific conference audiences, expert panels in methodological studies, or in research projects. The information collected has been invaluable in strengthening the validity of the HE, and has prompted one major revision of the instrument (Iwarsson & Slaug, 2010a). During this process, it has also been important to be open for new statistical methods of testing, and to continue examining different aspects of validity, such as how well data collected reflects underlying theoretical assumptions on differences between groups of persons or changes over time. For example, accessibility data has been correlated with data measuring perceived aspects of housing (Fänge & Iwarsson, 2003; Oswald et al., 2006) indicating that accessibility and perceived aspects of housing are related, but measuring different constructs. This kind of testing has favored from the extensive amount of data that has been available.

The instrument reliability may seem more straight-forward to examine as there are well-known techniques that are in common use for that purpose (Hripcsak & Heitjan, 2002). Within health sciences the reliability is typically examined and reported by analyzing the level of agreement between assessments made by one or several rater-pairs. Several such inter-rater agreement studies have been carried out with the HE instrument (Helle et al., 2010; Iwarsson & Isacsson, 1996; Nygren et al., 2005) with satisfying results. However, though the level of agreement provides an indication of reliability, in itself it is insufficient to establish reliable use of an assessment instrument. One reason may be if there are items covering the presence or absence of phenomena that rarely occurs, or always occurs; it is easy to agree if the discriminating ability will seldom be put to the test. Another reason may be that studies are often are highly sample dependent (Streiner & Norman, 2008). The HE should be possible to use in a variety of different dwellings (blocks of flats, rural houses, century-old buildings etc). If an inter-rater agreement study is accomplished where there is little variation in the dwellings, high agreement may be achieved, but the results can not be trusted to hold for all kinds of dwellings. One the other hand, poor agreement may be explained by inadequate training of a rater, and not by weaknesses of the instrument itself. There is thus a need for further research, exploring how inter-rater agreement can be improved and conditions for inference of results better known.

Aims

Methodology based on the notion of person-environment fit was the focus of all four studies in this thesis. Key aspects of the methodology were subject for research. That is, the studies had the notion of person-environment fit and the methodology for accessibility assessments built thereupon as its presumption, modeling research objectives accordingly. The main theme of the research approach was that of methodological, conceptual and statistical exploration, and instrument and methodology development, intertwined with the theme of the guiding philosophical principles of reduction of complexity and sufficient variation.

The overarching objective was to gain knowledge and insight of the components in a methodology for accessibility assessments based on the notion of person-environment fit, by means of methodological, conceptual and statistical exploration. Further, the objective was to expand the scope of use of this methodology and to promote societal benefit by developing new, practical and expedient applications for accessibility measures.

The specific aims were:

- To identify combinations of functional limitations for use in simulation analysis, in order to enable predictions of the potentially most severe accessibility problems among groups of older people.
- To identify the core items of the environmental component of the HE instrument, i.e., the environmental barrier items most important in terms of its overall validity to capture accessibility problems.
- To unfold the phenomenon of inter-rater agreement conceptually and statistically, i.e., to identify potential sources of variation in agreement data and to explore how they can be statistically accounted for.
- To construct a typology of person-environment fit constellations, as they are manifested in the HE instrument.

Methods and materials

Study approaches and designs

This thesis comprises four studies presented in four corresponding papers: the Profiles study (Paper I), the Screening study (Paper II), the Agreement study (Paper III) and the Typology study (Paper IV).The study approaches can be categorized according to their overarching research purposes: to gain knowledge and understanding of certain phenomena, i.e. exploration, and to make the best use of the knowledge gained by creating beneficial and practical applications, i.e. instrument and methodology development. Thus two of the studies were focused on exploration, the Profiles study and the Agreement study, while the other two studies were focused on development, the Screening study and the Typology study. The two approaches of exploration and development can be further categorized from the perspective of the previously mentioned guiding philosophical principles, which is reduction of complexity and sufficient variation, emphasized in respective study. The first two studies, the Profiles study and the Screening study had the emphasis on the first principle, to reduce the number of entities. The third study on the other hand, the Agreement study, had the emphasis on identifying sufficient variation, while the fourth study, the Typology study had the emphasis on balancing these two principles.

Figure 1 provides an overview of the thesis and the four studies in relation to the perspectives of study approaches in terms of overarching research purposes and guiding principles emphasized. The bronze and blue colours of the figure are used here and in subsequent figures to signify the emphasis of the reduction of complexity principle and the sufficient variation principle, respectively. Short descriptions of the analysis objectives for each study are provided within the figure.

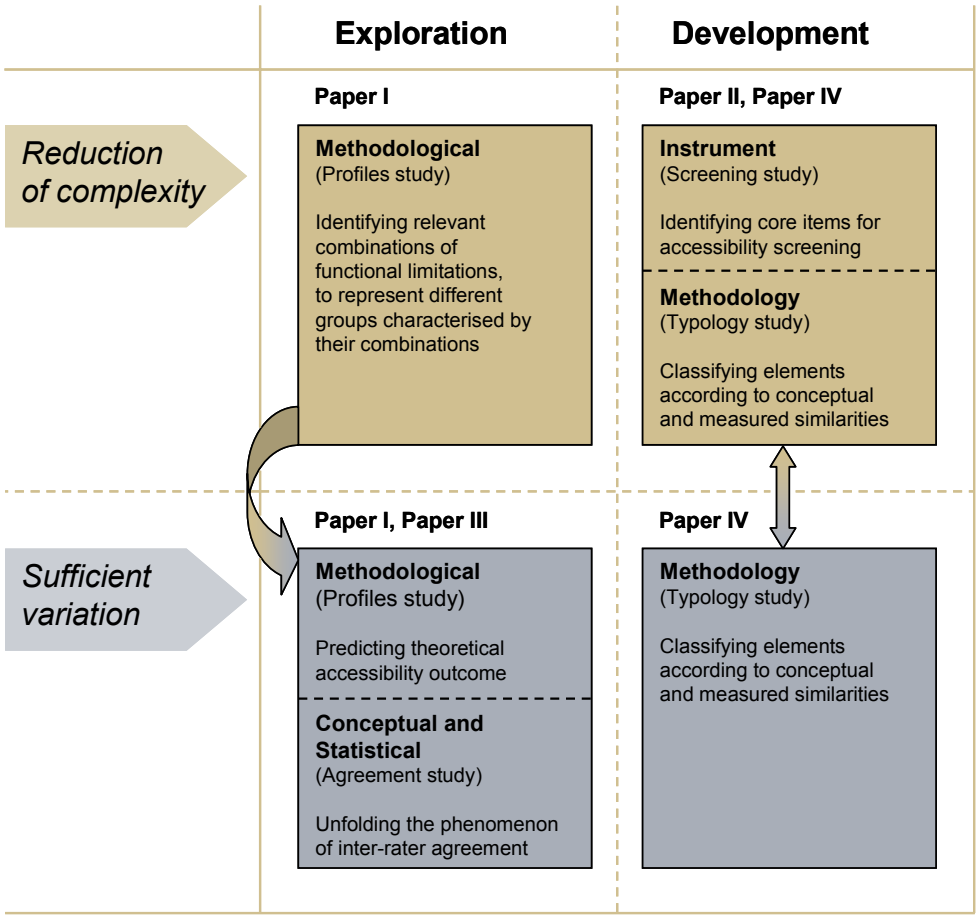

Figure 1. Thesis overview from the perspectives of study approaches and guiding philosophical principles emphasized. The Profiles study (Paper I) is focused on exploration but has two distinct analysis objectives, emphasized by each guiding principle. The Typology study (Paper IV) is focused on development and has one analysis objective where the guiding principles should be balanced.

In three of the four studies both quantitative and qualitative methods were applied. By using a mix of quantitative and qualitative methods, the research questions of these studies were comprehensively addressed (Patton, 2002).

The use of mixed methods can be outlined by relating to different designs suggested by Creswell & Plano Clark (2007) and the notations they recommend. Thus the QUAN+QUAL notation indicates that the outcomes of quantitative and qualitative analysis were merged with equal emphasis. This design was used in the

Screening study where statistical analysis and expert panel review both were considered equally important. In reaching the final results we could compare, contrast and evaluate results from the two approaches, thus strengthening the evidence for our conclusions. The QUAL (QUAN) notation indicates that a quantitative analysis was embedded within a qualitative analysis. This design was applied in the Agreement study, where the statistical analysis was framed within a prior conceptual analysis. Thereby the statistical analysis served the purpose of exemplifying and demonstrating the value of the conceptual analysis. The quan → QUAL notation indicates that analyses were used in a sequence, with a quantitative analysis carried out first and the subsequent qualitative analysis emphasized. The typology study used this design, where an initial statistical analysis was subordinate to subsequent expert review analyses and consensus discussions. The statistical analysis thus gave a starting point which the qualitative analysis could build upon and develop further.

Table 3 provides a methodological overview of the studies and their corresponding papers included in the thesis. Each study is detailed below.

Table 3. Methodological overview of the thesis.

Study	Paper	Study approach	Data used	N	Analysis objective	Quantitative methods	Qualitative methods	Mixed methods design[a]	Principle emphasized
Profiles	I	Methodological exploration	ENABLE-AGE[b]	1,542	Identifying relevant combinations; Predicting theoretical outcome	Configuration frequency analysis; Simulation of worst-case scenario	*Not used*	*Not applicable*	Reduction of complexity; Sufficient variation
Screening	II	Instrument development	ENABLE-AGE[c] HM[d] OP[e]	1,150 131 134	Identifying core items	Index of variance contribution; Scoring potential; Frequencies	Expert panel; Consensus discussions	QUAN + QUAL Merged; Equal emphasis	Reduction of complexity
Agreement	III	Conceptual and statistical exploration	Nordic HE[f] ENABLE-AGE[c]	1,880[g] 1,150	Unfolding inter-rater agreement	Kappa; Observed agreement; Relative shares of variance; Multilevel regression analysis	Conceptual analysis	QUAL (QUAN) Embedded; Equal emphasis	Sufficient variation
Typology	IV	Methodology development	Inherent elements of the Housing Enabler instrument	161[h]	Classifying elements according to conceptual / measured similarities	Principal component analysis	Expert review; Consensus discussions	quan → QUAL Sequential; Qualitative emphasis	Balancing reduction of complexity with sufficient variation

[a] Notation of Mixed methods design according to Creswell & Plano Clark (2007).
[b] Four countries included (Germany, Hungary, Latvia and Sweden) from the ENABLE-AGE project (Iwarsson et al., 2007), cross-sectional baseline data used.
[c] Three countries included (Germany, Latvia and Sweden) from the ENABLE-AGE project (Iwarsson et al., 2007), cross-sectional baseline data used.
[d] Home modifications clients project (Fänge & Iwarsson, 2003).
[e] Older people living at home project (Iwarsson & Isacsson, 1996).
[f] Nordic Housing Enabler project (Helle et al., 2010).
[g] Observations in a raters × items matrix generated from a sample where 10 rater pairs had assessed a 188 item checklist in 8-14 different cases each (total of 106 cases).
[h] Number of items in the instrument check list (Iwarsson & Slaug, 2010a).

