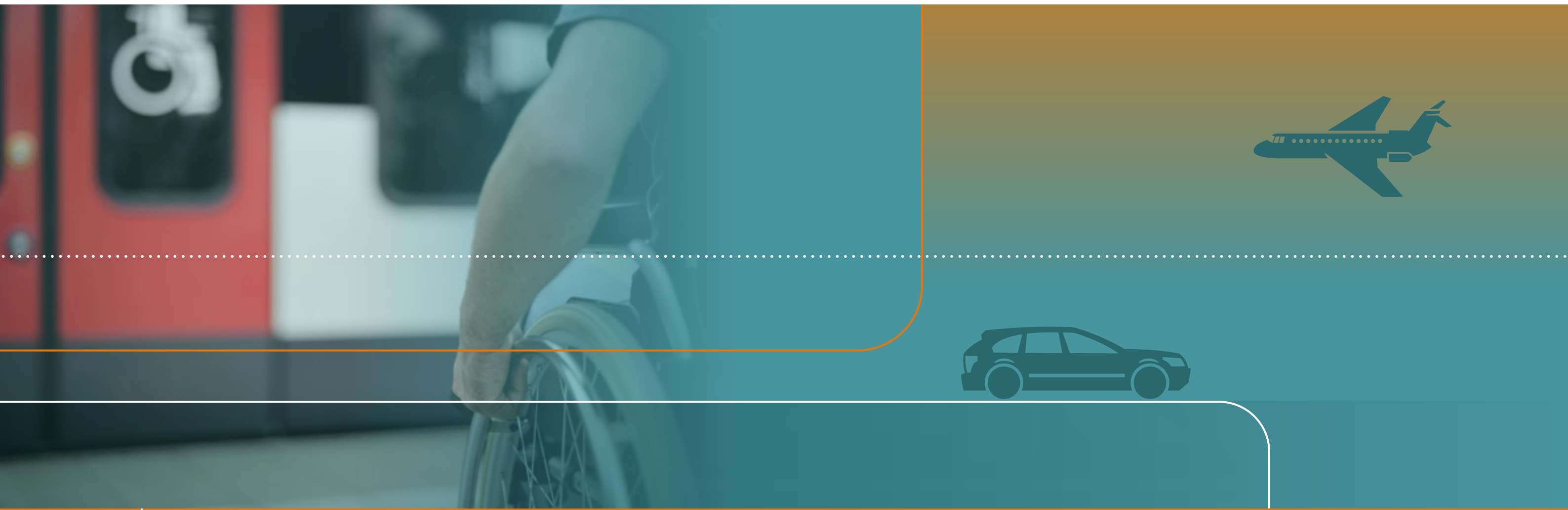
Institute of Transport Economics
Norwegian Centre for Transport Research



Universal design in transport

Editors: Nils Fearnley and Kjersti Visnes Øksenholt

Preface

The current literature on universal design has so far failed to fully address the challenges faced by transport agencies, and when the planners lack holistic knowledge, the solutions that are developed will not meet the required standard.

The aim of this collection of articles is to contribute to increased overall knowledge about what universal design and accessibility for all entails, and also the principles of how accessibility for all can be achieved in a transport context in terms of the planning process and physical solutions. In this way, the articles will contribute to the realisation of universal design, and thus promote a better quality of life and equality for people with disabilities.

The collection of articles is a topical reference work on universal design for various study programmes, fields of study and postgraduate courses in the higher education sector, and for transport agencies and planning authorities.

We would like to extend a big thank you to Liv Øvstedal and Stein Brembu at the Norwegian Public Roads Administration, who initiated and partly funded the articles, and to the Norwegian Directorate for Children, Youth and Family Affairs (Bufdir) who partly funded the collection through their grant scheme 'Universal design – knowledge development, skills development and information'. A big thank you also to Tanu Priya Uteng from the Institute of Transport Economics (TØI) who took on the role of substitute editor for the first article in the collection, which was written by the editors. And thank you very much to Hanne Sparre-Enger from the TØI's Department of Communication, who edited the texts and led the work on layout and design.

Finally, we would like to thank the anonymous reviewers who have peer reviewed all the contributions. The authors and editors agree that their close reading and thorough feedback have greatly improved the articles.

