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# Overall Accessibility of Public Transport for Older Adults

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To Claudia, Edward, and Beatrice



# List of studies

This doctoral thesis is based on the following four studies:

- Study I. Sundling, C., Berglund, B., Nilsson, M.E., Emardson, R., & Pendrill, L.R. (2014). Overall accessibility to traveling by rail for the elderly with and without functional limitations: the whole-trip perspective. *International Journal of Environmental Research and Public Health*, *11*(12), 12938–12968. doi:10.3390/ijerph111212938.
- Study II. Sundling, C., Nilsson, M.E., Hellqvist, S., Pendrill, L.R., Emardson, R., & Berglund, B. (2015). Travel behaviour change in old age: the role of critical incidents in public transport. *European Journal of Ageing*. doi: 10.1007/s10433-015-0358-8
- Study III. Sundling, C. (2015). Travel behavior change in older travelers: understanding critical reactions to incidents encountered in public transport. *International Journal of Environmental Research and Public Health*, *12*(11), 14741–14763. doi:10.3390/ijerph121114741
- Study IV. Sundling, C., Emardson, R., Pendrill, L.R., Nilsson, M.E., & Berglund, B. (2015). Two models of accessibility to railway traveling for vulnerable, elderly persons. *Measurement*, *72*, 96–101. doi.org/10.1016/j.measurement.2015.02.053

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# Abstract

This thesis is based on four studies that explore accessibility for older adults during whole trips by public transport. The overall goal was to gain knowledge of the interrelationships among key variables and to develop a conceptual model of the overall accessibility of public transport. More specifically, the research goals were: (a) to explore links among the key variables postulated to be involved in *overall accessibility* and to explore the links between these variables and railway accessibility; (b) to gain a deeper understanding of links between critical incidents in traveling and travel behavior decisions; and (c) to develop a conceptual model of overall accessibility. The key variables contributing to overall accessibility are functional ability (depending partly on the person's functional limitation or disease), travel behavior, and barriers encountered during whole-trip traveling involving train. Respondents with more than one functional limitation or disease reported lower functional ability than did those with only one such limitation and respondents with low functional ability were less frequent travelers than were those with high functional ability. Frequent travelers reported railway accessibility to be better than did those who traveled less frequently. The main barriers were ticket cost and poor punctuality, but respondents with the lowest functional ability attributed the barriers encountered to their own health. The critical incidents most frequently reported were found in the categories "physical environment onboard vehicles" and "physical environment at stations or stops", as well as in the "pricing and planning during ticketing" phase of the trip. Five *themes* of reactions to critical incidents were identified that had resulted in *behavior change*: firm restrictions, unpredictability, unfair treatment, complicated trips, and earlier adverse experiences. A conceptual model of overall accessibility was developed, grounded in the empirical research results. This model is summarized in the following propositions: Overall accessibility is a reciprocal relationship among the *barriers/facilitators* encountered, *functional ability*, and *travel behavior*. Accessibility emerges in the person–environment interaction. To understand accessibility, *past experiences* and *future expectations* should both be considered, because both will guide travel decisions.



# 1. Introduction

Like many developed countries, Sweden has an ageing population (Myck, 2015; UN 2009). As of year 2060, almost 25% of the Swedish population is expected to be over 65 years old, as compared with 19% in 2011 (Statistics Sweden, 2012), meaning that the proportion of journeys made by older adults is expected to increase. With age, functional limitations will become more common, and many older adults will experience more than one functional limitation, which may increase their vulnerability when traveling. Other groups can be vulnerable as well, such as children, people with heavy or bulky luggage, and parents with strollers. At some point in their lives, most people will be considered “vulnerable travelers.” The Swedish Parliament has set the goal of accessibility for everybody, throughout the country, though the deadline for reaching this goal has been continuously moved forward, partly because of lack of knowledge of how vulnerable travelers perceive their access to the public transport system (Swedish Parliament, 2014; The Swedish National Rail Administration, 2005).

The general aim of this thesis is to develop a conceptual model of overall accessibility in public transport for older people, a model based on an empirically grounded understanding of the main variables proposed to underlie overall accessibility. This was performed in three steps, by addressing the following research questions:

1. What are the interrelationships among the basic variables involved in the overall accessibility of public transportation for older people? The basic variables are functional ability (also including functional limitations), barriers, travel behaviors, and railway accessibility. (Study I)
2. How can the links between the barriers/facilitators encountered and travel behavior decisions be understood in a cognitive and behavioral framework? (Studies II & III)
3. How can overall accessibility be modeled, based on the empirical findings answering research questions 1 and 2? (Study IV)

To answer the three above questions, I have:

- explored interrelationships among variables proposed to underlie overall accessibility, that is, functional limitations/functional abilities, barriers encountered, and travel behavior, as well as the links between each of these variables and “railway accessibility” (Study I);
- identified barriers/facilitators perceived as incidents encountered during travel by public transport, especially critical incidents (Study II);
- examined the process by which travel behavior is affected by barriers/facilitators, by studying cognitive, emotional, and behavioral critical reactions to critical incidents encountered (Study III);
- examined critical reactions following critical incidents, in light of psychological theory (i.e., the cognitive and behavioral framework) (Study III); and
- developed an empirically grounded conceptual model of overall accessibility (Studies I & IV).

Many older adults would like to engage in activities more often than they do and transportation difficulties constitute one of the main obstacles to their doing so (Farquhar, 1995; Gabriel & Bowling, 2004; Su & Bell, 2009). Iwarsson and Ståhl (1999) found that up to 75% of a group of older and special transit service<sup>1</sup>-entitled respondents through that their ability to participate in society was reduced by problems encountered when going to and from the bus stop or when entering or exiting the bus. The encounter of barriers when traveling may reduce travel confidence, thus decreasing mobility (Farquhar, 1995; Gabriel & Bowling, 2004; Su & Bell, 2009).

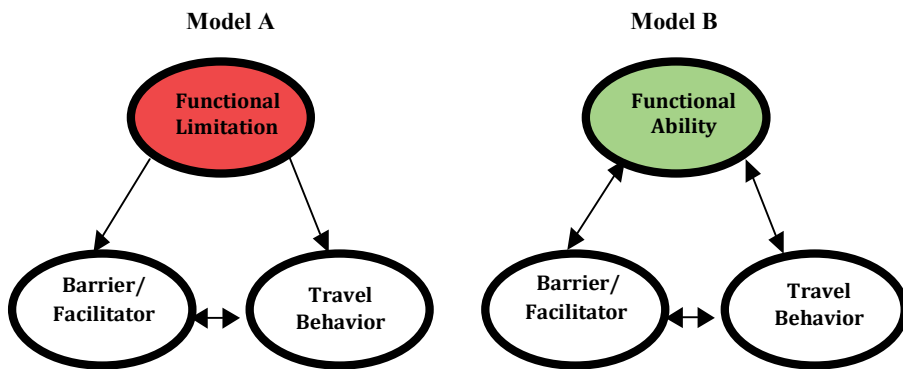
Although a seemingly straightforward concept, accessibility has been defined in various ways and still has no uniform definition in transport research. A theoretical framework is needed that allows us to design measurement instruments, select stimuli (e.g., what barriers should be investigated), and interpret results. It is becoming increasingly important to divert “mainstream” travelers from excessive car use to more sustainable travel behaviors, such as travel by public transport. However, to do so, public transport must be made attractive

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<sup>1</sup> Swedish “Färdtjänst”

enough to be considered a viable alternative to the car. Moreover, if older people were able to travel more independently, public expenditures might be reduced; for example, research in the United Kingdom found a 4% decrease in the number of special transit journeys if users could be encouraged to use the normal bus service by the provision of free fares (Mackett, 2014). Much could be gained if the travel environment were improved for people with various levels of ability and kinds of limitations, not only vulnerable travelers but also those who are presently excluded from public transport traveling.

## Overall Accessibility



*Figure 1: Two models of overall accessibility: Model A refers to travelers with or without various kinds of functional limitations and Model B refers to the same travelers' degrees of functional ability. Functional limitation is invariant, relative to travel behavior and the barriers/facilitators, whereas functional ability is variable because of reciprocal interactions.*

This research was conducted with two accessibility models in mind, both developed in the PhD project (Figure 1; see Studies I and IV). These models are inspired by Bandura's (1978) reciprocal determinism, which involves continuous interaction among cognitive, behavioral, and environmental influences. The accessibility models presented in this thesis are also influenced by the ecological model of Lawton and Nahemow, according to which a balance may be achieved by changing the individual's capacity, the environmental demands, or both (Jensen, Iwarsson, & Ståhl, 2002; Lawton, 1982; Lawton & Nahemow, 1982). In the present research, Jensen et al's concept of *capacity* is replaced with the concept of self-reported ability. The present PhD thesis is grounded in

two overall accessibility models of whole-trip traveling (Figure 1). These are presented in five propositions:

1. A functional limitation is a relatively stable person factor and it cannot be altered by changes in the transport system.
2. A person's functional limitation may lead to the encounter of incidents during travels. These incidents may differ perceptually in terms of (a) direction, i.e., positive (facilitators) or negative (barriers), and (b) importance.
3. The functional limitation may affect the choice of travel behavior (e.g., route or travel mode).
4. The chosen travel behavior may in turn lead to the encounter of specific incidents and, conversely, having encountered a specific incident may lead to a specific travel behavior.
5. By combining functional limitation with functional ability into a single determining characteristic, the model will become reciprocal. Functional ability may increase when barriers are reduced/facilitators increased or travel behavior is changed. The encounter of incidents may change when the level of functional ability or the travel behavior changes. Travel behavior may be altered through a change in barriers/facilitators or in functional ability.

The present thesis is based on four studies exploring the factors determining the accessibility of travel by public transport (Studies I-IV). In particular, I focus on the barriers, and to a lesser extent the facilitators that older people encounter on their trips, together with their functional ability and travel behavior. The positive word "ability" is central to this approach; therefore, the term "functional ability" is used rather than its opposite "disability." A key question is how to match people's abilities with potentially new public transport solutions, such that accessibility can increase and result in independent and competent travel behavior for those wishing to use the public transport system.