Methodological exploration

The Profiles study (Paper I)

In the Profiles study the personal component of the methodology for accessibility assessments was explored, applying a group or population approach (von Eye, 1990). For an individual assessment of functional capacity, a picture that is as complete as possible needs to be taken into account, for example when deciding on the appropriateness of a suggested home modification. That is, the best fit is dependent on observance of the individual specifics. However, considering a group or population for decisions at a societal level, all the individual variation cannot be accounted for. Thus there is a need to reduce complexity, to capture what is most essential. To do so, we first grouped together the functional limitation items included in the HE instrument into fewer and broader categories. After that we analyzed empirically combinations of functional limitations. A profile of functional limitations thus signifies a particular combination, where it is described which functional limitations are present and which are not. To be meaningful such an explorative analysis calls for extensive data and for that purpose we utilized the ENABLE-AGE survey database, where data on functional limitations for 1,542 persons aged 75-89 years was available (see Table 3).

To further exemplify and demonstrate why it may be relevant to identify particular profiles of functional limitations, a second explorative analysis was carried out. The analysis objective was to predict the environmental barriers theoretically causing the most severe problems for groups represented by the profiles of functional limitations. Thus we needed to maintain the full specificity of environmental barriers. For this purpose we employed non-empirical, simulated data, treating all barriers as if they were present.

In Figure 2 the design of the Profiles study is illustrated with a flow chart. There was a minor element of qualitative method in the categorization of functional limitations otherwise the methods employed were quantitative. The bronze colour signifies the emphasis of the reduction of complexity principle and the blue colour the sufficient variation principle.

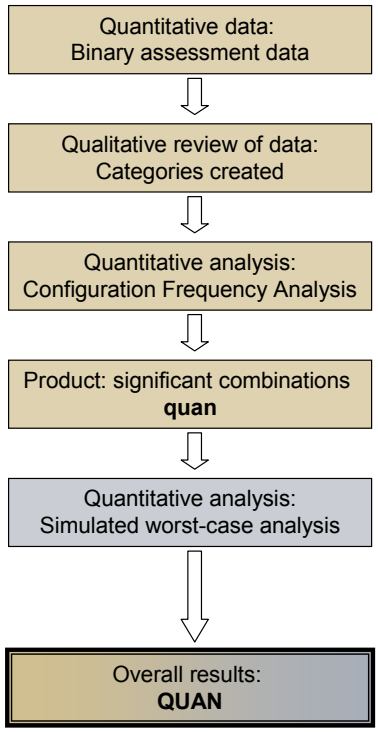

Figure 2. Study design of the Profiles study (Paper I). Notation according to Creswell & Plano Clark (2007).

Conceptual and statistical exploration

The Agreement study (Paper III)

In the Agreement study the phenomenon of inter-rater agreement was explored conceptually and statistically. When basing decisions or allocating societal resources on the results generated by data collected with an assessment instrument such as the HE (Iwarsson & Slaug, 2001), evidently it is crucial that the outcome measure can be trusted and relied upon. If the results are not reliable, decisions may be inadequate and resources allocated may be wasted. One indicator that is

commonly used for the level of trust attached to an instrument is the degree of agreement attained when assessments are made by different raters (Fayers & Machin, 2000). However, just knowing the level of agreement does not give guidance if there are indications that improvement is needed. Furthermore, a high level of agreement may be illusory if possible sources of disagreement that can be expected in real rating situations were overlooked in the test situation. Hence, there is a need to strive for explanatory sufficiency, i.e. what are the specifics we need to know in order to explain the level of agreement attained. To explore this, we conducted an initial conceptual analysis (e.g. Hospers, 1997), diversifying the concept of agreement into three main components. This conceptual analysis provided a theoretical framework for the subsequent statistical analysis. The statistical analysis made use of existing data from a previous agreement/reliability study (Helle et al., 2010) where potential sources of disagreement could be controlled for and their respective impact analyzed (Hox, 2002).

In Figure 3 the design of the Agreement study is illustrated with a flow chart. The quantitative analysis is supported by the qualitative and should be interpreted in the light of the theoretical framework provided. The blue colour signifies that the principle of sufficient variation was emphasized through-out the study.

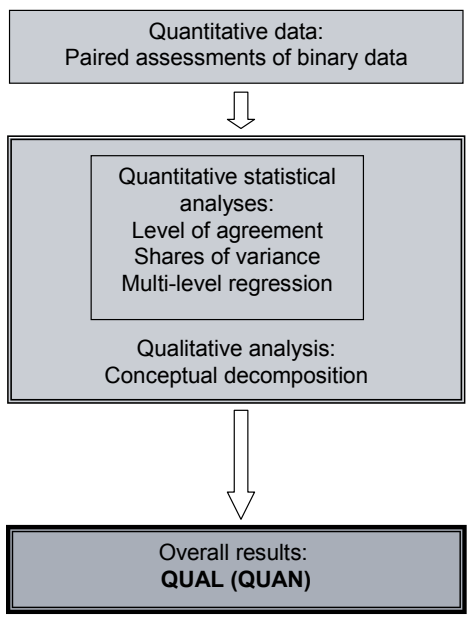

Figure 3. Study design of the Agreement study (Paper III). Notation according to Creswell & Plano Clark (2007).

Instrument development

The Screening study (Paper II)

In the Screening study the analysis objective was to identify the core items of the HE, within a broader perspective of instrument development. The intended scope of use for an instrument based on the core items was for efficient yet accurate detecting of accessibility problems at group or population level. With an existing pool of 188 items the task was that of reduction of complexity. To do so, both quantitative and qualitative methods were applied (Patton, 2002). The rationale being that the two approaches provide different but complementary information. The quantitative approach can make use of sophisticated statistical analysis, but will miss perceptions and experience that goes beyond the actual ratings. For example, experienced raters may provide information of perceptions of nuances in validity between items. Thus a stronger result is achieved by using both approaches, drawing on the respective advantages. The statistical approach called for the use of extensive data, why three different databases were used, the ENABLE-AGE, the Home modifications clients (HM) and the Older people living at home (OP) databases (see Table 3). The qualitative approach was based on an expert panel procedure (Bowling, 2002). The statistical analyses and the work in the expert panel ran in parallel but strictly separate, with no exchange of information between the two groups of researchers until the stage when each group had arrived at a core list of items. During this process, both approaches were given equal importance. To check the accuracy of the reduced set of items in detecting accessibility problems, accessibility scores were calculated for the two sets of items and then correlation analysis was carried out.

In Figure 4 the design of the Screening study is illustrated with a flow chart. The quantitative and qualitative approaches are merged and the final results are achieved by means of consensus discussion. The bronze colour signifies the emphasis of the reduction of complexity principle.

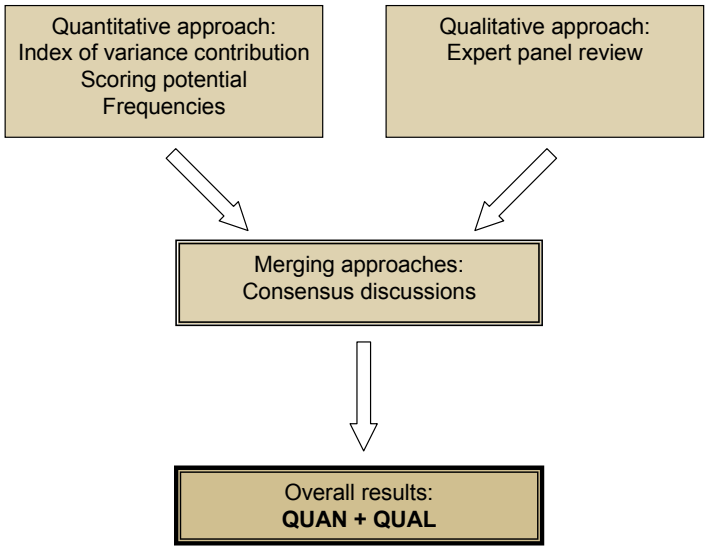

Figure 4. Study design of the Screening study (Paper II). Notation according to Creswell & Plano Clark (2007).

Methodology development

The Typology study (Paper IV)

In the Typology study the methodology for accessibility assessments was further developed, by applying an approach of classification (Collier, LaPorte & Seawright, 2011). In research practice as well as in professional practices and even in everyday life classification is one of the most basic yet central procedures (Bailey, 1994). For example in medicine, health conditions are classified into diagnoses, in the library books are classified by subjects and in biology organisms are classified in species. The essence of classification is to arrange a set of entities into groups by their similarities, thereby achieving minimum within-group variation and maximum between-group variation (Bailey, 1994). Thus a reduction of complexity in forming the groups has to be balanced with a sufficient variation in dividing the groups. To construct the typology of person-environment fit

constellations, which means a multi-dimensional classification, we classified inherent elements and properties of the HE instrument along three dimensions (scoring patterns, environmental contexts and aspects of functioning implicated), applying both quantitative and qualitative methods (Patton, 2002). The environmental component of the HE comprises 161 physical environmental barrier items (Iwarsson & Slaug, 2010a), divided into sections, where each item has a descriptive label attached and a scoring pattern denoting the severity of accessibility problems. Similarities of the scoring patterns were initially analyzed quantitatively. Thereafter a comprehensive procedure of expert review and consensus discussions was applied, further classifying the scoring patterns, the aspects of functioning (Cieza et al., 2005) and the environmental contexts, thus finalizing the typology.

In Figure 5 the design of the Typology study is illustrated with a flow chart. There was a sequential procedure where the qualitative methods were emphasized, after an initial quantitative analysis that provided a starting point (Creswell & Plano Clark, 2007). The blend of the bronze and the blue colour signifies that the emphasis of the reduction of complexity principle and the sufficient variation principles were intended to be balanced.

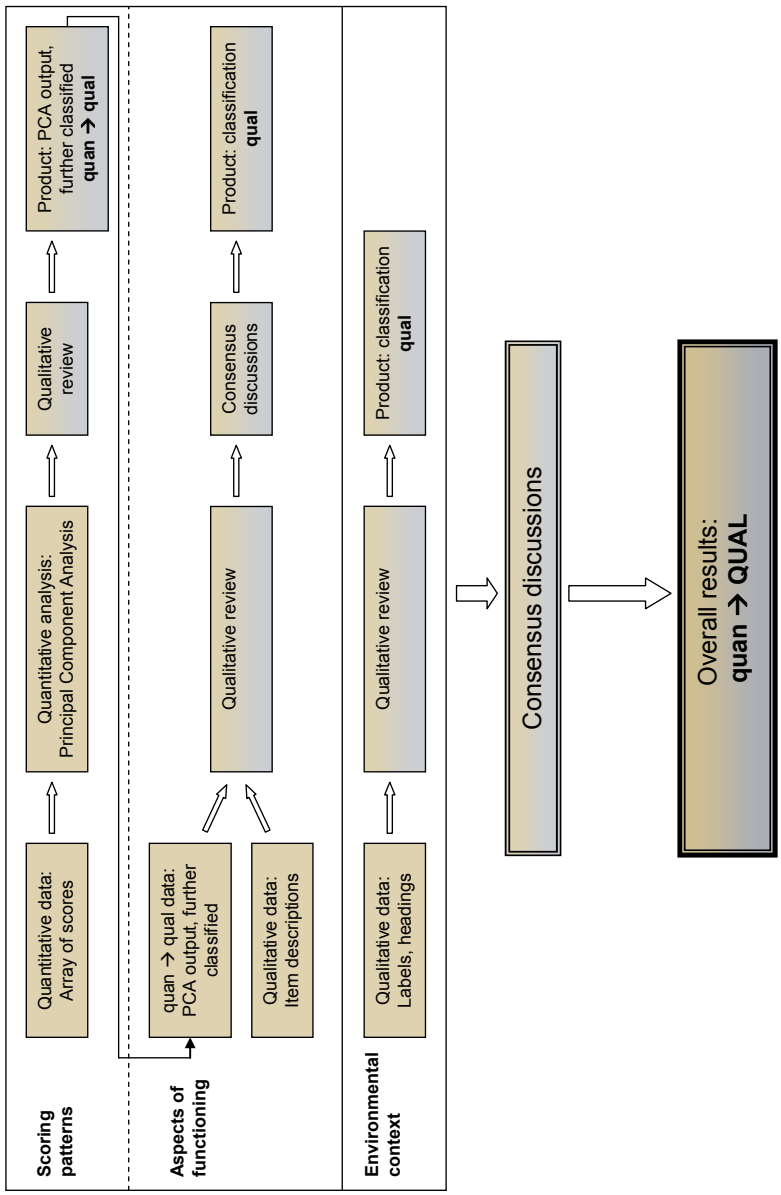

Figure 5. Study design of the Typology study (Paper IV). Notation according to Creswell & Plano Clark (2007).