Published by:
NEHF – Norwegian Society of Ergonomics and Human Factors
www.ergonom.no

ISBN 978-82-995747-8-5 E-bok (PDF)

Original title: Universell utforming i transportsektoren
Translation to English by Akasie språktjenester AS
Design: Melkeveien Designkontor AS

NEHF Norsk forening for ergonomi og human factors
Statens vegvesen
tøi Institute of Transport Economics
Norwegian Centre for Transport Research

A collection of articles: Universal design in the transport sector

The aim of this collection of articles is to contribute to increased knowledge about what universal design and accessibility for all entails, as well as principles of how accessibility for all can be achieved in a transport context in terms of both the planning process and physical solutions. We want the collection to strengthen universal design, and in turn contribute to a better quality of life and equality for people with disabilities.

The collection is comprised of seven articles, where this introductory article is Article 1. All shed light on various aspects of universal design in the transport sector.

Article 2. **'Functional requirements for inclusive transport'**, discusses the functional requirements that transport solutions must satisfy in order to facilitate social inclusion of people with disabilities (Bjerkan, 2022).

Article 3, **'Universal design and barriers to using public transport**, aims to deepen the understanding of how the transport system is perceived by different groups of people, and to understand and foresee challenges, weigh up the various issues, and facilitate good solutions that benefit as many people as possible (Nielsen and Øksenholt, 2022).

Article 4, **'Universal design and public participation in planning processes**', discusses how universal design can be better safeguarded in the planning process. The article aims to deepen the understanding of the complexity of the planning system, and how this can act as a hindrance for good and holistic solutions (Sjøstrøm et al., 2022).

Article 5, **'How can we ensure universal design of trip chains in a system with complex laws, regulations and responsibilities?'**, gives the reader an introduction to the statutory and organisational framework for universal design in the transport sector, with a particular focus on trip chains. The article discusses how to safeguard universal design of the transport system in a context where legislation and accountability are complex, and reforms alter the distribution of responsibility (Øksenholt and Krogstad, 2022).

Article 6, **'Effects of universal design: quality of life, demand and socioeconomic benefit'**, shows how the utility of universal design for passengers can be measured, and thus also used in cost-benefit analysis, which surprisingly often show that universal design measures in public transport are highly efficient, i.e. they improve social welfare because benefits exceed costs (Fearnley, Veisten and Nielsen, 2022).

Article 7, '**Transport solutions of the future: technology, design and innovation**, describes a selection of new and future transport solutions that are of particular relevance in Norway, and discusses these in the context of what we know about the needs of various user groups. The article demonstrates how new transport solutions are multifaceted and affect the various user groups in different ways (Aarhaug, 2022).

Effects of universal design: quality of life, demand and economic benefit

NILS FEARNLEY, KNUT VEISTEN AND ANJA FLETEN NIELSEN

The aim of this article is to deepen the understanding of the various effects that universal design can have, including the utility value of universal design in an economic perspective. Universal design is beneficial for everyone who travels and can enhance their quality of life and increase their participation in society, but it is difficult to identify and measure such gains in a demand analysis. This article explains why. Passenger benefit can, nevertheless, be measured in terms of their willingness to pay, and the article demonstrates how this has been done in recent studies. Once we understand the utility value of universal design measures to passengers, the overall value to society can be calculated relatively easily in a cost-benefit analysis using established tools.

Nils Fearnley

Nils Fearnley is a transport economist and senior researcher at the Institute of Transport Economics' Markets and Governance group. Since 2009, he has been working on universal design and public transport through a number of projects for the Norwegian Public Roads Administration, the Norwegian Directorate for Children, Youth and Family Affairs (Bufdir) and its predecessor, Deltasenteret. Fearnley has a particular focus on demand effects, preferences and socioeconomic analysis in relation to universal design.

Knut Veisten

Knut Veisten is an economist who graduated from the University of Oslo and the former Agricultural University of Norway. As a researcher at the Institute of Transport Economics' Department for Mobility, he has worked on the valuation of public goods, including the valuation of walking/cycling and measures for universal design in public transport.

Anja Fleten Nielsen

Anja Nielsen is a health geographer at the Norwegian University of Science and Technology (NTNU), Trondheim. She has been working in the field of universal design and transport systems for six years, focusing on how people with psychosocial disabilities experience transport systems.

1. Introduction

1.1 Universal design

In this article, we apply a definition of universal design as defined by Øksenholt and Fearnley (2022; Article 1 in this collection of articles) and the Ministry of Children and Equality (2017) Section 17:

> *'Universal design means designing or accommodating the main solution with respect to the physical conditions, including information and communications technology (ICT), such that the general functions of the undertaking can be used by as many people as possible, regardless of disability'[1].*

In universal design, as many people as possible must be able to use the built environment, as it is, regardless of age, disability, size, skills, language, culture, etc. Added elements, such as ramps for wheelchair users, are not considered universal design under this definition because they are not part of the original design of the infrastructure. Such added elements are used if the principal infrastructure design fails to eliminate the need for the ramp. The ramp aids accessibility when the main solution is inadequate but is not classified as a universal design measure.