Table 1 presents definitions of concepts central to this thesis. Although building on earlier published work (e.g., Flanagan, 1954; Iwarsson & Ståhl, 2003), the presented definitions have been formulated uniquely for the present research. Of the concepts defined in Table 1, "functional limitation" is the only characteristic viewed as entirely inherent in the person and "event" is the only feature viewed as belonging entirely to the environment. For example, a broken

leg will continue to be a broken leg regardless of the environment, and an elevator may be out of order regardless of whether or not travelers are present. The remaining concepts presented in Table 1 are defined by interactions between the person and the environment.

Table 1. Definitions of concepts central to this thesis.

Concept	Definitions and explanations
Overall accessibility	Theoretical construct capturing the possibility of performing a whole trip.
Railway accessibility	Variable capturing the possibility of traveling by train.
Functional limitation	A kind of self-reported limitation or disease referring to <i>inherently</i> existing physical, psychological/behavioral, and intellectual limitations; Study I uses the combined concept functional limitation/disease.
Events	Occurrences in the travel environment that may or may not be noticed by the traveler; involves objects or other people.
Functional ability	Level of a person’s perceived functioning.
Facilitator	Events (including objects or other people) in the travel chain that make traveling easier, as experienced by the individual passenger.
Barrier	Events (including objects or other people) in the travel chain that constrain traveling, as experienced by the individual passenger.
Incident	Barrier/facilitator encountered in a specific travel situation, indicating influence on travel behavior.
Critical incident	Barrier/facilitator encountered in a specific travel situation; indicating “high influence” on travel behavior.
Travel behavior	Actual travel, including travel frequency and transport-mode choice; a traveler’s behaviors throughout a journey <i>or</i> the “choice” not to travel because of previously encountered barriers.
Travel behavior change	Travel behavior following a self-rated “critical incident” exerting a “high influence” on travel behavior (in Studies II and III).

## 1.1 Structure of the thesis

This thesis is structured according to the following outline:

Section 1 introduces the current research area and states the aims of the thesis.

Section 2 provides background and reviews the literature in the relevant research areas. The areas reviewed are research into: (a) accessibility, including environmental characteristics and travelers' experiences and expectations, (b) vulnerable travelers, especially older people, and (c) travel behavior. Research gaps are identified.

Section 3 describes the methods, including the research process.

Section 4 summarizes the findings of the individual constituent studies of the thesis.

Section 5 presents a general discussion, reiterating the aims of the thesis. The model developed integrates the knowledge obtained in the four separate studies. Practical implications and suggestions for future studies are presented.



## 2. Previous research

In this section, I review the scientific literature on accessibility and travel behavior, especially for vulnerable travelers.

### 2.1 Accessibility

Accessibility is one of the United Nations' target areas for equal participation, as stated in the standard rules on the equalization of opportunities for people with disabilities (UN, 2007). Many countries have laws that to some extent define accessibility (see, e.g., Iwarsson & Ståhl, 2003), for example, in building and planning legislation in Sweden (see Ministry of Health and Social Affairs, 2010). Nevertheless, the key elements of accessibility are not self-evident, and there is no uniform definition of accessibility in transport research and no generally accepted way of measuring it. Gould (1969, p. 64) described accessibility as “a slippery notion...one of those common terms that everyone uses until faced with the problem of defining and measuring it.” Accessibility is conceptualized and/or operationalized in line with the research goals in many fields, such as geography, economics, occupational therapy, and psychology (Kwan, 1998). For example, Litman (2003) defines accessibility as the ability to attain desired goods, services, activities, and destinations – collectively referred to as opportunities. It often denotes the potential to arrive at activities from a specific location using a specific transportation system (Morris, Dumble, & Wigan, 1979). A major distinction can be made between accessibility viewed as an attribute of *people* (e.g., attitudes and how easily an individual can reach a certain location) and of *places* (e.g., measures combining physical distances and how easily places can be reached), (Envall, 2007; Kwan, 1998).

In people-based measures, accessibility is analyzed from the viewpoint of individuals, and captures limitations of people's freedom to act in the environment. An advantage of person-based accessibility measures, as opposed to place-based measures, is that they allow more sensitive assessment of individual variations. On the other hand, because of large data requirements, such applications are often restricted to small areas or populations, making results difficult to aggregate to whole populations (Geurs & van Wee, 2004). Research

into people with functional limitations often uses a person-based approach. Accessibility is viewed as the interaction between the person and her environment (Iwarsson & Ståhl, 2003), the perspective also applied here. This individually perceived accessibility may vary from the more “objective” place accessibility but, as individual perceptions are determinants of behavior, they are best suited for the purposes of the present research (cf. Morris, Dumble, & Wigan, 1979). According to Jensen, Iwarsson, and Ståhl (2002), accessibility is dependent on the physical environment and on functional limitations. In the ecological model of Lawton and Nahemow (see Wahl, Iwarsson & Oswald, 2012), a balance can be reached if the environmental pressure is lowered or the person’s ability is increased. It is therefore argued that to understand the concept of accessibility, knowledge of the characteristics of both the person and the environment is necessary. For this purpose, Iwarsson, Jensen, and Ståhl, (2000) developed the “The Travel Chain Enabler” instrument, based on observation, combining it with Critical Incident Technique. This instrument has been used in researching the accessibility of urban public bus transportation for people with functional limitations (Jensen et al., 2002; see also Flanagan, 1954).

### 2.1.1 Characteristics of the environment

Much transport research concentrates on “mainstream” travelers rather than on specific traveler groups and/or on identifying specific barriers and facilitators. Travelers find various characteristics of the environment to be important for the quality of their travels. These characteristics include service reliability (Chen, Yu, Zhang, & Guo, 2009; Friman & Gärling 2001), which includes punctuality (Edvardsson, 1998; Geurs & van Wee, 2004; Hensher, Stopher, & Bullock, 2003), driver behavior (Barabino, Deiana, & Tilocca, 2011), service frequency (Eboli & Mazzulla, 2008; Hensher et al., 2003;), comfort (Friman & Gärling, 2001; Hensher et al., 2003), cleanliness (Eboli & Mazzulla, 2008), and not having to change vehicles (Beirão & Sarsfield Cabral, 2007). Moreover, treatment by employees has been found to influence perceived satisfaction with service (Friman, Edvardsson, & Gärling, 2001; Friman & Gärling, 2001).

For persons with cognitive deficits, complex out-of-home activities are reportedly associated with higher negative affect (measured using The Positive and Negative Affect Schedule – PANAS) than for cognitively healthy people (Wettstein et al., 2014). For older adults or people with functional limitations, ticket prices and connecting travel modes have been identified as barriers to

public-transport travel (Su et al., 2009). Other barriers/facilitators are boarding/alighting and distance to bus stops (Wretstrand, Svensson, Fristedt, & Falkmer, 2009). Bus-stop density, but not rail and underground station density, has been found to increase older adults' travel frequency by the same travel mode (Schmöcker, Quddus, Noland, & Bell, 2008). Moreover, short walking distances within stations and service reliability have both been identified as facilitators. For travelers with cognitive deficits, serial tasks and high travel-environment complexity may be demanding (Rosenkvist, Risser, Iwarsson, Wendel, & Ståhl, 2009).

### 2.1.2 Features of travelers' experiences and expectations

Research into the features of travelers' experiences and expectations has often focused on finding unifying concepts of experience (Anable, 2005). For example, positive and negative incidents when using public transport may affect satisfaction, travelers being less satisfied with public transport after negative experiences and more satisfied after positive ones. Overall (over time) satisfaction with public transport services decreases with the increased frequency of negative incidents, and positive affect (i.e., sense of pleasantness) is related to satisfaction (Friman, 2004; Friman & Gärling, 2001). For bus traveling, well-being has been found to decrease with travel time and increase with access to bus stops (Ettema et al., 2011). According to Oliver and Swan (1989), a traveler's satisfaction with a trip results from evaluations of single elements of a journey as well as from expectations before and during a trip. Consumers tend to choose activities based on their expectations, and the actual performance will later be compared with the prior expectations. If the performance is better (worse) than expected, this results in positive (negative) disconfirmation. Consumer satisfaction is related to both the "costs" and anticipated rewards of travel and if travelers obtain benefits based on the time, effort, and economic cost invested, a journey is deemed worthwhile. Therefore, motivation to travel is influenced both by past experiences and by expectations of future journeys (Prebensen, 2006). In retrospective evaluations, people tend to judge their experience according to the peak-end rule, i.e., the judgment of an event is primarily based on the peak and end of an event, rather than based on the entirety of the event experienced (Kahneman, 2003).

For older adults, (in)security when traveling alone may be perceived as a barrier/facilitator (Wretstrand et al., 2009). Older adults constitute a heterogeneous group, however, and those aged 75 years or more are less satisfied with their travel opportunities than are those aged 65–74 years (Mollenkopf, Hieber, & Wahl, 2011). Likewise, people without a driver’s license, those living in rural areas, and women all experience unfulfilled travel needs (Siren & Hakamies-Blomqvist, 2006). With a lower frequency of driver’s licence and car possession, women may depend more on accessible public transport than do men. As comprising most of the oldest old, women are also more vulnerable than are men. Even though the life-expectancy gap between men and women is narrowing in some countries, most of the older old are still, and will remain, women (Hjorthol, 2013; Shergold, Lyons, & Hubers, 2015).

## 2.2 Functional limitations and functional ability (vulnerable travelers)

Old age and/or functional limitations may increase vulnerability in the public transport environment, although travelers may be vulnerable for other reasons, for example, because they are traveling with children or with heavy luggage. Accordingly, most people may at times be considered vulnerable in the travel environment; this thesis focuses on older people as potentially vulnerable subjects.