Data analysis

Statistical analysis

In this thesis conventional as well as less conventional statistical analysis was employed. Earlier unsuccessful attempts with conventional methods or the specific construction of the HE accessibility score, where the score generation is dependent on the coexistence of both functional limitations and environmental barriers, sometimes called for creativity in the choosing statistical analysis.

For the Profiles study we explored a statistical method, CFA (Krauth, 1993; Krauth & Lienert, 1982), specifically developed to analyze combinations of dichotomous variables, in terms of their internal associations. Basically, CFA implies statistical testing of whether the occurrence of a combination is significantly higher (overrepresented) or lower (underrepresented) than expected, relative to the individual occurrence. Thus, an overrepresented profile indicates stronger internal associations within a particular combination, while an underrepresented profile indicates weaker internal associations. In the Profiles study we also explored simulated accessibility analyses, in the sense of using simulated, non-empirical data for the environmental barrier items when calculating the accessibility scores.

At the onset of the Screening study we had a basic idea to rank environmental barrier items according to their respective contribution to the variance of the HE accessibility score. However, due to the specific construction of the HE accessibility score, we developed an *Index of variance contribution*. To estimate the variance contribution of any given environmental barrier item, the scores for occurring in combination with a particular functional limitation or dependence on mobility devices items, and the probabilities for such co-occurrence are needed. For the probability of environmental barriers co-occurring with functional limitations or dependence on mobility devices, we argued that the relative frequencies of the combinations as found empirically might be taken as estimates. However, as frequencies might be highly sample-specific because of e.g. regional characteristics in terms of housing and social composition, we decided to improve generalizability by following a logic of "placing every individual in every house". Thus we combine every observed profile of functional limitation or dependence on

mobility devices with every observed profile of environmental barriers. In other words, we rest the procedure on the theoretical assumption that, in general, environmental barriers and functional limitations or dependence on mobility devices occurs independently of each other. In addition to the Index of variance contribution, we analyzed barrier frequencies in the data samples and barrier scoring potential as a sum of pre-defined severity scores for each item. To arrive at a suggested list of candidates for core items, three overarching criteria were established. The three criteria were 1/ ranking among the 50 items contributing the most to the variance of the HE accessibility score in each of the three databases 2/ scoring potential higher than the median 3/ observed frequency higher than 33%.

In the Agreement study we defined a *Shares of agreement variation formula*, which intends to disentangle the contribution to the variation in agreement data of raters, items and the remaining residual into relative shares. Calculating standard agreement indices, kappa and observed agreement, the basic decomposition of the overall agreement variation would employ the variation due to both components and the residual variation. That is, the agreement values' total sum of squares (SST) could be decomposed into the sums of squares due to rater pair variation (SSR), due to item variation (SSI), and the residual sum of squares (SSres). Further, we used multi-level regression analysis to analyze the impact of potential predictors for agreement variation.

In the typology study we applied the Principal Component Analysis (PCA, e.g., Rencher, 2002; Thompson, 2004) for the initial classification of the scoring patterns. That is, we carried out PCA on the correlation matrix of the scoring patterns of the 161 barriers (treated as analysis variables) over the 14 functional limitations. By use of this algorithm we would get 13 principal components (as each barrier got scores for 14 functional limitations), accounting for the total variation of the scores across the functional limitations.

Qualitative analysis

In the Screening study an expert panel procedure (Bowling, 2002) was applied in order to identify core environmental barrier items. Item reviews were accomplished by each individual researcher and were iteratively combined with group reviews and consensus discussions. From the start a general strategy for decisions on inclusion and exclusion of items was avoidance of information redundancy. Through the process three additional criteria for item selection were identified: 1/ Potential score generation 2/ Environmental barrier items critical for

safety 3/ Environmental barrier items related to details of the design of features not applicable to all kinds of housing. In order to be selected as a candidate for inclusion in a reduced version of the HE instrument, an environmental barrier item had to be identified by way of at least two of the three criteria.

Also in the Typology study, expert review was applied in order to classify elements of the HE instrument, but individually and without the formation of a formal panel. The general guiding principle for the reviewers in classifying the elements was to strive after a balance of the principles of reduction of complexity and sufficient variation. That is, the elements of the typology should not be too few and thereby too general, and on the other hand not to many and thereby too specific. The classifications were then finalized through iterative consensus discussions.

The Agreement study evolved from the application of a conceptual analysis. This analysis, emanating from the tradition of analytical philosophy (e.g. Hospers, 1997) consisted of breaking down the concept of inter-rater agreement in its constituent components, thus gaining insight and better understanding of the phenomena. The analysis was aided by literature review but mainly conducted by pure thinking.

Data used

ENABLE-AGE (Paper I-III)

In the Profiles, Screening and Agreement studies (Paper I-III) data from the ENABLE-AGE project were utilized. The ENABLE–AGE project was a major, cross-national, interdisciplinary project, including very old people in five European countries, i.e. Germany, Hungary, Latvia, Sweden and the United Kingdom. The main objective of the project was to examine the housing environment as a determinant for autonomy, participation and well-being among the very old (aged 75-89 years). It comprised three major studies: the ENABLE-AGE survey study, the ENABLE-AGE in-depth study and the ENABLE-AGE update review. Details of the project have been published elsewhere (e.g. Iwarsson et al., 2007; Oswald et al., 2007). For this thesis data from four of the national samples of the ENABLE-AGE survey study was utilized (N=1,542). In the survey

study a questionnaire comprising a comprehensive set of standardized instruments, including the HE, and project specific questions, was administered at home visits with each participant. Data was collected by trained raters, by means of interview and observational assessments. The database originating from the ENABLE-AGE survey study is noteworthy in its variety and wealth of details, related to different aspects of health and housing. Especially the rich source of data on the built environment from countries with different cultural and political background deserves to be highlighted. This data includes the extensive HE checklist of environmental barriers, a housing standard checklist, information of housing adaptations, type of dwelling, building year etc. To the best of my knowledge, such a database is rarely to be found elsewhere.

For the Profiles study data from the ENABLE-AGE covering the personal component of accessibility, i.e. functional limitations was used, while in the Agreement study only data on the environmental component was used. For the Screening study, data on both the personal and environmental component was used. For a description of sample characteristics for the ENABLE-AGE data used, see Table 4.

Table 4. Sample characteristics ENABLE-AGE[a] data used in Paper I-III.

Sample characteristics	Paper I N=1,542[b]	Paper II-III N=1,150[c]
Demography		
Age, mean (SD)	82.7 (3.8)	83.4 (3.8)
Sex, n (%)		
Men	309 (20.0)	233 (20.3)
Women	1,233 (80.0)	917 (79.7)
Multiple functional limitations (≥2)	1,112 (72.1)	871 (75.7)
Housing, n (%)		
Multi-dwelling	1,307 (84.8)	992 (86.3)
Necessary housing standard	1,444 (93.6)	1,087 (94,5)
Proportion of core barriers[d], mean (SD)	42.1 (11.2)	46.0 (7.9)

[a] The ENABLE-AGE project (Iwarsson et al., 2007), cross-sectional baseline data used.
[b] Four countries included, i.e. Germany, Hungary, Latvia and Sweden.
[c] Three countries included, i.e. Germany, Latvia and Sweden.
[d] Core barriers according to Carlsson et al. (2009).

I had an active role in the research process of the ENABLE-AGE project throughout the life time of the project and still have. I was responsible for data management in Sweden and for data quality assurance issues in the cross-national project as a whole. This responsibility included setup, building and monitoring of the Swedish database. I was also responsible for validating the database for accuracy and completeness, which implied close collaboration with the national teams of data collectors. As member of a group within the ENABLE-AGE project dealing with methodological issues, I took part in international meetings during the study period, as well as in the final ENABLE-AGE conference.

Home modification clients and Older people living at home (Paper II)

For the Screening study (Paper II), in addition to the ENABLE-AGE data, two databases representing different populations in target for public health efforts in housing provision were utilized. The Home modifications client database (HM) comprised data from a consecutive sample of clients in Kristianstad municipality in Sweden, who were being considered for home modification grants (N=131; Fänge & Iwarsson, 2005). The Older people living at home database (OP) comprised data on older Swedish people in the Municipality of Hässleholm, living in ordinary housing (N = 134; Iwarsson & Isacsson, 1996). The participants were randomly selected from the Swedish national population register. In contrast to the ENABLE-AGE sample that was selected from urban areas, the HM and OP samples consisted of persons living mainly in rural areas. I was assisting in data collection and data quality assurance issues also for these databases. For sample characteristics of the HM and OP samples, see Table 5.

Table 5. Sample characteristics HM and OP data used in Paper II.

Sample characteristics	HM N=131[a]	OP N=134[b]
Demography		
Age, mean (SD)	70.7 (14.6)	79.2 (3.4)
Sex, n (%)		
Men	43 (32.8)	57 (42.5)
Women	88 (67.2)	77 (57.5)
Multiple functional limitations (≥2)	124 (94.7)	70 (52.2)
Housing, n (%)		
Multi-dwelling	69 (52.7)	78 (58.2)
Necessary housing standard	120 (91.6)	109 (81.3)
Proportion of core barriers[c], mean (SD)	43.2 (10.9)	50.5 (8.3)

[a] Home modifications clients project (Fänge & Iwarsson, 2003).
[b] Older people living at home project (Iwarsson & Isacsson, 1996).
[c] Core barriers according to Carlsson et al. (2009).

Nordic Housing Enabler (Paper III)

In the Agreement study (Paper III) a dataset generated from a previous agreement/reliability study, the Nordic Housing Enabler was utilized (Helle et al., 2010). The Nordic HE was a cross-national project, heading towards reliable accessibility assessments of the physical environment, for use in a Nordic context. The dataset was generated from a sample where 10 rater pairs had assessed 8-14 different cases each (in total 106 cases), and included data from Denmark, Finland, Iceland and Sweden. Each case concerned a unique dwelling and comprised pair-wise dichotomous assessments of presence/absence of 188 physical environmental barriers in the home and the immediate outdoor environment, as defined by the HE instrument. To fit the design of the Agreement study the dataset was re-structured in a raters × items matrix. That is, for each constellation of rater pair and item the cell frequencies were computed by cross-tabulating the pair-wise assessments of presence/absence of the barriers. As a result, a dataset comprising 1,880 observations (10 rater pairs × 188 items) was generated.

In the Nordic HE project I was coordinating data collection in Sweden, and was responsible for quality assurance of the Swedish database, which included validating the database for accuracy and completeness.

Ethics

The ENABLE-AGE, the HM and the OP projects were all accomplished after approval by the Ethics Committee, Faculty of Medicine, Lund University, Sweden. As regards the Nordic HE project, in Iceland formal ethical consent was applied for and granted, whereas based on the character of the study, at the time when it was conducted this was not necessary in the other countries. From participants in all above projects, informed written consent was received, and they were assured of anonymity, as stated in oral as well as written information. Databases are kept in accordance with current legislation in respective country.

Results

Methodological exploration

Type profiles

As a result of the Profiles study 19 combinations of categories of functional limitations came out as statistically significant ($p<0.05$) in the CFA, out of 63 possible combinations (six categories, only persons with at least one functional limitation included). Eleven of the profiles occurred more often than expected, that is, they were overrepresented in the sample, and eight occurred less often than expected, that is, they were underrepresented in the sample. The values of 1 or 0 signify presence or absence of a category of functional limitations. The most frequent combinations are shown in Table 6.

Table 6. Profiles of functional limitations / use of mobility devices, based on a sample of older persons in four European countries (n=1,333) [a]

Type profiles, n (%)	P[b]	Category of functional limitations / use of mobility devices					
		Difficulty interpreting information	Severe loss of sight / blindness	Severe loss of hearing	Limitations movement	Limitations upper extremity	Use of mobility devices
356 (26.7)	(+)	0	0	0	1	0	0
158 (11.9)	(-)	0	0	0	1	1	0
136 (10.2)	(+)	0	0	0	1	1	1
123 (9.2)	(-)	0	0	0	1	0	1
67 (5.0)	(ns)	0	1	0	1	0	0
44 (3.3)	(-)	0	0	1	1	0	0
40 (3.0)	(+)	0	0	1	1	1	1
39 (2.9)	(ns)	0	1	0	1	0	1
37 (2.8)	(+)	0	1	0	1	1	1
30 (2.3)	(ns)	0	0	1	1	0	1
29 (2.2)	(-)	0	1	0	1	1	0
26 (2.0)	(-)	0	0	1	1	1	0
25 (1.9)	(+)	0	0	0	0	1	0
23 (1.7)	(+)	0	0	1	0	0	0
21 (1.6)	(ns)	1	0	0	1	0	0
18 (1.4)	(+)	0	1	0	0	0	0
18 (1.4)	(ns)	1	0	0	1	1	0
14 (1.1)	(ns)	1	0	0	1	1	1

[a] Only subjects with at least one functional limitation / use of mobility devices included
[b] (+) = overrepresented, (-) = underrepresented, ns = not significant

Simulations of accessibility problems

Ten type profiles were selected for simulated accessibility analysis. The type profiles demonstrated varied patterns of barrier ranking. When the category "Limitations in movement" was included in a type profile, there was a larger proportion of Outdoor and Entrances items among the top ranking environmental barriers, compared to type profiles with "Limitations in upper extremity" included. In the latter type profiles, the Indoor items dominated the top ranking barriers. In five type profiles "Wall-mounted cupboard/shelves placed extremely high" and "No grab bars at shower/bath" had the two top positions. In three type profiles with "Severe loss of hearing included", "No telephone with amplified sound" had the top position in two, and in the third, this item was found in position three. In two type profiles with "Loss of sight" included, environmental barrier items related to stairs and lifts held half of the top twenty positions. The type profile including only "Limitations in upper extremity" had items related to apparatus / control handling and door mechanisms in more than half of the top twenty items. Sixty-two (33 %) of the 188 environmental barrier items had at least one top twenty position, and 58 (31 %) of these had a top twenty-position among the significantly overrepresented type profiles.

Conceptual and statistical exploration

Shares of agreement variation

As a result of the conceptual analysis in the Agreement study, the concept of agreement was diversified into the three components: items, raters and contexts. Variation in agreement data was disentangled into relative shares, demonstrating similar patterns. The raters accounted for 6-11% of the variance, the items accounted for 32-33% of the variance and the residual accounted for 57-60% of the variance. That is, varying characteristics of the raters and/or the items altogether explained 40-43% of the agreement variation.

In terms of statistical significance, for both agreement indices item assessment type, prevalence estimate and raters' familiarity with standardized assessment instruments appeared as substantial predictors, whereas raters' housing adaptation experience did not. With respect to the sign of the effects, disagreement increases if the barriers are assessed by means of evaluating judgments and if one or both raters are not familiar with standardized instruments. The four predictors altogether account for some substantial, but not too large share of agreement variation. As these R^2 values indicate variance contribution from particular characteristics of items and raters, it may be taken as further explanation of the 40-43% of the non-residual variance due to the general variance decomposition. For details, see table 7.

Table 7. Predictors of agreement variation.

	Agreement index[a]			
Rater and item characteristic	Observed, P_o *N=1,880*		Kappa, $\varkappa$ *N=1,402* [b]	
	Est.[e]	*P*	Est.[e]	*P*
Housing adaptation experience (raters)[c]	0.024	0.444	-0.048	0.529
Familiarity with standardized instruments (raters)[c]	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)[d]	-0.258	**<0.0001**	-0.099	**0.010**
Level-1 R^2	0.16		0.12	

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

Instrument development

Screening tool

The result of the Screening study was a reduced version of the HE with the environmental component composing 61 environmental barrier items. Of these, 16 items concern the outdoor environment, 14 items entrances, and 31 the indoor environment. That is, all communication items, constituting a subsection of the original HE instrument, were excluded. Most of the items of the reduced version were potential accessibility score generators for people dependent on mobility devices, and most of them (79%) were based on design norms and guidelines. For all three samples, the effect size of rank correlations between the accessibility scores generated by the original version and the revised version was large: $r = .99$ ($p < .001$) for the EA and OP samples, $r = .97$ ($p < .001$) for the HM sample. That is, the overall validity between the two instrument versions was demonstrated. In Figure 6, two of the core environmental barriers selected are illustrated.

Figure 6. Two of the core environmental barriers identified. Letterboxes can only be reached via differences in level (left), and handrails are too short (right).

Methodology development

Typology of person-environment fit constellations

As a result of the Typology study the initial 13 principal components identified by the PCA were further subdivided into a final list of 48 type scoring patterns, representing typical person-environment fit constellations. Five of the type scoring patterns covered ten or more barriers, and fifteen type scoring patterns covered just one barrier.

In classifying the items according to ICF, eight different blocks of functioning from the three chapters Learning and Applying Knowledge, Communication and Mobility (all covered by the Activity and Participation component) were identified, either alone or in combination. The Environmental context dimension was classified in nine different classes based on headings and subheadings of the HE instrument. The areas with highest frequencies were Hygiene area, 28 items, Kitchen/Laundry/Utility kitchen, 24 items and stairs with 22 items. The Functioning classes of Walking and moving and Purposeful sensory experiences were represented in all environmental classes. Applying knowledge and Changing and maintaining body position were represented in all classes except Sitting out place/balcony/supplementary housing facility and Parking, respectively. Most type scoring patterns, even those covering ten or more items, showed large extent of homogeneity also in the Functioning implicated. In contrast, the environmental context varied for most of the type scoring patterns covering several items.

Discussion

In this thesis key aspects related to the components of a methodology based on the notion of person-environment fit were explored and developed. Methodological exploration resulted in the suggestion of using type profiles, representing combinations of functional limitations for analyses of accessibility problems at group or population level. In this context the potential benefit of simulated accessibility analysis was also explored, as a novel approach to supporting planning procedures and decisions related to the built environment. Based on a conceptual and statistical exploration, new recommendations for in-depth examination of inter-rater agreement data emerged, that will be helpful in improving reliability of assessment instruments, not only of the HE but of other assessment instruments. The approach presented and recommended applies not only to the area of public health, but also to medicine and health sciences and behavioral and social sciences at large. For detecting accessibility problems in targeted areas a preliminary version of a new tool for accessibility screening was developed. A typology of person-environment fit constellations was suggested as a further development of methodology for accessibility assessments, laying a ground for extension of the methodology to environmental arenas other than housing. The results have implications for further methodological research aiming at improved accessibility, and call for renewed attention to the built environment within public health research.

The Profiles study suggests the use of type profiles, to represent groups characterized by certain combinations of functional limitations. This signifies a novel approach to conceptualizing functional capacity at group or population level, compared to earlier attempts (Carlsson et al., 2002), and complementary to approaches made to capture multi-morbidity (van den Akker et al., 2001; Karlamangla et al., 2007; Crisafulli et al., 2008). Nevertheless, the type profiles identified in the Profiles study should be considered cautiously, and more research is needed before inferences and generalizations can be made.

At present, maybe the most interesting aspect of the Profiles study is that it demonstrates the usefulness of basic simulation techniques (Fone et al., 2003; Gaba et al., 2004). Potential benefits are obvious as it has been shown for other

public health related areas (Kuljis, Paul & Stergioulas, 2007; Eldabi, Paul & Young, 2007). In areas such as hospital scheduling and organization, screening for diseases, economic evaluation of health care costs, experimentation is not possible. Simulations offer a method to compare different potential scenarios, and thus inform policy makers in the provision of health care of possible consequences for different changes, for example in the scheduling and organization of health provision, if there is an increased demand for certain treatments etc (Fone et al., 2003). A similar, but more basic approach can be applied with respect to accessibility. By matching the type profiles with lists of possible barriers in the environment, a distinctive contribution is that outcomes in terms of accessibility problems may be foreseen on a detailed level, even in the form of a ranking order of environmental barriers. In the Profiles study we simulated "worst-case" scenarios, but other scenarios can be simulated as well. Besides the usefulness in research, in practice contexts this approach can serve as a support for architects and others involved in planning processes concerning housing for different groups of people. That is, already at an early designing stage there is potential for such simulations to identify the environmental barriers most important to avoid, depending on the group of inhabitants at target. Different architectural solutions can be compared with regard to the accessibility problems predicted, and balanced with other issues under consideration, thus representing a novel approach that remains to be tested in practice.