In this thesis, a functional limitation is defined as a reduction in physical, psychological/behavioral, or intellectual ability. It is, thus, a characteristic of a person. Functional limitation should be distinguished from functional ability (or disability), which is not viewed as a person characteristic. Disability is commonly defined as a phenomenon reflecting the interaction between a set of personal features and various characteristics of the environment (see, e.g., WHO, 2016). In the context of this thesis, I use the concept of functional ability, defined as the self-reported level of functioning. According to Statistics Sweden, 20% of the Swedish population has some kind of functional limitation (Davidsson, 2001). Hearing impairment is the most common functional limitation in Sweden followed by restricted mobility. Among older people (aged 65–84 years), the order is reversed, restricted mobility being the most common functional limitation followed by hearing impairment (Brundell, 2014). The “older old”, i.e., those over 75 years old, often have more than one functional limitation. In Sweden, approximately 150,000 people with functional limitations are

excluded from public transport and an additional 60,000 travel at least a few times a month, but with difficulty. However, most people with functional limitations have no difficulties traveling by public transport (Börjesson, 2002).

## 2.3 Travel behavior

For older people, the car is the most common travel mode in Sweden, as in many other countries (Alsnih & Hensher, 2003; Linder, 2007; SIKÅ, 2007;). With increasing age, however, there is a shift from car driving to other travel modes. Driving cessation is associated with negative consequences such as increased dependency, social isolation, depression, and increased mortality (Webber, Porter, & Menec, 2010). With increasing age (above 60 years), people make fewer and shorter trips, women make fewer and shorter trips than do men, and people with functional limitations make the fewest trips of all (Boschmann & Brady, 2013). Shopping trips made by public transport have been found to be negatively associated with functional limitations (Schmöcker et al., 2008). Travel frequency decreases, especially at the age of 75 years or more (Heikkinen & Henriksson, 2013), and over the age of 85 years, travelers tend to make less complex trips (Su & Bell, 2009).

It is not self-evident how future travel behavior is linked to the barriers and facilitators encountered. Since barriers/facilitators differ between travelers, a focus on the individual might help reveal needs not discernable in the population at large. There is a lack of knowledge of how people with functional limitations generally perceive travel by public transport, especially from a whole-trip perspective (Swedish Parliament, 2014), and of how travel is experienced, for example, what emotions and meanings are ascribed to travels (Levin et al., 2007; Swedish Parliament, 2014; Ziegler & Schwanen, 2011). Therefore, the present thesis focuses on how older adults' experiences throughout a journey can explain how the barriers/facilitators encountered are associated with their travel behavior and how the travel experience affects their perceived functional ability. To understand public-transport accessibility, the whole travel chain must be studied, from start to arrival at the intended destination, including local residential environments on the way to stations/stops (Ståhl, Carlsson, & Hovbrandt, 2008).

Prevailing theories in cognitive and behavioral psychology may advance future person–environment research into traveling experiences and travel behavior from the individual's perspective. A person's judgment of her ability (i.e.,

self-efficacy) may affect behavior, outcome expectations, and how much effort a person is willing to make to reach a specific goal (Bandura, 1997). According to the Theory of Planned Behavior, TPB (Ajzen, 1991; Ajzen, 2002), often used in travel-behavior research (Avineri, 2012; Bamberg, Fujii, Friman, & Gärling, 2001), a person's *intention* to perform a behavior is shaped by: (a) *attitudes* towards the behavior, because of beliefs about the likely consequences, (b) *normative expectations* of others, and (c) *perceived behavioral control*. The last factor refers to a person's confidence in the ability to perform a particular behavior (cf. self-efficacy). If perceived behavioral control is considered when predicting a certain behavior, prediction accuracy has been found to increase, but only to the person's *actual degree* of behavioral control (Gärling, Gillholm, & Gärling, 1998). Likewise, *habit* has proved useful in predicting behavior, and may be understood in terms of both automatic and intentional behavior (Schwanen, Banister, & Anable, 2012). Forward (2009) demonstrated that past behavior is important in predicting *intentions* regarding car-driving violations. Past behavior has proven to predict behavior better than intentions in a stable context; however, for infrequent behaviors in unstable contexts, intentions predict behavior better than does past behavior (Sheeran, 2002). The consistency of behavior is therefore situation specific. As the features of a situation change, different behaviors may be created (Mischel & Shoda, 1995). Even though it is possible to overcome a single barrier, the total demand of barriers encountered in the travel chain might be insurmountable (Jensen et al., 2002). There might well be a threshold, above which the effort needed to travel is perceived as too demanding. Travel motivation will therefore decline, at least as long as other alternatives exist (Iwarsson et al., 2000). Thaler and Sunstein (2008) advocates "choice architecture" for behavioral-change interventions in order to "nudge" individuals to choose behaviors that are good for them and to overcome cognitive biases, through promotion of "user-friendly" alternatives.

## 3. Methods

In the following section, I will present the research design, methods, and progression of the research process.

### 3.1 Research design for person–environment interaction

My overall goal is to provide a basis for understanding the concept of accessibility that can help in developing travel environments (i.e., public transport in general and railway transport in particular) to meet vulnerable travelers' needs. In all, four studies were conducted. Because I wanted to study the whole journey, I included not only the rail portion of the journey, but also the connecting public transport modes as well as the way to and from stations/stops—for rail travels to be accessible, the entire journey must be seamless. The target group of older people was chosen because of demographic changes in the ageing population combined with the relatively high prevalence of functional limitations in this group compared with other age groups.

In this thesis, accessibility is framed as a matter of interaction between the person and the environment and is examined from the individual's point of view. A “whole-trip perspective” is used, extending from the planning stage to the arrival at the intended final destination. The users of the transport system are viewed as “experts” on their own travel accessibility, meaning that they are the people to be asked about it (Iwarsson & Ståhl, 2003; Levin et al., 2007); accordingly, the individual is treated as “the measurement instrument” of accessibility. Because of their different research goals, different methodologies were used in the different studies. Ethical approval was obtained from the Stockholm Area Local Ethical Committee (2011/1169-31/5). All participants received information on anonymity and gave informed consent.

I conducted Study I, a questionnaire study in order to explore the concept of overall accessibility for older people in railway traveling; that is, I researched the variables I assumed would underlie overall accessibility. The questionnaire was developed specifically for this research: Except for a few questions adopted from recent surveys, the questions were formulated to support creation of the accessibility models shown in Figure 1. Apart from the inherent person variable

(a) kinds of functional limitations/diseases, the variables researched are a person's (b) level of functional ability, (c) experiences of and attitudes to various potential barriers, and (d) travel behaviors. Because the sample of participants was random, it included people with different travel behaviors, ranging from frequent travelers to those not traveling at all. A main goal was to assess how the four abovementioned variables were related to a fifth variable, (e) railway accessibility as perceived by the participant, in order to outline an overarching conceptual model of overall accessibility. The questionnaire contained five sections addressing the variables outlined above.

The first two parts of the questionnaire investigated the travelers' functional limitations/diseases and their own perceived functional ability including their use of assistive devices (e.g., canes or glasses), and special transit service (i.e., Swedish Färdtjänst). Functional limitation/disease was assessed by one question with 15 response options, selected through a literature review of functional limitations and of transport research. This question refers to a medical diagnosis or symptom. Functional limitation is defined as a reduction in inherently existing physical, psychological/behavioral, or intellectual abilities (e.g., restricted mobility, vision, or cognitive impairments). Three additional questionnaire items assessed authority-evaluated needs, such as mobility service and disabled parking permits and one item concerned disability aids (with eight response options). The self-reported degree of functional ability and health status were measured using five-point category scales.

The third and main part of the questionnaire measured perceived potential *barriers* in the travel environment encountered during *the whole trip* (i.e. the whole door-to-door travel chain). These included travelers' actual past experiences as well as their future expectations of traveling. Subsections addressed barriers encountered in: (a) long-distance train traveling, (b) train traveling in general, and (c) public transport, including transport modes other than the train. The items about barriers were in the format of scales or open-ended questions. In addition, one item contained 30 response alternatives regarding barriers/facilitators for more frequent travel by long-distance train. Most barriers were therefore pre-defined and selected through reviewing the literature, although the respondents were also allowed to suggest barriers.

The fourth part of the questionnaire explored actual *travel behavior*. This was assessed using items about the following eight aspects of travel: travel frequency, mode of transportation, destination, purpose of trip, ticket purchase, luggage brought, travel companion(s), and change of transportation mode(s).



The fifth part of the questionnaire consisted of one item addressing the accessibility of train travel specifically, here denoted *railway accessibility*. The respondents' perceptions of accessibility in railway traveling were measured using a single five-point category scale.

Taken together, in Study I, the five measured empirical variables (i.e., functional limitation/disease, functional ability, barrier, travel behavior, and railway accessibility) define the overarching theoretical construct overall accessibility. The variable railway accessibility constitutes the empirically measured accessibility whereas overall accessibility, as presented above, is the theoretical counterpart that takes account of the whole trip. The remaining four variables; i.e., functional limitation/disease, functional ability, barriers, and travel behavior, are regarded as underlying the overall accessibility construct. In addition, the person variable functional limitation/disease can be viewed as a background class affecting functional ability; in the conceptual model, it is therefore included in the functional ability variable.

To understand and assess accessibility in greater depth, Study II was conducted. It examines the link between two of the concepts researched in Study I, and regarded as underlying overall accessibility, namely barriers and travel behavior (Figure 1). The research goal of Study II was to, qualitatively examine the encountered barriers and facilitators perceived as incidents and, in particular, to examine the incidents regarded as important enough to influence the interviewees' actual travel behavior. These incidents are deemed critical incidents. To elicit experiences of interaction with the travel environment, travelers were interviewed about the incidents encountered. These incidents were used as the unit of analysis and categorized in two dimensions. In addition, the interviewees (a) scaled these incidents according to importance on a scale of 1–3 and (b) classified these incidents as either positive or negative or, in a few cases, as both positive *and* negative. Together with content analysis, Critical Incident Technique (CIT; Flanagan, 1954) was used to collect and analyze the data (Bitner, Booms, & Stansfield Tetreault, 1990; Gremler, 2004).

In Study III, I investigated how and why the barriers/facilitators perceived as critical incidents had seriously influenced travel behavior (Figures 1 and 2). For this reason, the psychological process of travel behavior-change was examined. The research goals were (a) to assess how the critical cognitive, emotional, and behavioral reactions to the critical incidents had contributed to travel behavior decisions, according to the interviewees themselves, and (b) to propose a theo-

retical basis in psychological theory, particularly cognitive and behavioral theory. Thematic analysis was used to identify critical-reaction themes. In all, five themes were identified.