The reduced version of the HE instrument presented in the Screening study represents a preliminary version of a screening tool with potential to detect accessibility problems. Subsequently, after further development and reliability testing (Iwarsson, Slaug & Fänge, 2011), we published a screening tool based on the reduced version of the HE (Iwarsson & Slaug, 2010b). The reduced version of the HE adds to the still scarce arsenal of instruments available for screening of environmental barriers and accessibility problems in housing, useful for practical societal planning and research within public health, gerontology, health sciences, etc. The reduced version of the HE can be used by a range of professions, e.g., occupational therapists, architects, estate owners, building constructors, and officials responsible for housing provision for older citizens and persons with disabilities. Currently in many countries, housing provision for senior citizens and persons with disabilities is a burning issue (e.g. WHO, 2002). With reliable survey data on housing accessibility at hand, housing provision and planning in general could most likely be positively influenced to create healthy and supportive environments (WHO, 1991). Until now, no empirically based, valid information on which environmental barriers in housing constitute the most important factors generating accessibility problems for persons with functional limitations and dependence on mobility devices existed. Based on solid, cross-national empirical research, the reduced version of the HE represents the first evidence- based

screening tool for detecting accessibility problems. By evidence-based, we are implying that the reduced version has been developed through application of principles of scientific reasoning, including systematic use of data and information systems (Brownson, Fielding & Maylahn, 2009). However, it could be argued that for time-efficient accessibility problem identification even less than 61 items should be required. Admittedly, we did not test how low it would be possible to go with respect to the number of items included, with a preserved high correlation between the reduced instrument accessibility score and the complete instrument accessibility score. This remains a future research task to undertake. It should be kept in mind though, that lowering the number of items may impact content validity negatively (Cook & Beckman, 2006).

By exploring and proposing new strategies for in-depth examination agreement, the Agreement study has relevance for research at large, that is, whenever assessment instruments involving several raters are being used (Brandt et al., 2008). Using a multi-component strategy, where the different steps complement and strengthen each other, our approach focuses on identifying the most important sources of disagreement. Therefore, for future studies on instruments involving contextualized assessments, we recommend a study design and data collection that enables an analytical strategy, systematically crossing characteristics of raters, items and contexts. Such a strategy would enhance the possibilities of detecting weaknesses threatening reliable instrument use, yielding a basis for refinement of the instruments themselves, improved rater training and a raised awareness of potential impacts of various contextual circumstances. Our recommendations for study design and data analysis have the potential of ultimately improving the reliability of assessment instruments. It should also be noted that reliability normally places an upper limit on validity (Norman & Streiner, 2008). In that regard it is important to pay attention to item impact on variation in agreement. For example, in our study there were items with either high or low prevalence estimates that impacted significantly on agreement variation. From a reliability point of view this could be taken as evidence that the items in question are not providing much additional information, as they seem not to differentiate between phenomena (Kottner et al., 2010). However, these items may be justified from the content validity point of view (Cook & Beckman, 2006). Even if they are "problematic" with respect to reliability, they may be important in capturing relevant aspects of accessibility problems. Thus, it is necessary to balance considerations of reliability with considerations of validity.

Based on the Typology study, we suggest a typology of person-environment fit constellations along the dimensions of environmental contexts, physical functioning and scoring patterns. The typology we suggest was achieved by

classifying the inherent elements and properties of the HE instrument (Iwarsson & Slaug, 2010b). By classification of typical person-environment fit constellations, similarities as well as differences in how the constellations are manifested become more easily recognized. The housing and close neighborhood environment covered by the HE instrument only constitutes one out of several different environmental arenas where people live their lives, and cannot presumably cover all possible person-environment fit constellations creating accessibility problems in everyday life. Nevertheless, it provides a starting point for the development of a more far-reaching typology of such constellations. Consequently, with the specific barriers of the HE instrument targeting the housing environment classified according to their conceptual similarities, the extension to other environmental arenas now has valid support. The scoring of accessibility problems, generated by juxtaposing each environmental barrier with each functional limitation, is thereby adhered not only to individual environmental barriers but to general person-environment fit constellations. Hence, when creating new checklists for other environmental contexts, providing the severity scores is ideally only a matter of finding the proper classification. Likewise, the typology allows for expeditiously scanning contexts where particular constellations are concentrated, such as stairs where only a few constellations are recurrent. Thus, the typology serves both as an inventory tool and a guide for identification of person-environment fit constellations. However, the typology suggested only represents an initial step and further methodological research and development is needed before it can be validly used.

Study Limitations

For the Profiles study, even more extensive data on functional limitations would have been desirable. Applying a group or population perspective calls for population data or data that are representative for the population at target. The ENABLE-AGE database (e.g. Iwarsson et al., 2007) is a rich and extensive database, but it was not designed to be representative of the population. However, the comparison with aggregated data from Statistics Sweden (SNIPH, 2010) on the same age group, presented in Table 2, shows a striking similarity in the prevalence of functional limitations. Moreover, in the presentation of the type profiles in the Profiles study, maybe the underrepresented type profiles should not have been given equal attention as the overrepresented type profiles. Rather, it should have been emphasized that there are two principles for relevance that has to be balanced: that of strong internal association (the overrepresented profiles) and that of high frequency.

In the Screening study a sensitivity analysis could have been carried out, in order to determine the optimal number of environmental barrier items to retain. However, the objective was not to have a minimum number of items, but to have a set of items that reflected the most important items also from a content validity point of view. The expert panel contributed for example with considerations of items critical for safety, and applicability to all kinds of housing, which would risk being lost with as completely reductionist approach. Though the reduction of complexity principle was emphasized, it was not entirely prevailing.

For the Agreement study we did not have access to a database where we could control for contextual characteristics, for example the same rater pair systematically assessing the dwellings both at daytime and evening, or both with other persons present and without other persons present during the administration of the assessment. In the current study, we ended up with a large share of the agreement variation (57-60%), that we did adhere to contextual particularities, which of course limits the explanatory power of rater and item characteristics.

Reflections on methodology

The studies of this thesis were all based on a methodology emanating from the notion of person-environment fit, as conceptualized by Lawton & Nahemow (1973). One of the major advantages of this notion, and what makes it so appealing, lies in the reduction of complexity. The outcome can be determined as a function of the relation between personal and environmental dimensions. This outcome can vary and is dependent on what aspects are considered inherent in the personal and environmental dimensions, respectively. In Lawton & Nahemow's person-environment fit model, the outcome is behavior and affect, resulting from the degree of match between the person in terms of a set of competencies, and the level of press from the environment. In the methodology that has been explored in this thesis, the outcome is accessibility and the personal dimension is the functional capacity, while the environmental dimension is related to physical barriers. This flexibility is another of the virtues of the person-environment fit notion, and a reason why it has been so widely used, especially within environmental gerontology (Oswald et al., 2003; Wahl & Lang, 2006).

Moreover, the reduction of complexity is also the reason that the notion of person-environment fit has been so successfully translatable into a tool for measurement, such as the HE. However, with the reduction of complexity there is also the risk of explanatory inadequacies. Thus for instance, the person-environment fit model has been criticized for being static and not taking dynamic processes into account (Scheidt & Norris-Baker, 2003). Also earlier criticism pointed to the fact that the model treats the person as passive (Carp & Carp, 1984), and in a gerontological perspective the model has been criticized for only explaining decline, and not the possibilities of development also at later stages in life (Baltes & Baltes, 1990; Rowe & Kahn, 1998). Relating the model to biographical methods, T. Svensson (Birren et al., 1996) has proposed a revised person-environment fit model including mediating factors such as personality, ego strength, subjective perception of own competence, etc., which most likely would increase the explanatory power. Yet, adding complexity to the original model has disadvantages as well. The instrumental efficiency of a simple model would thus be weakened, making it more difficult to translate it into a tool for measurement. When explanatory sufficiency is the objective, several instruments must be used in combination, in order to complement each other by capturing different dimensions, such as for example the "Four-domain model of perceived housing" (Oswald et al., 2006). The aim of the Four-domain model is to achieve a more comprehensive understanding and measuring of perceived housing in old age. To do so, four conceptual domains of subjective housing have been introduced, housing satisfaction, usability in the home, meaning of home and housing-related control beliefs, which are measured by four different instruments. Yet, if the process of validating an instrument such as the HE is a long-term process of accumulating evidence, it is even more challenging to gather evidence for a model dependent on four different instruments. Not only should there be evidence for each of the instruments, but also for the combination of them.

However, there are weaknesses of the methodology for accessibility assessments we have developed that need to be addressed. Even though measurements may indicate accessibility problems, observations of the interaction of the person with the environment can point in the other direction, and vice versa. This is partially due to the reduction of complexity in the underlying model, but it is also due to the definitions of when environmental barriers are present and when not. Most of the barrier definitions are based on norms and standards, indicating for example in exact millimeters how high the threshold can be without being considered a barrier. From that follows that the proportion of persons considered to have accessibility problems is also dependent on exactly where this cut-off point is set (Helle et al., 2011). As was found by Helle et al., the evidence behind these norms and standards is often weak and mostly based on intuition and practical experiences. Thus, there is a need for observational studies giving more solid

evidence for defining the norms and standards needed in national regulations on housing design.

It should also be kept in mind that accessibility as it is defined in the methodology which is the basis for this thesis, does not take subjective perceptions of the individual into account. The four-domain model mentioned earlier represents an attempt of reaching a comprehensive understanding of perceived aspect of housing. One of the domains included is of particular relevance in relation to accessibility, and that is the domain of usability. In addition to the personal and environmental components, usability comprises an activity component referring to human activities in the environment (Fänge & Iwarsson, 2003; Iwarsson & Ståhl, 2003). Hence, usability gives important additional information regarding the built environment as a health determinant. In research aiming to understand and explain how the built environment impacts on different aspects of health, the complexity of reality needs to be reflected in the data obtained. In practice that is equally important, when for instance the architect can not only consider only one dimension, but has to take many different dimensions into account, such aesthetics, utility, material and also accessibility.

Research relevance

The results presented in this thesis have high societal and political relevance. A built environment that is accessible for all citizens is a political goal that has gained a growing interest. The new methods and tools for measuring accessibility that are provided by the studies of this thesis can benefit societal planning and public health efforts by facilitating valid and reliable problem detection, accessibility screening of targeted areas and simulated analysis to support planning and decision procedures. That is, they have potential to foster improved housing accessibility at societal level. The foundation for an extension of the methodology so that it can be applied to different environmental arenas has also been laid

The results are also highly relevant in relation to health promotion. If the tools and methods provided by this thesis can support societal efforts of improving the accessibility to the built environment, ultimately it will also promote the health status of the population (WHO, 1991). The results are particularly relevant in the light of the ageing population where functional limitations are more common. For

the older segment of the population access to the built environment has the strongest association with different aspects of health (Oswald et al., 2007). An accessible environment is also supportive of physical activities in daily life (Iwarsson, 1997). Further, there is evidence that improved accessibility may prevent fall accidents and reduce the fear of such accidents that otherwise may restrict activities (Ståhl & Iwarsson, 2007).

The results presented in this thesis have high relevance for further research. New methodological insights and knowledge have been gained, related to group and population approaches where more research is needed before it can be validly applied. The new recommendations of inter-rater agreement examination that so far only have been explored in a first study, not originally designed for the type of analyses we pursued, need to be applied already from the design phase, and can be used in methodological studies on instrument development and testing at large. Although the typology person-environment fit constellation needs further development, it provides a reference point for future studies, and research oriented in the direction toward how the built environment can be designed to be supportive for activity, participation and health.

An interdisciplinary research environment

This research of this methodological thesis was shaped not only by its explorative nature, but also by the interdisciplinary setting where it emerged and evolved, the Centre for Ageing and Supportive Environments (CASE). The author constellations for each individual study represented different disciplines, knowledge traditions and conventions, where the individual contributions were merged in recurrent meetings and discussions over the years, thus creating a synthesis representing true interdisciplinarity. Swedish, German, Danish and Latvian researchers were involved, representing community health sciences, occupational therapy, gerontology, psychology, traffic planning and engineering, data management, and statistics. Myself, I have a background in philosophy that was also fused into the work. One asset of CASE, forming also part of the research strategy for the centre, is the availability of databases of different character, possible for PhD students and other researchers affiliated with the centre to use. Hence, at the prospect of the studies leading to this thesis substantial databases from different studies were at hand, which was essential as access to sufficient empirical data is necessary to ensure quality (Johnston, Keith, & Hinderer, 1992).

Among these databases, the largest and most important was originating from the cross-national, interdisciplinary project ENABLE-AGE (e.g. Iwarsson et al., 2007). Reflected by the complexity and intricate nature of the research issues, all studies contained elements of more or less unconventional and creative methods, making benefit of the blend of disciplines not only directly involved in our studies but engaged in the research centre. To conclude, the inter-disciplinary setting was a precondition for how the studies evolved and for the results that were achieved.

However, as mixed and divergent the setting for the research presented in this thesis may appear, it has connections to the core of public health. Public health is particularly well suited for an interdisciplinary approach, as it once emerged from the blend of different disciplines, such as epidemiology, biostatistics and biomedicine (Andersson & Ejlertsson, 2009). Moreover, historically, there is a strong link between health promotion and improvements in the built environment (Shaw, 2004). This link was reinforced with the Ottawa Charter (WHO, 1986) and the Sundsvall statement on Supportive environments for health (WHO, 1991), where the physical environment was described as a central health determinant. Nevertheless, in recent years there has been a tendency to consider relations between health and the environment too narrowly (Lawrence, 2010). That such aspects as features of the built environment facilitating or obstructing access are associated with different aspects of health, is often overlooked. The studies presented in this thesis represent an attempt to draw the attention of public health to issues related to accessibility and the built environment. Against the background of the demographic development, where older people are the fastest growing group of the population in developed countries (OECD, 2001), such renewed research attention appear particularly urgent (Walker et al., 2011).

Future perspectives

Research activities related to the methodology based on the notion of person-environment fit continues. After the publication of the reduced version of the HE in the Screening study, the set of core items was further adjusted and optimized, and a final Screening tool valid for use within research as well as in practice was launched (Iwarsson & Slaug, 2010b). A reliability study using the Screening Tool in a practice setting involving staff without academic training was conducted, described elsewhere (Iwarsson, Slaug & Fänge, 2011). The Typology study is still in manuscript and remains to be completed for submission. Further research

applying the typology in order to explore the feasibility for extension of the methodology to other environmental arenas can be foreseen. A photo library with a wealth of illustrations of all the environmental barriers covered by the HE instrument is currently being compiled. This photo library will contribute to strengthen valid assessments by the HE.

Furthermore, I have been involved and is still in a parallel thesis project (T. Helle) focused on evidence-based norms and guidelines for housing design, which is complementary to this thesis.

The ENABLE-AGE project also continues with new data collection waves, that includes HE and other data related to different aspects of housing and health.

Conclusions

This thesis represents an attempt to refocus public health with on the built environment that it once had. In a historical context, the link between features of the built environment and the health status of the population was evident, and early interventions for health promotion often targeted the material and sanitary conditions of the built environment. For this thesis however, the targeted features of the environment concern the degree to which the environment is accessible for all persons including those with reduced functional capacity. In the four studies of this thesis, a methodology for assessments and analysis of accessibility problems was explored and developed, which led to the following main conclusions.

- The use of type profiles that represent groups characterized by their combinations of functional limitations is suggested as an approach for analyzing accessibility problems at the group or population level.
- To support planning and decision procedures at the societal level, simulations of accessibility analyses are suggested as a method that can support the process of identifying different sets of housing improvement priorities for groups with different functional limitation profiles.
- The reduced version of the HE instrument comprises core environmental barriers in terms of accessibility problem detection. This set of core environmental barrier items represents the basis for a preliminary version of an accessibility screening tool, already published based on the results of this thesis.
- To the best of my knowledge, the reduced HE is the first globally available evidence-based screening tool for detection of housing accessibility problems. It has the potential to be an efficient tool that is useful for practice contexts, research within public health, gerontology, health sciences as well as for societal planning.
- Supported by a conceptual analysis, an in-depth approach of examining inter-rater agreement is proposed. The proposed strategy has the potential to enhance the ability to detect weaknesses that threaten reliable instrument use, which yields a basis for refinement of the instruments,

better rater training and a raised awareness of how contextual circumstances may influence assessments.

- The typology of person-environment fit constellations is supported as a methodological extension for accessibility assessments to be applicable in different environmental arenas. The typology also contributes to the knowledge on how relations between aspects of functioning and physical environmental barriers generate typical problematic person-environment fit constellations, i.e. accessibility problems. Thereby the typology furnishes a reference point for further studies and research oriented on how the built environment may be supportive for activity, participation and health.

Svensk sammanfattning / Summary in Swedish

För att förbättra folkhälsan är det av största vikt att utveckla miljöer som främjar aktivitet delaktighet och hälsa. För äldre och andra grupper med begränsad funktionell kapacitet är härvid tillgängligheten en aspekt av den byggda miljön som är av central betydelse. Med denna avhandling anknyts till folkhälsoämnets historiska fokus på sambandet mellan den byggda miljön och olika aspekter av hälsan.

Folkhälsa är en förhållandevis ung forskningsdisciplin som internationellt växte fram under senare delen av 1800-talet. Folkhälsa står för en befolknings hälsotillstånd, både avseende nivå och fördelning. Det som karaktäriserar forskning inom folkhälsa är att den har ett brett allmänintresse, att den i vid bemärkelse studerar faktorer som påverkar hälsan och att den har som utgångspunkt att förbättra hälsotillståndet i befolkningen. Historiskt har folkhälsa sitt ursprung i de samhälleliga insatser som gjordes framför allt för att förbättra materiella och sanitära förhållanden i den byggda miljön, i syfte att minska sjuklighet och dödlighet i infektionssjukdomar. Det handlade om renhållnings-arbete, att få fram rent vatten, att bygga avlopp med mera. Detta innebar avgörande insatser som hade stor betydelse för att förbättra folkhälsan.

Den byggda miljön är dock betydelsefull för hälsan även i andra avseenden. Ett område som kommit alltmer i fokus under senare tid avser i vilken utsträckning den byggda miljön är tillgänglig, även för personer med begränsad fysisk kapacitet. Konkret handlar det till exempel om att kunna ta sig fram, att aktivera kontroller och funktioner på köks- och tvättutrustning, och att kunna nå och hantera olika föremål och utformningsdetaljer i miljön. Det vill säga, det handlar om miljömässiga förutsättningar för att kunna utföra vardagliga aktiviteter.

Uppkomsten av funktionella begränsningar är en del av åldrandeprocessen och i takt med att den förväntade livslängden ökar, berör tillgänglighetsproblemen en allt större andel av befolkningen. Det finns därför behov av att utforska och

utveckla metoder så att man på ett giltigt och tillförlitligt sätt kan bedöma och mäta tillgänglighetsproblem. Problemen ska kunna identifieras på ett giltigt och tillförlitligt sätt och vidtagna åtgärder ska kunna utvärderas.

Det övergripande syftet med denna avhandling var att i fyra delstudier utforska och utveckla metoder som kan stärka den forskning som krävs för att stödja samhällets insatser för att göra den byggda miljön tillgänglig för alla, oberoende av funktionell kapacitet. Tillgänglighet är ett relativt begrepp, som definieras som relationen mellan funktionell kapacitet och miljöns utformning. Tillgänglighet har därmed definitionsmässigt två komponenter; en personkomponent och en miljökomponent. Ett viktigt antagande, som baseras på Lawton och Nahemows ekologiska modell, är att om människans funktionella kapacitet avtar kan detta kompenseras genom att minska miljöns krav - tillgängligheten kan därmed upprätthållas eller förbättras. Det är denna modell som avses med ”the notion of person-environment fit”.

Med utgångspunkt i denna tankegång har den forskargrupp där denna avhandling har sitt ursprung ägnat sig åt utvecklingen av ett bedömningsinstrument för tillgänglighetsproblem i boendemiljön, nämligen Housing Enabler. Bedömning av tillgänglighet genomförs med detta instrument i tre steg. Först bedöms de funktionella begränsningarna hos individen och sedan de hinder som finns i boendemiljön. Därefter beräknas en poängsumma som uttrycker graden av tillgänglighetsproblem för den aktuella kombinationen av funktionella begränsningar och miljöhinder. Housing Enabler var också en förutsättning och en utgångspunkt för de fyra delstudierna.

I den första delstudien utforskades ett nytt angreppssätt för att analysera tillgänglighet på grupp- eller populationsnivå, baserat på principen att den funktionella kapaciteten hos en individ uttrycks som kombinationen av funktionella begränsningar. I ett grupp- eller populationsperspektiv finns det behov av att identifiera de mest relevant kombinationerna av funktionella begränsningar, för att kunna definiera tillgänglighetsproblemens omfattning. Med en metod som testar vilka kombinationer som förekommer oftare eller mer sällan än förväntat, givet förekomsten av varje enskild funktionell begränsning, identifierades tio typprofiler av funktionella begränsningar i ett datamaterial insamlat hos äldre personer (75-89 år) i deras boendemiljöer, i fyra europeiska länder (N=1,542). För att demonstrera möjligheterna att använda typprofilerna i exempelvis planeringsskedet av nybyggnationer, undersöktes med hjälp av simuleringar vilka miljöhinder som skulle utgöra störst problem för de grupper som representerades av typprofilerna.

I den andra delstudien utvecklades en preliminär version av ett screeningverktyg för mer effektiv problemidentifiering av tillgänglighetsproblem och för kartläggning på samhällsnivå. Verktyget togs fram genom att identifiera vilka av de 188 bedömningspunkter som ingår i miljökomponenten av Housing Enabler som är mest centrala, i betydelsen att förutsäga tillgänglighetsproblem. Genom ett angreppssätt där både statistisk analys och expertgranskning användes, identifierades en lista med 61 miljöhinder som de mest centrala. I den statistiska analysen användes tre olika databaser (N=1,150, N=131, N=134) för att ge ett varierande statistiskt underlag. Omfattningen av tillgänglighetsproblem som förutsägs av denna lista korrelerades med omfattningen av tillgänglighetsproblem som förutsägs av det fullständiga instrumentet med 188 bedömningspunkter. Överensstämmelsen var nära nog perfekt.

I den tredje delstudien utforskades ett nytt sätt att analysera data avseende överensstämmelse där olika bedömare bedömt samma sak under likartade förhållanden. Syftet var att ta fram metoder för att förbättra tillförlitligheten vid användning av bedömningsinstrument. Med stöd i en begreppsanalys där överensstämmelse delades upp i komponenterna bedömare, bedömningspunkt och kontext analyserades variationen i överensstämmelsedata, mätt med två gängse mått för överensstämmelse (observerad överensstämmelse och kappa). Variationen i överensstämmelse delades upp i relativa andelar och påverkan av specifika egenskaper hos bedömare och bedömningspunkter analyserades. Metodstudien resulterade i rekommendationer för hur mellanbedömarstudier bör läggas upp för att bäst kunna utnyttja analysredskap med vars hjälp källor till bristande överensstämmelse kan identifieras och åtgärdas.