In Study IV, the goal was to further develop the conceptual accessibility model from Study I and present it in more detail. The model was originally presented briefly in a paper by Sundling et al. (2013).

## 3.2 The research process

In this section, I give an overview of how the empirical studies evolved during the research project and I also discuss the methodologies applied in the four studies.

### 3.2.1 Overview of studies

Study I was a questionnaire study. Initially, it attempted to explore how a target group of older people (65–85 years old) in the County of Stockholm perceived the accessibility of the public transport system, especially in railway travels, and to identify the problems this group encountered. The questionnaire was also designed to study the variables hypothesized to be involved in accessibility. A first step in theory building is to define central concepts. To obtain an overview of experiences of and attitudes towards accessibility, a random sample of older people was chosen. The present sample of participants therefore includes both travelers and non-travelers. A pilot study was first conducted and, after refining the questionnaire, the main study proceeded. A total of 1000 questionnaires were sent to people aged 65-85 years in the County of Stockholm, Sweden. In the analysis of the empirical data of Study I, two conceptual models of accessibility were developed (see Figure 1). In these models, functional limitation, which is a person variable, inherent in the person, sometimes at least partly determines the barriers encountered and/or the travel behavior chosen. By reducing the important barriers in the transport system, the perceived functional ability would be expected to increase, allowing for more flexible travel behavior.

Study II focuses on the link between barriers encountered and subsequent travel behavior. It was therefore necessary to choose people who had actually traveled by public transport and who were therefore “experts” on the travel environments and potential barriers of public transport. I specifically wanted to focus on those people who are most vulnerable in the transport environment and who therefore could be expected to experience barriers, because of reduced *level* of functional ability and/or some *kind* of functional limitation/disease. For selection purposes, all interviewees were screened based on age, gender, functional limitations, functional ability, and travel frequency. This second empirical study was designed as a qualitative study to identify barriers experienced as incidents. The goal was to investigate the barriers/facilitators, perceived as critical incidents that had highly influenced travel behavior according to the travelers themselves.

Study II constitute 30 semi-structured interviews. Potential participants were screened for inclusion. Critical Incident Technique was used. In the first step, a framework was created and critical incidents were defined for this study. In step two, data were collected in the form of in-depth interviews. Participants were recruited partly from Study I and partly in other ways, i.e., using snowball sampling, newspaper advertisements, and advertisements at municipal elderly care. In the interviews, detailed information on incidents was collected, including negative and positive incidents. Sample size was determined, not by the number of participants, but by the number of critical incidents identified and by whether or not these incidents adequately covered the trips studied. In step three, the data were analyzed. A categorization scheme was created and two independent coders, who categorized all incidents, extracted critical incidents from the interviews. Finally, the categories obtained were organized into two dimensions of incident categories. To ensure the soundness of the results, standardized credibility checks were conducted.

Study III used critical incident data from the second study as a starting point for further analysis by examining the interviewees’ reactions following the incidents encountered. The goals were to find out why the particular incidents had resulted in changed travel behavior and how this process of travel behavior change could be understood within a psychological theoretical framework. The (a) cognitions, (b) emotions, and (c) behaviors, following the incidents were therefore assessed. A thematic analysis was conducted to identify themes in the reactions to the incidents encountered.

Study IV expands on the accessibility models of Study I by discussing and deepening the definitions of the variables underlying overall accessibility.

### 3.2.2 Description of the studies

An overview of the four studies as regards research goal, research approach, method, data analysis, and empirical basis can be found in Table 2.

Table 2. Overview of Studies I–IV as regards research goal, approach, method, analysis, and empirical basis.

	Study I	Study II	Study III	Study IV
Research goal	Examine associations among variables; develop conceptual model	Identify barriers/facilitators influencing travel behavior	Identify how and why barriers/ facilitators influence travel behavior	Further develop conceptual model
Research approach	Quantitative, cross-sectional	Qualitative	Qualitative	Theoretical
Methods	Questionnaire	Interviews, Critical Incident Technique	Interviews, Critical Incident Technique	
Data analysis	Statistical associations	Inductive Content Analysis	Inductive Content Analysis, thematic analysis	
Empirical basis	574 respondents (57% response rate) aged 65–85 years; residents of Stockholm County, Sweden.	30 interviewees aged 65–91 years.	29 interviewees aged 65–91.	Theoretical article based on empirical findings in Studies I–III.

## 4. Results

In Section 4, I briefly summarize the main findings of Studies I–IV of this thesis and highlight contributions.

### 4.1 Study I

*Overall accessibility to traveling by rail for the elderly with and without functional limitations: the whole-trip perspective*

The first study was an initial examination of the perceived accessibility of railway travels for older people (65–85 years old) with and without functional limitations/diseases, and of links among these people’s functional ability, barriers encountered, travel behavior, and perceived railway accessibility. The results indicate that younger participants (aged 65–74 years) had fewer concurrent functional limitations/diseases than did older participants (75–85 years). Measured as “railway accessibility,” a majority (59%) considered the accessibility of train travel to be “very good” or “fairly good,” though 10% considered it “very bad” or “rather bad.” Of the whole sample, 41% of the respondents did not travel as much as they would have liked. For participants with restricted mobility and chronic pain, railway travel was perceived to be less accessible than for respondents with other functional limitations/diseases. Certain barriers were reported to strain some respondents with certain functional limitations/diseases, for example, people with restricted mobility found it difficult “to move around onboard long-distance trains”. Moreover, frequent travelers perceived railway accessibility to be better than did those who traveled less frequently, and those with higher functional ability traveled more frequently than did those with lower functional ability. The main barriers to more frequent traveling were travel costs and low punctuality; while these barriers applied to respondents with high functional ability and to the whole sample, those with severely reduced functional ability viewed their own health as the main barrier.

A principal components analysis (PCA) (see Table 3) indicated an underlying pattern of associations among functional limitations/diseases. The first component consisted of cognitive deficits, including: attention, memory, or concentration disabilities, reading, writing, or speech disabilities and poor mental

health. Chronic pain and restricted mobility (including associated neurological conditions) formed the second component. The third component comprised the two main sensory impairments, i.e., impaired hearing and vision; diabetes might also contribute because of associated visual deficits. The fourth component consisted of cardiovascular and lung-associated diseases, including asthma, allergy and hypersensitivity, and the fifth component consisted of neurological disorders, including epilepsy. Systemic diseases (i.e., rheumatic disease and diabetes) and travel sickness constituted the sixth and seventh components, respectively. Notably, travel sickness was not associated with any other functional limitations/diseases.

Table 3. Principal components analysis of the prevalence of 15 functional limitations/diseases (total  $n = 745$ ; for each of the 15,  $n = 5-121$ ); sample of older adult participants in Study I.

Functional limitations/ Diseases	Principal components						
	C1	C2	C3	C4	C5	C6	C7
<i>Functional limitations</i>							
Attention, memory, or concentration disability	0.83						
Reading, writing, or speech disability	0.72						
Poor mental health	0.54						
Chronic pain		0.79					
Restricted mobility		0.74					
Hearing impairment			0.78				
Vision impairment			0.73				
<i>Diseases</i>							
Chest disease				0.68			
Cardiovascular disease				0.60			
Asthma, allergy, hypersensitivity				0.59	0.41		
Epilepsy					0.80		
Neurological disorder		0.34			0.51		
Rheumatic disease						0.77	
Diabetes			0.40			0.55	
Travel sickness							0.55

Footnote: C1–C7 refer to the seven extracted components of a PCA of the coefficients of the correlation ( $r$ ) between pairs of the 15 functional limitations/diseases. In total, 60% of the variance is explained. Only the loadings with absolute values greater than 0.3 are shown.

In Study I, the concept of whole-trip accessibility was applied. The variables suggested to explain overall accessibility are functional limitations, functional ability, barriers encountered, travel behavior, and (measured) railway accessibility. One result of Study I is a better understanding of the complex construct of the overall accessibility of railway travel and of how the suggested underlying variables are interlinked. The study indicates a need for further research into the barriers that are important enough to affect travel behavior.

Table 4 shows the results of 30 barriers/facilitators of “traveling by long-distance train more often than presently” presented in Study I. Cost was the most important barrier: 62% of the participants said they would travel more often if it were less expensive. This was followed by barriers/facilitators concerning punctuality (i.e., keeping to the schedule and arriving at the destination on time) and not having to change travel modes. The least important barriers/facilitators were: possibility of traveling at different times, improved attitudes of other passengers, and not having to travel underground. Table 4 shows a complete list of the 30 response alternatives presented to the respondents as well as the percentages of responses. A PCA of the 30 alternatives yielded no useful  $n$ -dimensional patterns for improving the travel environment.



Table 4. Thirty barriers/facilitators for traveling by long-distance train more often.

Question:	Response Frequency *
I would travel more often by train, if...	
If it would be less expensive to travel	62%
If departure and arrival times were kept	49%
If I knew I would be in time at the final destination	48%
If I knew I would be in time for my connection	47%
If I would not have to change modes of travel during the trip	43%
If I knew I would get help if I need	42%
If it would not be crowded onboard	40%
If I knew I would be in time for the long-distance train	33%
If the travel time would become shorter	33%
If it would be easier to find an empty seat	33%
If it would be easier to book/purchase tickets for the whole trip at the same time (even connections)	33%
If there were service staff at the platform	29%
If I would feel secure going to and from the station	26%
If the attitude of the staff would be more service minded	26%
If I would not be afraid of being harassed	25%
If I could be sure I would manage the whole journey	25%
If it would become easier to get help from staff onboard	25%
If it would become easier to book/purchase tickets	24%
If the environment would become less busy	24%
If I would have more time to get on or off the train	24%
If the departures were more frequent	22%
If it were easier to get help from staff within the station area	22%
If I were healthier and therefore could manage to travel	20%
If the staff would be more proficient	20%
If it would be easier to park at the station	19%
If I would not have to keep track of so many things during the trip	18%
If trains and stations were designed in a more homogenous way	15%
If it would be possible to travel at other hours (for example at night)	11%
If fellow passengers' attitudes were better	11%
If I would not have to travel under the ground	9%

\* Depending on the question, the response frequency is  $n = 483-506$ .