I den fjärde delstudien klassificerades i tillgänglighetshänseende problematiska konstellationer av relationen människa-miljö, så som de manifesteras i instrumentet Housing Enabler. Syftet var att genom att identifiera de allmängiltiga egenskaperna i de problemkonstellationer som manifesteras i boendemiljön skapa ett underlag för att utsträcka metoden till att vara tillämpbar för olika domäner av den byggda miljön, och då framför allt den offentliga miljön. Klassifikationen tillhandhåller också en inventering av typiska problemkonstellationer och ger därmed ökad kunskap om vad det är som genererar tillgänglighetsproblem.

Resultaten av denna avhandling innebär att metoder för utvecklingen nya verktyg och redskap utforskats och förfinats. Den metodik som presenterat kan med stor träffsäkerhet och tillförlitlighet ge underlag som stödjer forskning som syftar till att förstärka arbetet med att förbättra tillgängligheten i den byggda miljön för äldre

och andra grupper med begränsningar i den funktionella kapaciteten. Ytterst kan därmed aktivitet, delaktighet och hälsa främjas hos befolkningen, vilket är en av de grundläggande utgångspunkterna för folkhälsovetenskapen.

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References

van den Akker, M., Buntinx, F., Roos, S., Knottnerus, J. A. (2001). Problems in determining occurrence rates of multimorbidity. *Journal of Clinical Epidemiology, 54*(7)*,* 675-679.

Alves, L.C., Leite, I.C., Machado, C.J. (2008). The concept and measurement of functional disability in the elderly population: a literature review. [Article in Portuguese] *Ciência Saúde Coletiva, 13*(4)*,* 1199-207.

Andersson I, Ejlertsson G. (Eds). (2009). *Folkhälsa som tvärvetenskap – möten mellan ämnen*. [In Swedish] Lund: Studentlitteratur.

Bailey, K.D. (1973). Monothetic and poloythetic typologies and their relation to conceptualization, measurement and scaling. *American Sociological Review, 38(1)*, 18-33.

Bailey, K.D. (1994). *Typologies and taxonomies. An introduction to classification techniques.* Sage Publications. Thousand Oaks CA: Sage.

Baltes, P. B., Baltes, M. M. (1990). *Psychological perspectives on successful aging: The model of selective optimization with compensation*. In P. B. Baltes & M. M. Baltes (Eds.), Successful aging: Perspectives from the behavioral sciences (pp. 1–34). New York: Cambridge University Press

Barbotte, E., Guillemin, F., Chau, N. & Lorhandicap group. (2001). Prevalence of impairments, disabilities, handicaps and quality of life in the general population: a review of recent literature. *Bulletin of the World Health Organisation [online]*, *79*(11), 1047-1055.

Beaglehole, R., Bonita, R., Horton, R., Adams, O., McKee, M. (2004). Public health in the new era: improving health through collective action. *Lancet, 363,* 2084-2086.

Birren, J., Kenyon, G., Ruth, J.E., Schroots, H. & Svensson, T. (Eds.) (1996). *Aging and biography: Explorations in adult development,* (pp. 100-116). New York: Springer.

Blandin De Chalain G., Stephenson P. (2009). *Built Environments as a Determinant of Health*. Oxford University Press.

Borst C.H., Henk M.E., Miedema S., de Vries I., Jamie M.A., Graham, J., van Dongen, E.F. (2008). Relationships between street characteristics and perceived attractiveness for walking reported by elderly people. *Journal of Environmental Psychology, 28*(4), 353-361.

Bowling, A. (2002). *Research methods in health. Investigating health and health services (2nd ed.)*. Maidenhead, UK: Open University Press.

Brandt, Å., Löfqvist, C., Jónsdottir, I., Sund, T., Salminen, A-L., Werngren-Elgström, M., & Iwarsson, S., (2008). Towards an instrument targeting mobility-related participation: Nordic cross-national reliability. *Journal of Rehabilitation Medicine, 40*(9), 767-772.

Brownson, R.C.., Fielding, J.E.., Maylahn, C.M. (2009). Evidence based public health: a fundamental concept for public health practice. *Annual Review of Public Health, 30*, 175-201.

Calman K. (1998). The 1848 Public Health Act and its relevance to improving public health in England now. *British Medical Journal, 317*:596–98.

Carlsson, G., Iwarsson, S., Ståhl, A. (2002). The personal component of accessibility at group level: Exploring the complexity of functional capacity. *Scandinavian Journal of Occupational Therapy, 9*(3), 100-108.

Carlsson, G., Schilling, O., Slaug, B., Fänge, A., Ståhl, A., Nygren, C., & Iwarsson, S. (2009). Toward a screening tool for housing accessibility problems: A reduced version of the Housing Enabler. *Journal of Applied Gerontology, 28* (1)*,* 59-80.

Carp, F., Carp, A. (1984). A complementary/congruence model of well-being on mental health for the community elderly. In I. Altman, M.P. Lawton, & J.F. Wohlwill (Eds.) *Elderly people and their environment* (pp 279-336). New York: Plenum Press.

Cieza, A., Geyh, S., Chatterji, S., Kostanjsek, N., Üstün, B., Stucki, G. (2005). ICF linking rules: an update based on lessons learned. *Journal of Rehabilitation Medicine, 3,* 212–218.

Clarke, P., George, L.K. (2005). The Role of the Built Environment in the Disablement Process. *American Journal of Public Health, 95*(11), 1933-1939.

Collier, D., LaPorte, J., Seawright, J. (2012). Putting Typologies to Work: Concept-Formation, Measurement, and Analytic Rigor . *Political Research Quarterly, 65*(2).

Cook, D.A., Beckman, T.J. (2006). Current Concepts in Validity and Reliability for Psychometric Instruments: Theory and Application. *The American Journal of Medicine, 119*, 166.e7-166.e16.

Creswell, J.W., Plano Clark, V.L.. (2007). *Designing and Conducting Mixed Methods Research*. London UK: SAGE Publications.

Crisafulli, E., Costi, S., Luppi, F., Cirelli, G., Cilione, C., Coletti, O., Fabbri, L.M., Clini, E.M. (2008). Role of comorbidities in a cohort of patients with COPD undergoing pulmonary rehabilitation. *Thorax 63*(6), 487–492.

Eldabi, T., Paul R.J., Young, T. (2007). Simulation modelling in healthcare: reviewing legacies and investigating futures. *Journal of the Operational Research Society, 58*(2)*,* 262-270.

von Eye, A. (1990). *Introduction to Configural Frequency Analysis: The search for types and antitypes in cross-classifications*. Cambridge, UK: Cambridge University Press.

Fayers, P.M., Machin D. (2000). *Quality of Life - Assessment, Analysis and Interpretation*. John Wiley & Sons, Ltd. New York, USA.

Finlayson, M., Peterson, E. (2010). Falls, Aging and Disability. *Physical Medicine & Rehabilitation Clinics of North America 21*, 357-373.

Fone, D., Hollinghurst, S., Temple, M., Round, A., Lester, N., Weightman, A., Roberts, K., Coyle, E., Bevan, G., Palmer, S. (2004). Systematic review of the use and value of computer simulation modelling in population health and health care delivery. *Journal of Public Health Medicine, 25*(4), 325-335.

Fuller-Thomson, E., Hulchanski, J.D., Hwang S. (2000). The housing/health relationship: what do we know? *Reviews on Environmental Health, 15*(1-2), 109-33.

Fänge, A., Iwarsson, S. (2003). Accessibility and usability in housing – Construct validity and implications for research and practice. *Disability and Rehabilitation, 25*(23), 1316-1325.

Fänge, A., Iwarsson, S. (2005). Changes in accessibility and aspects of usability inhousing over time – An exploration of the housing adaptation process. *Occupational Therapy International, 12*(1), 44-59.

Fänge, A., Iwarsson, S. (2007). Challenges in the development of strategies for housing adaptation evaluations. *Scandinavian Journal of Occupational Therapy, 14*(3), 140-149.

Fänge, A., Iwarsson, S., Persson, Å. (2002). Accessibility to the public environment as perceived by teenagers with functional limitations in a south Swedish town centre. *Disability and Rehabilitation, 24*(6), 318-326.

Fänge, A., Risser, R., Iwarsson, S. (2007). Challenges in implementation of research methodology in community-based occupational therapy: The Housing Enabler example. *Scandinavian Journal of Occupational Therapy, 14*(1), 54-62

Gaba, D.M., (2004). The future vision of simulation in health care. *Quality and Safety in Health Care, 13*(Suppl 1), 2-10.

Hagberg, B.J.A. (1996). Stödjande miljöer för det hälsobefrämjande arbetet. *Socialmedicinsk tidskrift, 2-3*, 91-99.

Helle, T., Brandt, Å., Slaug, B., & Iwarsson, S. (2011). Lack of research-based standards for accessible housing: problematization and exemplification of consequences. *International Journal of Public Health, 56*(6), 635-644.

Guralnik, J.M., Ferrucci, L. (2003). Assessing the building blocks of function: Utilizing measures of functional limitation. *American Journal of Preventive Medicine, 25*(3 Suppl 2), 112-121.

Helle, T., Nygren, C., Slaug, B., Brandt, Å., Pikkarainen, A., Hansen. A-G., Pétersdóttir,E., Iwarsson, S. (2010). The Nordic Housing Enabler: Inter-rater reliability in cross-Nordic occupational therapy practice. *Scandinavian Journal of Occupational Therapy, 17*(4), 258-266.

Hospers, J. (1997). *An introduction to philosophical analysis*. London, UK: Routledge.

Hox, J.J. (2002). *Multilevel analysis.* Mahwah: Lawrence Erlbaum.

Hripcsak, G., Heitjan, D.F. (2002). Measuring agreement in medical informatics reliability studies. *Journal of Biomedical Informatics, 35,* 99-110.

Iwarsson, S. (1997). *Functional capacity and physical environmental demand: Exploration of factors influencing everyday activity and health in the elderly population*. ISBN 91-628-2351-5. Doctoral dissertation. Department of Community Medicine Dalby/Lund, Lund University. Lund, Sweden.

Iwarsson, S. (2005). A long-term perspective on person-environment fit and ADL dependence among older Swedish adults. *Gerontologist, 45*(3), 327-36.

Iwarsson, S., Isacsson, Å. (1996). Development of a novel instrument for occupational therapy assessment of the physical environment in the home - a methodologic study on "the enabler". *Occupational Therapy Journal of Research, 16*, 227-244.

Iwarsson, S., Horstmann, V., Oswald, F., Carlsson, G., & Wahl, H-W. (2009). Person-environment fit predicts falls in older adults better than the consideration of environmental hazards only. *Clinical Rehabilitation, 23* (6), 558-567.

Iwarsson, S., Slaug, B., & Malmgren Fänge, A. (2011). The Housing Enabler Screening Tool: Feasibility and inter-rater reliability in a real-estate company practice context. *Journal of Applied Gerontology*, Online advanced release. doi: 10.1177/0733464810397354.