## 4.2 Study II

### *Travel behavior change in old age: the role of critical incidents in public transport*

Starting from the broader picture from Study I of the accessibility, Study II was conducted to gain a deeper understanding of the link between specific barriers or facilitators encountered during the whole trip and subsequent travel behavior, that is, according to the travelers themselves.

Critical Incident Technique (CIT) was used in in-depth interviews with 30 older participants who had some kind of functional limitation/disease and/or level of functional ability. Incidents were collected that had been encountered during trips made at least partly by rail-bound modes. The interviewees (a) scaled the importance of the incidents for travel behavior on a 3-point category scale and (b) classified them as positive or negative. The most influential incidents for travel behavior (i.e., greatly influencing travel behavior) according to the interviewees were deemed critical incidents.

Each incidents was categorized into two dimensions, i.e., a Travel Environment Dimension and a Travel Chain Dimension. The categories in the Travel Environment Dimension are: (1) Pricing, (2) System flexibility, (3) Physical environment, (4) Information, (5) Fellow passengers, (6) Staff, and (7) Time and Connections. The categories in the Travel Chain Dimension are: (1) Ticketing, (2) To and from station, (3) At station, (4) On and off vehicle, (5) On board, and (6) More than one part of the trip. Most reported critical incidents were negative (67 out of 77) and these negative incidents were most often encountered in the physical environment (i.e., in the travel environment dimension) at stations or on-board vehicles (i.e., in the travel chain dimension). Escalators/elevators being out of order or lurching vehicles (with the risk of falling) are examples of such incidents. The third most frequently reported area of critical incidents was the “pricing and planning” during “ticketing” phase of the trip. It was found that critical incidents were experienced along different parts of the travel chain, implying that the whole trip is important for accessibility. One result of Study II is a categorization system found useful in identifying decisive points in the travel environment, no matter where in the travel chain they appear, without preconditions. It could be used to identify barriers and facilitators in public transport travels for other groups of travelers as well. The findings suggest that more personal assistance, better driving behavior, and

swift maintenance of elevators and escalators could facilitate traveling for vulnerable older travelers.

### 4.3 Study III

*Travel behavior change in older travelers: understanding critical reactions to incidents encountered in public transport*

The purpose of Study III was to examine the process of travel behavior change and to improve our theoretical understanding of it. Via in-depth interviews, critical reactions to critical incidents encountered throughout the trip were assessed. Reports of cognitive, emotional, and/or behavioral reactions were identified. These reactions to critical incidents may help explain how and why long-term travel behavior is affected.

A scientific basis in cognitive and behavioral theory was proposed. The psychological process of travel behavior change was studied and a conceptual framework modeled. In the simplified model, this process consists of triggering events in the environment, perceived by the traveler as critical incidents, interpreted and followed by critical reactions. The retention of the critical incidents will affect the perceived functional ability, the motivation to travel, and actual travel behavior. Five critical reaction themes were identified as having resulted in changed travel behavior according to the interviewees themselves: (1) firm restrictions, (2) unpredictability, (3) unfair treatment, (4) complicated trips, and (5) earlier adverse experiences.

Key findings of Study III were that a predictable travel environment in which the traveler perceives a high level of control is essential for travel behavior. The findings suggest that to improve older travelers' access to public transport, service must be designed in a way that strengthens the travelers' sense of control throughout the journey. Personal service might increase predictability in the travel chain and decrease travel complexity. The findings indicate that not only is "formal" accessibility (such as elevators installed) important for motivation and the perceived ability to travel, but also beliefs and expectations as travel behavior is based on both "rational" behavior and impulsive or emotional factors. One suggestion is therefore that policy makers should be aware of the underlying psychological factors that can shape travelers' behaviors, to be able to

design travel environments that increase travelers' *perceived* ability without requiring excessive effort. Other results of Study III are the identified critical-reaction themes. These themes offer a pattern explaining how critical incidents are perceived and why they might result in changed travel behavior.

## 4.4 Study IV

### *Two models of accessibility to railway traveling for vulnerable, elderly persons*

In Study I, a conceptual model and a mathematical model of whole-trip accessibility were developed. In Study IV, the two models are developed in more detail and extended as well. According to the conceptual model, a person's functional limitation, which is inherent in the person, will to some extent determine the barriers encountered by the traveler and how travel behavior might be affected, but reducing the barrier or changing the travel behavior will not affect the functional limitation. By replacing functional limitation with the functional ability concept, accessibility can be modeled as a three-way reciprocal relationship; vulnerable travelers' functional ability can then be improved by reducing barriers in the travel chain, allowing for more independent travel behavior. More specifically, in the mathematical model, accessibility can be modeled by applying travelers' individual weightings of sets of barriers. An individual traveler's overall accessibility measure for a journey is constructed from the weight of each barrier and the probabilities of encountering the different barriers when traveling to a certain destination (i.e., travel behavior). The weight (or severity) of a barrier therefore depends on the perceived effort needed when facing it. If more effort is required to deal with a specific barrier, the functional ability needs to be higher than if less effort is needed. A main conclusion is that customized actions must be taken to improve accessibility for everyone, especially for vulnerable travelers.

## 5. General discussion

In this section, I will reiterate the overall goals of the thesis, namely to develop a conceptual model of overall accessibility in public transport for older persons, built on an empirically grounded understanding of the main variables proposed to underlie overall accessibility. This will be accomplished by merging the results of the four studies into a single model, in that way framing the concept of the overall accessibility of public transport within a person–environment perspective. This is followed by methodological and theoretical reflections on and discussion of practical implications. The section will conclude with a consideration of future research possibilities.

### 5.1 Older people’s perceptions of the accessibility of public transport

A first prerequisite for studying overall accessibility in this thesis was to identify the concepts to be used and to find out whether and how they are interlinked (Research Question 1). The key variables were identified in Study I and the model was further developed in Study IV. In Study I, the variables in the conceptual accessibility model were quantified. A majority of the respondents (59%) in Study I considered the measured railway accessibility to be “very good” or “fairly good.” For 10% of respondents, however, such accessibility was “very bad” or “rather bad.” Therefore, the participants selected for Studies II and III, were those expected to have encountered barriers in traveling, while being habitual travelers. This group was studied in detail regarding what problems older vulnerable travelers encountered and *why* these problems were perceived to be serious. All participants, therefore, reported functional limitations and/or reduced functional ability, i.e., “transportation disability.” It is acknowledged that accessibility can form in the interaction between the person (i.e., traveler) and the environment (Jensen et al., 2002). However, in a psychological framework, accessibility for older people in public transport has been underinvestigated. This thesis develops an empirically and theoretically grounded model of the overall accessibility of public transport (Figure 2).

The main focus of the four constituent studies of this thesis is on the three variables: *functional ability*, a concept that includes, but is not limited to, the person variable functional limitation, *barriers/facilitators*, and *travel behavior*.

In Study I, I examined how each of these variables is linked to the measuring variable railway accessibility (Table 1). The results indicate that railway accessibility is at least weakly correlated with each of the three variables. In addition, participants with the functional limitation/disease restricted mobility and/or chronic pain found railway accessibility to be lower than did respondents with other functional limitations.

The conceptual model with the three variables functional ability, barrier and travel behavior is, in this thesis, inspired by Bandura's (1978) reciprocal determinism of a self-system in which the person, environment, and behavior are determinants of each other and thus explain how behavior is regulated. In Lawton and Nahemow's ecological model (Lawton & Nahemow, 1973; Wahl et al., 2012), a balance is reached if the environmental pressure declines or the person's ability increases. In this thesis, building on these two models, the reciprocal view of the variables underlying overall accessibility means that all three variables constitute both starting points and outcomes. Travel behavior can result from functional ability and barriers/facilitators encountered, but can also constitute a starting point because different travel behaviors will result in different barriers/facilitators. Likewise, functional ability will be a starting point but will also be affected by the travel behavior, for example because of training opportunities, and functional ability can be affected by the barriers encountered. Thus, if the important barriers are removed, functional ability will increase. Together, the variables form the theoretical basis of the concept of overall accessibility. To understand accessibility, knowledge of the characteristics of both the person and the environment, in interaction, is therefore necessary.

In this thesis, the travelers' identification of characteristics of the environment that are assessed as barriers in Study I and operationalized as critical incidents in Studies II and III, is combined with the identification of features of the travelers' experiences, such as cognitions and emotions. A model is proposed in which accessibility emerges from the person–environment interaction (Figure 2). This is in agreement with Jensen et al. (2002), who suggest that accessibility is based on the relationships between functional limitations and the travel environment. The model in Figure 2 contains three spheres, that is, a person sphere, an environment sphere and a person–environment interaction sphere. The model provides a perspective according to which accessibility is based on a combination of travelers' past *experiences* in the travel environment and future *expectations* of travel situations.

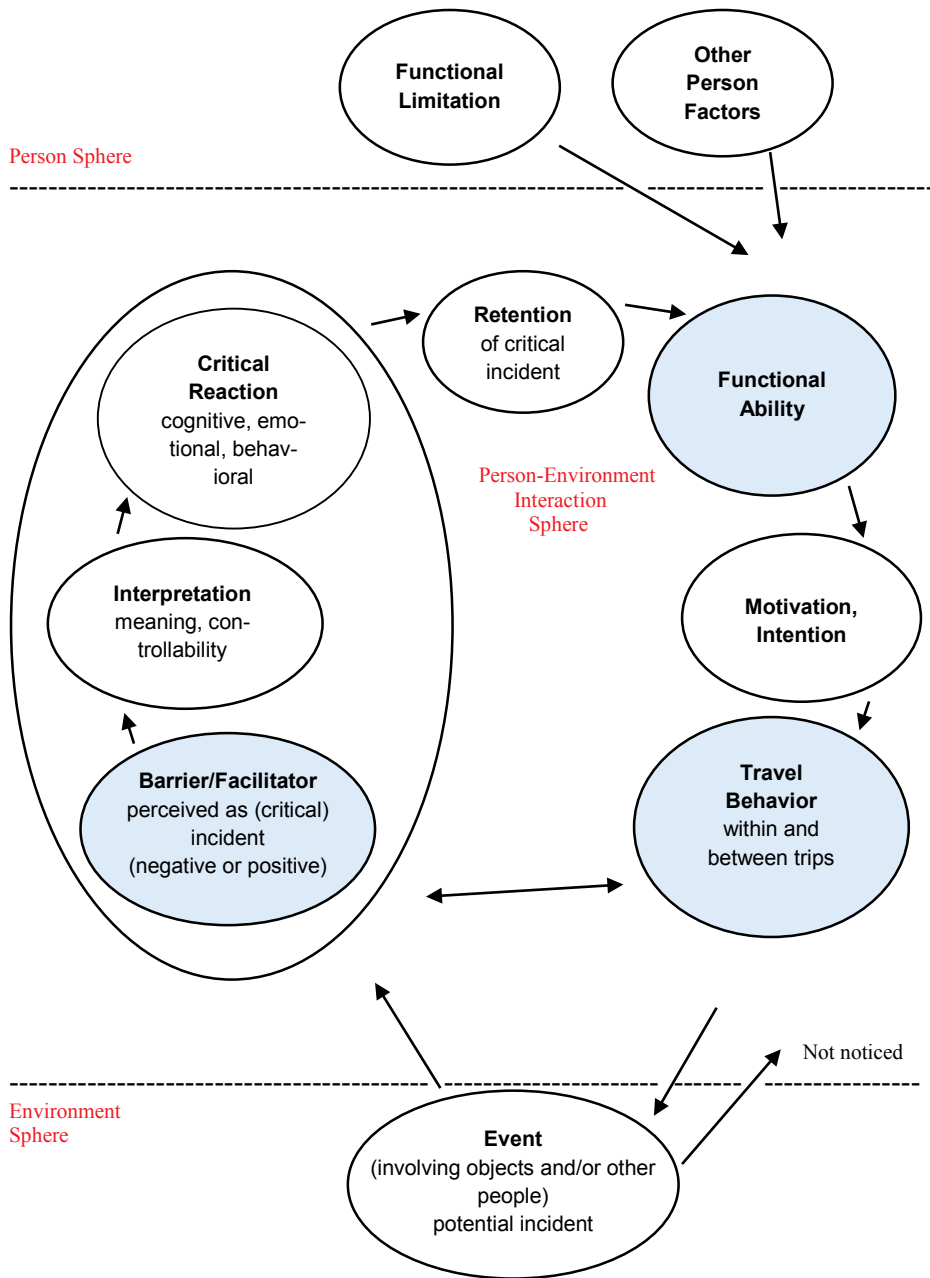


Figure 2: A cognitive and behavioral framework for person-environment interactions. This extended accessibility model constitutes a one-directional model of travel behavior change combined with a reciprocal overall accessibility model (Figure 1).

### 5.1.1 Functional limitations and functional ability

A functional limitation is viewed, in this thesis, as a relatively stable person factor inherent in the individual, and thus does not depend on environmental factors. It belongs to the person sphere. In this thesis, a functional limitation is a self-reported limitation or disease, defined as a limitation of inherent existing physical, psychological/behavioral and/or intellectual function. In the random sample of older people (Study I), vision impairment and hearing impairment were found to be the most common functional limitations (from a list of 15 functional limitations/diseases).

Functional ability is defined, in this thesis, as the perceived level of functioning, manifested in person–environment interaction; compare this with the concept of disability defined as reflecting “the interaction between features of a person’s body and features of the society in which he or she lives”; WHO (2016). For different people, the same functional limitation may result in different degrees of functional ability and different (travel) behaviors (Figures 1 and 2). In Studies I, II, and III, people with the same functional limitation, for example restricted mobility, scale their functional ability over the full range of the response scale extending from “not reduced,” to “extremely reduced.” In Study I, some functional limitations/diseases were more often than others reported to cause serious reductions in functional ability. Respondents with restricted mobility or chronic pain reported that they had reduced functional ability to a higher extent than, for example, respondents with impaired vision or hearing. Even for the same person, the same functional limitation may result in different degrees of ability and different behaviors, for example, through learning to handle the barriers encountered (i.e., increasing ability) or seeking different environments that involve different barriers. Functional ability can be viewed as a general ability not tied to the travel environment (e.g., as asked in the questionnaire in Study I), but operationalized more specifically in specific travel situations because it typically emerges in the interplay with specific environmental situations.

Notably, according to the conceptual model of overall accessibility (Figure 1), a functional limitation can affect functional ability, but the reverse is not possible: functional ability cannot affect functional limitation. Impaired vision will still be impaired regardless of the person’s ability. In the longer term, functional ability can have a certain impact on functional limitation(s). For example, a low physical ability (e.g., serious balance problems) may heighten the risk of



falling, thus establishing a functional limitation. The “young-old” do differ from the “old-old” in terms of functional limitations. Study I demonstrated that the older participants were more likely to have more than one functional limitation than were younger participants and that functional ability declines with the increasing number of concurrent functional limitations.

### 5.1.2 Functional limitations and barriers

The functional limitation partly determines what traveling barriers are encountered on a specific trip. In Study I, the barrier “difficulty moving around onboard long-distance train” was most strongly associated with two functional limitations, neurological disease and restricted mobility; note, however that these subgroups were small, so the finding should be cautiously interpreted. However, Study II and III reveal in more detail how such barriers affect travelers. For example, “difficulty reaching the exit of a moving bus” may induce fear of falling, in a person with restricted mobility. Here, it is suggested that driving style is a key to reducing such barriers:

“I thought I would fall. It is done so easily. If you’re not young like my grandchildren who can jump from the balcony without consequences. Bus drivers are stressed, there is not enough time. Most often, they are sympathetic, but when there are lots of passengers, there might not be enough time for them to think of it.”

Because this thesis treats events as properties of the environment, these are regarded as independent of travelers, for example, “a person occupying the priority seat,” or “sudden breaking.” The environment along the entire travel chain here constitutes the travel environment, from start to finish, including the local residential neighborhood. If events are encountered, they may constitute barriers or facilitators for a particular traveler. Study II demonstrated that the events most often experienced as barriers and/or facilitators are those happening in the physical environment at stations/stops or onboard vehicles. This applies to any incidents, including *critical* incidents resulting in changed travel behavior.

### 5.1.3 Functional limitations and travel behavior

According to the conceptual model (Figure 1), functional limitations may affect travel behavior. In Study I, restricted mobility had the highest (negative) correlation with travel frequency ( $r = -0.14, p < .01$ ). Also, attention/memory/concentration were negatively correlated with travel frequency ( $r = -0.12, p = .01$ ). Similarly, vision impairment was negatively correlated with travel frequency ( $r = -0.13, p = .05$ ). All these associations were low but in line with the results of Davidsson (2001), who reported that people with restricted mobility and vision impairment tend to travel less frequently than others.

### 5.1.4 Functional ability and barrier/facilitator

Between the two person and environment spheres (Figure 2), *person–environment interaction* takes place. The variable functional ability constitutes part of the reciprocal model of overall accessibility. Functional ability can be altered by changes taking place in the environment sphere. However, a person's functional ability may itself change the environment and, in turn, also what is perceived to constitute barriers and facilitators. If events are changed such that new information is introduced, a barrier reduction may be perceived, resulting in increased perceived functional ability for the person involved. The reverse will also apply: A person with low functional ability may receive extra help from staff or fellow passengers; the traveling environment will thereby be altered *because* of the low functional ability. Notably, the barrier can be viewed as both an item (e.g., non-functioning elevator) and a quantity (e.g., the price level of tickets). Barriers can therefore be removed or reduced. In Study II, ticket prices were found to exemplify both facilitators and barriers, as reported by interviewees. Although functional ability is regarded as a feature emerging from the person–environment interaction, it is grounded in person factors such as functional limitations, physical characteristics, and intra- and inter-psychological factors, such as personality, self-perception, and attitudes toward others. Functional ability can also depend on age, gender, and socioeconomic factors (Crawford, Jackson, & Godbey, 1991). Moreover, travelers' geographical locations in relation to available public transport can also influence their ability to travel. Because functional ability cannot exist theoretically other than in coexistence with

the environment, it is a variable created situationally and dependent on complex structures in the person and in the environment in interaction.

Ticket prices were perceived to be important barriers to traveling more often. This was found in both Studies I and II, while a desire for more convenient tickets purchasing was more commonly expressed in the questionnaire study (Study I) than in Study II. In Study II, physical obstacles were the most frequently reported critical incidents, perhaps because the respondent group had more functional limitations and lower ability than did the group in Study I. The most important barriers were found to differ between persons with high and low functional ability (Study I). Whereas people with high functional ability regarded time keeping as important, those with low functional ability regarded their own health as important (from a list of 30 potential barriers/facilitators to long-distance train traveling, Table 4). Likewise, time keeping was regarded as more important in the questionnaire study (Study I) than in Study II, in which all participants had some kind of functional limitation or some reduction in functional ability. Notably, earlier research has demonstrated that, for older people, travel costs are often more important than travel time (Su & Bell, 2009). This relationship is supported by the interviewees' reports. Some of the interviewees also conclude that they, as retirees, have few appointments to keep, so delays are not regarded to be as serious as when they had been working; however, as retirees, private finances may be more strained than they were earlier. Whereas costs were perceived as an important barrier to people regardless of their functional ability, one's own health was the most common perceived barrier to travel for people with low functional ability (Study I). Attributing barriers to one's own health (functional limitation/disease = person sphere) could be reflected on and understood from an environment–sphere perspective. In examining critical reactions to barriers and facilitators encountered (Study III), attributions to health or to other person factors were identified. For example, when encountering electronic devices that they did not know how to handle, some interviewees attributed this barrier partly to themselves, because they “should have been able to learn.” Because of deteriorating health, they also felt more fragile than in their earlier years and had to adapt their traveling accordingly.

Although I found no gender differences regarding the number of concurrent functional limitations or levels of functional ability (Study I), women may be more vulnerable than men to public transport inaccessibility. This is because women are less likely to possess a driver's license than are men and women also

report more unfulfilled travel needs than do men (Siren & Hakamies-Blomqvist, 2006).