Iwarsson, S., Nygren, C., Slaug, B. (2005). Cross-national and multi-professional inter-rater reliability of the housing enabler. *Scandinavian Journal of Occupational Therapy, 12*(1), 29-39.

Iwarsson, S., Slaug, B. (2001). *The Housing Enabler: An instrument for assessing and analysing accessibility problems in housing*. Nävlinge & Staffanstorp: Veten & Skapen HB & Slaug Data Management.

Iwarsson, S., & Slaug, B. (2nd, Revised Ed.). (2010a). *Housing Enabler — A method for rating/screening and analysing accessibility problems in housing. Manual for the complete instrument and screening tool*. Lund & Staffanstorp, Sverige: Veten & Skapen HB och Slaug Enabling Development.

Iwarsson, S., & Slaug, B. (2010b). *The Housing Enabler Screening Tool - Short manual*. Lund & Staffanstorp, Sverige: Veten & Skapen HB och Slaug Enabling Development.

Iwarsson, S., Ståhl, A. (2003). Accessibility, usability, and universal design – Positioning and definition of concepts describing person-environment relationships. *Disability and Rehabilitation, 25*(2), 57-66.

Iwarsson, S., Fänge, A., Hovbrandt, P., Carlsson, G., Jarbe, I., & Wijk, U. (2004). Occupational therapy targeting physical environmental barriers in buildings with public facilities. *British Journal of Occupational Therapy, 67*(1), 29-38.

Iwarsson, S., Wahl, H-W., Nygren, C., Oswald, F., Sixsmith, A., Sixsmith, J., Széman,Z., & Tomsone, S. (2007). Importance of the home environment for healthy aging: Conceptual and methodological background of the European ENABLE-AGE Project. *Gerontologist, 47*(1), 78-84.

Haak, M. (2006). *Participation and Independence in Old Age - Aspects of home and neighbourhood environments.* Lunds universitet/Department of Health Sciences, Division of Occupational Therapy and Gerontology, Lund University, Sweden.

Jensen, G., Iwarsson, S., Ståhl, A. (2002). Theoretical understanding and methodological challenges in accessibility assessments, focusing the environmental component: an example from travel chains in urban public bus transport. *Disability and Rehabilitation, 24*(5), 231-242.

Jette, A.M. (2006). Toward a common language for function, disability and health. *Physical Therapy, 86*(5), 231-242.

Johnston, M.V., Keith, R.A., Hinderer, S.R. (1992). Measurement standards for interdisciplinary medical rehabilitation. *Archives of Physical Medicine and Rehabilitation, 73*(12), S3-23.

Karlamangla, A., Tinetti, M., Guralnik, J., Studenski, S., Wetle, T., Reuben, D. (2007). Comorbidity in older adults: Nosology of impairment, diseases, and conditions. *Journal of Gerontology, 62A*(3), 296-300.

Kottner, J., Audige, L., Brorson, S., Donner, A., Gajewski, B.J., Hróbjartsson, A., Roberts, C., Shoukri, M., Streiner, D.L. (2011). Guideline for reporting reliability and agreement studies (GRRAS) were proposed. *Journal of Clinical Epidemiology, 64,* 96-106.

Krauth, J. (1993). *Einführung in die Konfigurationsfrequenzanalyse (KFA)*. [Introduction to Configural Frequency Analysis (CFA).] Weinheim: Beltz, Psychologie Verlags Union.

Krauth, J., Lienert, G.A. (1982). Fundamentals and modifications of configurational frequency analysis (CFA), *Interdisciplinaria 3*, 1–14.

Kuljis, J., Paul, R.J., Stergioulas, L.K. (2007). Can health care benefit from modeling and simulation methods in the same way as business and manufacturing has? *Proceedings of the 2007 Winter Simulation Conference*, ed. S.G. Henderson, B. Biller, M-H Hsieh, J. Shortle, J.D. Tew, and R.R. Barton, Washington DC, USA

Lawrence, R. (2010). Housing and health promotion: moving forward. *International Journal of Public Health, 55*, 145-146.

Lawton, M.P., Nahemow, L. (1973). *Ecology and the ageing process.* In C Eisdorfer, MP Lawton (Eds.), The psychology of adult development and ageing. Washington DC: American Psychological Association.

Lawton, M.P. (1986). (2nd ed.). *Environment and Aging.* Los Angeles, USA: Brooks/Cole Publishing Co.

Lewin, K. Field. (1951). *Theory in Social Science*. New York: Harper & Brothers.

Molton, I.R., Jensen, M.P.. (2010). Aging and disability: biopsychosocial perspectives. *Physical Medicine and Rehabilitation Clinics of North America*, 21(2):253-65.

Nagi, S.Z. (1991). Disability concepts revisited: Implications for prevention. In A. M. Pope & A. R. Tarlov (Eds*.), Disability in America: Toward a national agenda for prevention*. Washington DC: National Academy Press.

Northridge, M., Sclar E., Biswas P. (2003). Sorting out the connections between the built environment and health: A conceptual framework for navigating pathways and planning healthy cities. *Journal of Urban Health, 80*(4), 556-68.

Nutbeam, D. (1998). Health promotion glossary. *Health Promotion International, 13* (4), 349-364.

Nygren, C., Oswald F., Iwarsson S., Fänge A., Sixsmith J., Schilling O., Sixsmith A, Széman Z., Tomsone S., Wahl H-W. (2007). Relationships Between Objective and Perceived Housing in Very Old Age. *The Gerontologist , 47*(1), 85-95

OECD (2001). *Ageing and transport- mobility needs and safety issues*. Paris, France: Organisation for economic co-operation and development.

Oswald, F., Wahl, H-W., Martin, M., Mollenkopf, H. (2003) Toward Measuring Proactivity in Person-Environment Transactions in Late Adulthood. *Journal of Housing For the Elderly, 17*(1), 135-152

Oswald, F., Wahl, H-W., Schilling, O., Nygren, C., Fänge, A., Sixsmith, A., Sixsmith, J., Széman, Z., Tomsone, S., Iwarsson, S. (2007). Relationships between housing and healthy ageing aspects in very old age: Results from the European ENABLE-AGE Project. *Gerontologist, 47*(1), 96-107.

Oswald, F., Schilling, O., Wahl, H.-W., Fänge, A., Sixsmith, J., & Iwarsson, S. (2006). Homeward bound: Introducing a four domain model of perceived housing in very old age. *Journal of Environmental Psychology, 26 (3)*, 187-201.

Patton, M. Q. (2002). *Qualitative methods and research evaluation* (3rd). Newbury Park, CA: Sage.

Preiser, W.F.E. & Ostroff, E. (Eds). (2001). *Universal design handbook*. New York: McGraw-Hill.

Rantakokko, M., Mänty, M., Iwarsson, S., Törmäkangas, T., Leinonen, R., Heikkinen, E., et al. Fear of Moving Outdoors and Development of Outdoor Walking Difficulty in Older People. *Journal of the American Geriatrics Society. 2009;57*(4):634-40.

Raffle, A.E., Muir Gray, J.A. (2007). *Screening: Evidence and Practice*. New York, NY: Oxford University Press.

Regeringens proposition 1999/2000:79. *Från patient till medborgare – en nationell handlingsplan för handikappolitiken*. [In Swedish]. Stockholm. Socialdepartementet.

Rencher, A.C. (2002). *Methods of multivariate analysis*. New York: Wiley.

Rowe, J. W., & Kahn, R. L. (1998). *Successful aging*. New York: Pantheon/Random House.

SCB (2010). Survey of Living Conditions (ULF). Website [in Swedish]: http://www.scb.se/Pages/Product____12199.aspx

Scheidt, R. J., & Norris-Baker, C., (2003). *The general ecological model revisited: Evolution, current status, and continuing challenges*. In H.-W. Wahl, R. Scheidt, & P. Windley (Eds.), Environments, gerontology and old age. Annual review of gerontology and geriatrics 2003 (pp. 34–58). New York: Springer.

Schopenhauer, A. (2003). *On the fourfold root of the principle of sufficient reason*. La Salle, Illinois: Open Court Publishing Co.

Shaw, M. (2004). Housing and Public Health. *Annual Review of Public Health 25*, 397-418.

Smith, D.G., Dorling, D., Shaw, M. (2001). *Poverty, Inequality and Health in Britain, 1800–2000: A Reader*. Bristol, UK: Policy Press.

Steinfeld, E. & Danford, G. S. (1999). *Theory as a basis for research on enabling environments*. In Steinfeld, E. & Danford, G. S. (Eds.). Enabling Environments: Measuring the Impact of Environment on Disability and Rehabilitation. New York: Kluwer Aca-demic/Plenum Publishers.

Steinfeld, E., Schroeder S., Duncan J., Faste R., Chollet D., Bishop M., Wirth P., & Cardell P. (1979). *Access to the Built Environments: A Review of the Literature.* Washington, DC: U.S. Government Printing Office.

Streiner, D.L. & Norman,,G.R. (2008). *Health Measurement Scales. A Practical Guide to Their Development and Use*. 4th ed Oxford University Press, Oxford

Swedish National Institute of Public Health (SNIPH). (2010). *Äldrestatistik 2010 - Äldres hälsa, funktionsnedsättning, boende och hjälpmedel*. [In Swedish] ISBN 978-91-86633-21-9.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis*. Washington, DC: American Psychological Association.

United Nations, [UN]. (1993). *Standard Rules on the Equalisation of Opportunities for Persons with Disabilities*. New York: United Nations.

United Nations. (2006). *Convention on the rights of persons with disabilities.* NewYork: United Nations. http://www.un.org/disabilities/.

Wahl, H.-W. & Iwarsson, S. (2007). *Person-environment relations in old age*. In R. Fernandez-Ballesteros (Hrsg.), Geropsychology. European perspectives for an ageing world, (pp. 49-66). Göttingen: Hogrefe.

Wahl, H-W., Lang, F. (2006). Psychological Aging. A contextual view. In P.M. Conn (Ed.), *Handbook of models for human aging* (pp. 881-895). Amsterdam: Elsevier.

Wahl, H-W., Iwarsson, S., Oswald, F. (2012). Aging Well and the Environment: Toward an Integrative Model and Research Agenda for the Future. *The Gerontologist*, published online doi:10.1093/geront/gnr154.

Wahl, H-W., Fänge, A., Oswald, F., Gitlin, L.N., Iwarsson, S. (2009). The home environment and disability-related outcomes in aging individuals: what is the evidence? *Gerontologist, 49* (3), 355-367.

Walker, A., Maltby, T. (2012). Active ageing: A strategic policy solution to demographic ageing in the European Union. *International Journal of Social Welfare*, published online doi: 10.1111/j.1468-2397.2012.00871.

Verbrugge, L.M., Jette, A.M. (1994). The disablement process. *Social Science and Medicine, 38*(1), 1-14.

World Health Organization, [WHO] (1991). *Sundsvall Statement on Supportive Environments.* June 9-15, 1991, Sundsvall, Sweden. Geneva: WHO

World Health Organisation (WHO). (2001). *ICF: International classification of functioning, disability and health*. Geneva, Switzerland: WHO.

World Health Organization, WHO (2002). *Active ageing: a policy framework*. Website: http://who.int/agieng/publications/.