### 5.1.5 Functional ability and travel behavior

According to the conceptual accessibility model (Figure 2), both experiences and expectations are important for overall accessibility. The way earlier barriers/facilitators have been experienced and handled will affect travelers' perceived functional ability, which in turn may affect travel behavior. For example, the critical reaction theme "earlier adverse experiences," can be interpreted as indicating the importance of perceived functional ability. In "earlier adverse experience", functional ability is perceived to be too low for a specific situation. As one of the interviewees said, "Nowadays, I can't run away from anyone, I have a cardiac dysrhythmia so I wouldn't dare run...I have to be careful." The interviewees choose ways of traveling aligned with their perceived ability to handle similar situations. For example, they choose not to travel alone or not to travel late in the evening because of their perceived fragility, even though the feared situation might not occur. Not only the barriers per se, but also emotions and attitudes, may therefore be important factors influencing travel behavior decisions. In addition, imagined barriers may result in problems using public transport (Rosenkvist, Risser, Iwarsson, & Ståhl, 2010).

Study I finds positive correlation coefficients between functional ability and travel behavior. People with high functional ability travel more often than do people with low functional ability. According to the conceptual model (Figure 2), a functional ability perceived to be low in a particular travel situation will be accompanied by a low motivation to travel in the same way. In Study III, five themes were identified that tended to lead to changing one's way of traveling: (1) firm restrictions, (2) unpredictability, (3) unfair treatment, (4) complicated trips, and (5) earlier adverse experiences.

### 5.1.6 Barriers/facilitators and travel behavior

According to the conceptual accessibility model (Figure 1), the barriers or facilitators encountered may influence travel behavior. In Study II, more barriers (i.e., negative critical incidents) than facilitators were reported. This may reflect the interviewees' actual experiences of public transport: this may also indicate

that they were directed towards negative associations by the word “incidents,” used in the instructions given during the interview. Another possible reason is the general tendency for negative events to elicit stronger and more lasting reactions than positive events (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). Moreover, it can be hypothesized that the frequency of incidents could be one reason why some incidents are perceived to be serious enough to affect travel behavior. Earlier, Friman, Edvardsson, and Gärling (2001) demonstrated that overall satisfaction with public transport services is inversely related to the frequency of remembered critical incidents.

In Study II, the physical environment both on board vehicles and at stations/stops was found to be especially critical in the travel chain; constituting the most frequently reported categories. These incidents typically restrict travel behavior because of a perceived low functional ability in the travel situation, for example, being afraid of falling on an escalator. However, travel behavior is not affected only by functional ability but also for example, by individual determination. In Study III, the theme “unfair treatment” contains examples of barriers relating to the relationship with the transport provider, resulting in an unwillingness to travel because of feeling badly treated. When accompanied by internal attributions of the barrier, the ability to overcome the barrier is perceived to be lowered as well.

In Study I, there was a tendency for frequent train travelers to mention “lower ticket prices” and “increased convenience of buying tickets for the whole trip” as important reasons for traveling more often by long-distance train. By contrast, those who traveled more infrequently, reported their own health and security factors (e.g., not having to be afraid of harassment) to be most important. However, high ticket prices were also important to these people, as barriers to traveling more often by long-distance train. The same barriers were also reported in Studies II and III. However, some of the interviewees did not regard ticket price as too high and as therefore constituting a barrier; instead, they regarded ticket prices as low, constituting a facilitator of traveling.

By choosing a specific travel behavior, for example taking the bus instead of the train, some barriers are more likely to be encountered than others. To a certain extent, we “choose” the specific barriers encountered during a trip. Frequent traveling helps the traveler overcome certain existing barriers in the travel environment by exploiting “training” opportunities. For example, more frequent traveling would improve the traveler’s ability to find her way to the designated

platform at the railway station. Also, travel behavior can change the travel environment itself, for example a fellow passenger offers his seat to an older passenger with a walker.

The conceptual model described above suggests that if events in the environment are encountered, for example, due to certain chosen travel behavior, these events may be perceived as barriers/facilitators (in the person–environment sphere). Some degree of dissonance will result, which could increase with the severity of the barriers and decrease with the degree of functional ability, in situations along the travel chain. I call the resulting factor *overall accessibility*.

1. *Increasing the level of accessibility*: The traveler may find it easier than previously to travel a specific route (i.e., travel behavior) because the traveler has gained a higher functional ability in the travel situations encountered along the specific travel chain, or because the barriers have been decreased.
2. *Decreasing the level of accessibility*: The traveler may find it more difficult than previously to travel a specific route, because the traveler has acquired a reduced functional ability in the travel situations encountered along the specific travel chain, or because the barriers have been increased.

Studies II and III were designed to examine the association between barriers/facilitators and travel behavior at a more detailed level than was possible in Study I. The questions addressed in Study II concerned *what* barriers/facilitators are important, while those addressed in Study III concerned *why* they are important. The goal in Study II was to identify the barriers/facilitators encountered, especially the barriers assessed as critical incidents, important enough to change travel behavior. These goals are covered by Research Question 2. Most reported critical incidents reported are negative and most of them were encountered in the physical environment at stations or on board vehicles.

Study III was, like Study II, designed to answer Research Question 2, which concerns the link between barriers/facilitators and travel behavior, specifically, why specific critical incidents resulted in changed travel behavior and how this process should be understood. The reasons for changing one's travel behavior after having encountered a negative critical incident are classified into five themes: firm restrictions, unpredictability, unfair treatment, complicated trips, and earlier adverse experiences. Insecurity because of unpredictability was

found to result in reduced travel confidence, leading to avoidance of traveling, according to the travelers themselves.

In this thesis, the general conceptual framework of the process of *travel-behavior change* is grounded in environmental as well as in individual psychological factors. The starting points are cognitive and behavioral theories, including social-cognitive theory (Bandura, 1978, 1997, 2001). The framework consists of a “travel-behavior circle” in which events in the form of barriers or facilitators and perceived as critical incidents are interpreted in such a way that a critical reaction follows. The retention of the incident in turn affects the person’s perceived functional ability, motivation to travel, and actual travel behavior.

Study IV was designed to develop the conceptual and mathematical models presented in Study I and, thus, to provide an integrated model of overall accessibility for use in theory building and measurement (Research Question 3). Accessibility can be measured with the aid of individual weightings of barriers. In the mathematical model, barriers can assume different perceptual values for different travelers. For each traveler, the severity or weight of a barrier depends on the perceived effort needed to overcome. This perceived effort corresponds to functional ability in the conceptual model, shown in Figure 1. Perceived effort is used to measure functional ability in the context of a specific travel situation. Moreover, the probability of encountering a specific barrier differs depending on fixed factors in travel modes, for example, stairs, as well as dynamic factors in the travel environment that are unpredictable for traveler and transport providers, for example, an elevator suddenly out of order. For every trip, the probability of encountering a specific barrier, influences the perceived accessibility.

Whether viewed empirically or conceptually, overall accessibility in public transport, can be summarized as follows:

1. Overall accessibility is modeled from functional ability (including functional limitations), barriers/facilitators, and travel behavior (Figures 1 and 2).
2. By removing important barriers, functional ability can be improved.
3. Improved functional ability can result in more independent travel behaviors and improved overall accessibility.
4. Accessibility can be measured by the effort needed, by adding the traveler’s individual weightings of barriers in specific travel situations (Study 4).

## 5.2 Methodological reflections and contributions

In the four constituent studies of this thesis, I have used various research methods. I will reflect on the methodological insights that can be gained from this work.

First, the thesis offers a definition of accessibility in traveling. For the heterogeneous group of older adults in combination with the diversity of travel modes, accessibility has so far been underresearched. The present thesis considers the possibility that accessibility varies depending on people's functional abilities (including functional limitations), their travel behaviors, and the barriers/facilitators they encounter on their trips. The thesis also takes account of the whole journey, since it must function smoothly from start to finish in order to be accessible. Moreover, the thesis considers that not only the journey per se but also the expectations of it are important for how accessible a journey is perceived to be—that is, both experiences and expectations are considered. Because of the heterogeneity of the group of older adults, the individual or small group must be explored, otherwise, average results may hide important individual differences. Study I was therefore designed to identify subsamples within the total random sample and to find prevalence with regard to the variables examined.

Studies II and III focus on a small sample of “accessibility expert” interviewees. Detailed individual experiences and expectations could be identified by taking account of cognitive and emotional characteristics using the participants' own words. The Critical Incident Technique (CIT; Flanagan, 1954) is explorative and therefore particularly useful when knowledge is lacking. CIT can provide the groundwork for theory development. It has often been used in appraising system performance from the consumer's perspective (Kolbe & Burnett, 1991). The CIT procedure is defined specifically for collecting events and human behaviors for categorizing them to make them useful for addressing practical problems (Bitner et al., 1990). A reason for choosing the CIT in this research was that it can capture a broad range of experiences without influencing the participants' thoughts in a certain direction (cf. Flanagan, 1954). Moreover, the data are collected directly from the interviewees using their own words. CIT can therefore facilitate insights into participants' decision processes because it uses and builds on their actual experiences (cf. Edvardsson, 1998). CIT can also identify rare events that might be missed by other methods. In this thesis, CIT



emphasizes characteristics of the public transport system that may be particularly decisive. Content analysis of interview data is used. The contents of the participants' stories were treated as factual and the free responses were assembled into a framework by means of ad hoc categorization (Bitner et al., 1990; Gremler, 2004; Hopkinson & Hogarth-Scott, 2001). I used a conventional approach to content analysis in that the categories are derived from the data instead of from existing theory or prior research. In this way, it is possible to gain a richer understanding of the data (cf. Hsieh & Shannon, 2005). Also, the reasons for changing one's travel behavior were described in 21 categories. These categories were identified in order to pinpoint where along the travel chain and in what travel environments the incidents were encountered. The dimensions of categories identified are intended to be usable, by transport providers and by researchers.

### 5.2.1 Validity and reliability of methods

The critical incidents (Studies II and III) are identified for different people on different transport modes and on different trips. This could be one reason why the same kind of incident can be negative for one interviewee but positive for another. For example, ticket prices are viewed as either a barrier or as a facilitator. This may be due to individual differences, for example, regarding financial situation, or to different journeys, as the barriers reported refer to different distances and travel modes. In the County of Stockholm, where all participants lived, public transport includes different travel modes. Compared with other, less densely populated areas in Sweden, public transport is well developed: the nearest stop or station is closer and the frequency of service is higher than in many other areas. The problems for older adults, who do not own a car may therefore be more pronounced in other parts of the country.

### 5.2.2 Sample representativeness

In the general population, active people tend to participate more frequently in questionnaire studies, which should call into question representativeness of the results of the four studies presented here. In Study I, many of those who did not want to participate specified the reason as "do not travel by train," implying that

they were supposedly not of interest to the study. Also, a possible self-selection bias may exist because of the paper-and-pen form of the questionnaire. People with difficulties in the Swedish language might be underrepresented, as well as those with severely reduced functional ability, for example, in terms of functional limitations such as vision or cognitive impairment.

In the random sample of Study I, most of the respondents reported “no reduction” in functional ability, so the subgroups with more severe problems were small, especially if divided further according to different kinds of functional limitations. This is a disadvantage in people-based as opposed to place-based accessibility research; although the former allows for more sensitive assessment of individual variations than does place-based research, it entails difficulties gathering detailed individual data from other than small regions or subsets of populations, so results are difficult to aggregate to whole populations (Geurs & van Wee, 2004). Moreover, the correlation coefficients are generally low, meaning that the results may be vague. As in all cross-sectional research, causal inferences may not be appropriate and no test-retest was possible. Regarding gender representativeness in Study I, the gender split of respondents agrees with that of the population of Stockholm County (Statistics Sweden, 2012).

In Studies II and III, the reason for obtaining the large majority of negative incidents might be that negative events tend to have more impact than positive ones, for example mobilizing reactions to a greater degree (cf. Edvardsson & Roos, 2001; Friman et al., 2001). Moreover, it should be pointed out that, aside from complete cessation of travel by public transport, travel behavior change for some is possible only if alternative travel modes are available. Some interviewees were dissatisfied with the public transport service, but reported having no choice. A few of them could travel by private car and others by special transit service.

When asking retrospectively about events, memory biases might come into play (Kahneman, 2003). A time period of two years was used in Studies II and III so both recent incidents and those more distant in time are included in the same data set. More recent incidents should be easier to recall, although a minor incident might also grow in memory, affecting long-term behavior. Moreover, since the memory-retrieval system is variable, evaluations can also vary between situations and points in time (Hastie, 2001). Older adults have been found to have positively biased autobiographic recall (Kennedy, Mather, & Carstensen, 2004) suggesting that there could have been even more of negative critical incidents (currently 67 out of 77) if they had been reported contemporaneously with their occurrence. It could be argued that memory and decision making

should be separated; for current travel behavior decisions, what actually happened is not necessarily most important, because travel behavior may be decided based on what is remembered. For actions taken, however, the barriers prioritized should be those deemed most important when they were actually encountered.

### 5.3 Theoretical reflections

This thesis delivers empirical results that support the conceptual models presented in Figure 1, although model B needs further testing. Overall, the general pattern of the present findings strengthens previous knowledge of older persons' experiences of the transport system. With its mixed-method design, the qualitative method helped in interpreting the quantitative results, whereas the quantitative method helped in quantifying the qualitative results for a representative sample of the population. The barriers identified in Study I were further explored in the qualitative interviews of Studies II and III. Examples of such barriers were those relating to security concerns.

As the weakest part of the travel chain largely determines the accessibility level of the whole trip (Studies I–III), a whole-trip perspective, rather than a focus on selected parts of a trip, is useful for identifying the parts of a trip decisive for accessibility. Moreover, in travelers' minds, several whole trips are bound together with earlier experiences and future expectations of trips (Figure 2) becoming determinants of travel behavior. For these reasons, it is important to research the individual traveler's own point of view.

Groups are often segmented according to background variables, such as functional limitations. Although people with similar functional limitations may encounter the same kinds of barriers, functional limitations are not solely decisive for what will be perceived as barriers. If a barrier is encountered, the traveler's reactions may be expected to differ, for example, because of personality variables. In certain cases, the "universal-design" approach increases accessibility even for those not in the target groups, for example in the case of doors that open automatically or "kneeling" buses (Jensen et al., 2002). Psychological equivalents to universal design may be discovered by studying underlying psychological needs that everybody shares when traveling. Such research should map the *psychological qualities* (independent of specific barriers) that must be

built into the environment, especially so that vulnerable travelers can navigate it more independently. For example, a finding of Study 3 is that one reason for travel-behavior change is not knowing what to expect. Moreover, being treated with respect, being able to take uncomplicated trips without many small problems, and feeling secure, were common psychological needs. If an expected travel scenario is perceived to exceed one's ability, traveling may be experienced as impossible even though the feared alternative might not be realized (cf. Risser, Leksell, Bell, Iwarsson, & Ståhl, 2015). For some interviewees, ticket prices were perceived as barriers. However, while some regarded ticket prices as "unfair" because they varied depending on for example, the time remaining until departure, others perceived ticket prices as simply too expensive and therefore out of reach. Lower ticket prices would therefore reduce the barrier for the latter group, but not for the former. For certain barriers to be reduced, the (potential) travelers' interpretations and subsequent reactions must be known.

The findings of this thesis suggest that two concepts, here called formal accessibility (cf. absolute accessibility, Church & Marston, 2003) and actual accessibility, should be distinguished. For example, even if an elevator is installed (formal accessibility), it will not be accessible if it is broken (actual accessibility). Moreover, a distinction can be made between the two concepts physical accessibility (Fänge, Iwarsson, & Persson, 2002) and psychological accessibility: Too high a step into a bus would give rise to a physical inaccessibility, whereas difficulty urging a bus driver to use the ramp during rush hours would constitute psychological inaccessibility. The latter would also be an example of formal but not actual inaccessibility.

## 5.4 Practical implications

Encountering negative critical incidents when using public transport may not only reduce actual travel possibilities, but also travel confidence and result in avoidance of travel (Farquhar, 1995; Gabriel & Bowling, 2004; Su & Bell, 2009). Mobility can reduce the risk of social exclusion, in turn increasing well-being (Stanley, Hensher, Stanley, & Vella-Brodric, 2011). Therefore, it is important that actions taken in public transport systems should increase vulnerable travelers' motivation to travel by public transport and participate in society.

This may be accomplished by increasing the sense of security and of control in the travel environment.

This thesis has practical implications for both managers and service design. Accessibility is complex, and no single research method can capture the whole phenomenon and provide all the answers. Therefore, combining methods is necessary and the various entities, responsible for the different parts of a journey need to be coordinated. The present thesis illustrates how accessibility depends on the weakest part of the travel chain, so the whole-trip perspective is utilized. The thesis also demonstrates that accessibility depends on both experiences and expectations.

The universal design approach can help improve accessibility for all passengers, not only those who are vulnerable (Carr, Weir, Azar, & Azar, 2013). However, it is not always possible to find solutions that suit everyone. What is perceived as a barrier by some people may be perceived as a facilitator by others. For example, in Studies II and III, opinions were divided regarding variable versus fixed ticket prices. In some cases it is necessary to set accessibility standards designed for the needs of specific target groups by using specific indicators of fixed distance, cost, or scheduling. For example, a service should not be located more than  $x$  meters from a particular group of households (Envall, 2007). In some cases these groups are obvious, but at other times, there might be difficulties identifying the target groups with the greatest needs, and deciding whether they should be identified based on predefined characteristics, such as socio-demographic factors, or whether other instruments should be used. Anable (2005) has proposed segmentation on the basis of attitudes.

Successful ageing has been linked to the feeling of being in control (Golant, 2011). Barriers relating to insecurity, identified here, can be reduced by preventive strategies that make aversive outcomes in the environment less probable, reducing travelers' "catastrophizing" about uncontrollable outcomes (Abramson, Seligman, & Teasdale, 1978). For example, when needed, available staff can compensate for shortfalls in one's own internal control and ability to handle everything oneself. Staff can be viewed as a "universal service" with "inbuilt flexibility" (cf. universal design). Therefore, a high degree of internal control may not be necessary for a sense of ability; in fact, if external help can be depended on, it might sometimes be an even better alternative than learning to manage everything by oneself. The possibility of getting in touch with staff if something unexpected happens could strengthen predictability and increase the feeling of security. One such example is the availability of "help telephones" for use if one is stranded on a platform in the underground because the elevator

does not function. The findings presented here suggest that service should be designed in a way that increases predictability throughout the trip. More personal assistance, better driving behavior, and swift maintenance of elevators and escalators are facilitators that could improve predictability and older people's feeling of security when traveling. The transport system should be designed, not only with a view of functionality but also to how it is experienced, both cognitively and emotionally.

With an increasing proportion of older people in the population and with functional limitations becoming more common with age, the challenges facing future transport systems are likely to increase. If public-transport environments are improved to meet the needs of people with various functional limitations and levels of functional ability, other groups might benefit as well. There would be much to gain, as much of what is needed to improve accessibility for vulnerable travelers favors other travelers as well. Such improvements might well divert more travelers from excessive car use to more environmentally sustainable travel by public transport.

## 5.5 Future research

This thesis provides an empirically and theoretically grounded understanding of accessibility for older people in the public-transport system. However, the conceptual model developed here is explorative and needs further testing in order to be confirmed. This should be accomplished parallel to further refining and testing of the questionnaire, with the help of the results from Studies I–IV. A shorter, more streamlined version of the questionnaire should be developed, omitting more peripheral questions and formulating the remaining questions more uniformly. Such a questionnaire could then be used for screening travelers and potential travelers as a first step in selecting samples for overall accessibility assessment. These selected target groups could then assess specific travel scenarios. The categories identified in Study II could be used to select barriers for examination. The responses could be used in weighting various barriers given specific routes and probabilities of encountering them according to the mathematical model described in Study IV. The streamlined questionnaire could be used to test different solutions for improving the psychological quali-

ties found to be important in Study III, for example, predictability. Such research could result in improved knowledge of how to measure accessibility in public transport, creating a measurement system adapted to different kinds of vulnerability when traveling and giving rise proposals for improving accessibility where it is most needed.

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