In transport, universal design is particularly relevant for public transport and walking. Public transport is a common good that should be accessible for everyone, and therefore all passengers have general protection as outlined in, for example, the EU Regulation (EEA, 2011) on the rights of passengers in bus and coach transport, Article 9 Right to transport:

> *'Carriers, travel agents and tour operators shall not refuse to accept a reservation from, to issue or otherwise provide a ticket to, or to take on board, a person on the grounds of disability or of reduced mobility.*
>
> *Reservations and tickets shall be offered to disabled persons and persons with reduced mobility at no additional cost.'*

1 This definition, using 'as many as possible', does not imply that universal design should cater for everyone's needs. For instance, the UN (2007) definition is more comprehensive and includes products, programmes, environments and services, in addition to physical conditions and ICT-related aspects. The UN definition also uses the word 'all' instead of 'as many as possible', and disabilities are only mentioned in the context that 'Universal design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed.'.

Walking is the only type of transport that is entirely free, and it is therefore financially accessible to everyone. This is why the provision of footways and outdoor areas is crucial for participation in society. Furthermore, users of local public transport have lower incomes on average than the rest of the population (Fearnley, 2006; Fearnley and Aarhaug, 2019). Table 4 shows lower incomes and car ownership among people with disabilities. This article will therefore focus on public transport and walking.

There is no precise definition of where the boundary lies between universal design and other quality improvement measures because universal design is about making services accessible to as many people as possible. In doing so, the utility of universal design is not limited to people with disabilities:

'Per definition, universal design benefit 'as many as possible'.

One such example is low-entry buses. Step-free boarding and alighting is necessary for wheelchair users, but it improves quality for everyone. It also expedites the boarding and alighting processes by saving time and reducing delays, which benefits all passengers, including those already on board, as well as the bus company. By the same token, intuitive and easy-to-read information is necessary for some and enhances the quality for all.

1.2 How many people does this apply to?

Data from the Norwegian national travel survey 2018/19 (Grue et al., 2021) shows that around one in ten people have physical impairments that restrict their ability to use different modes of transport or move around outdoors. This proportion is highest among women (13%, compared to 7% for men) and in the older age groups (Figure 1). The most common issue reported is difficulty walking. Three per cent report problems using public transport.

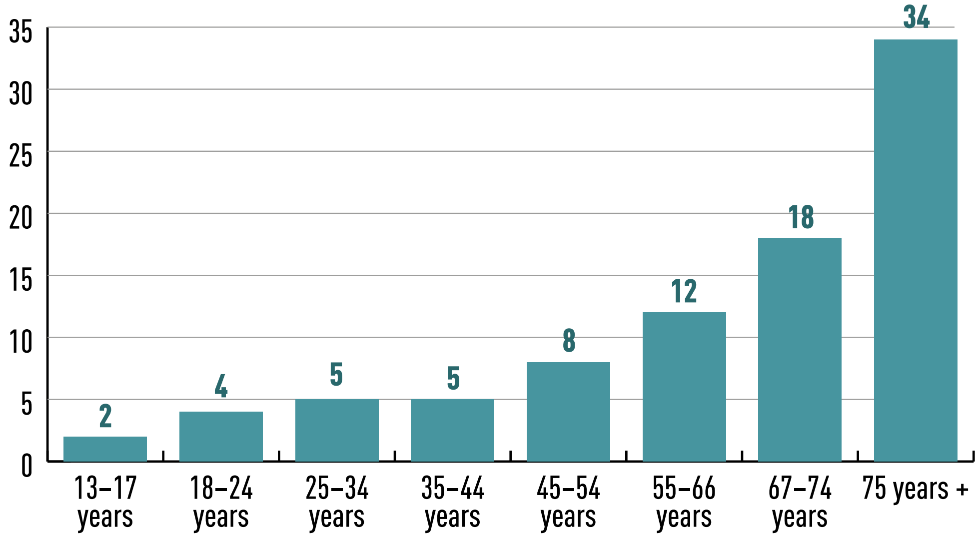


Figure 1: Percentage with mobility issues by age group. RVU 2018/19. Percentage and 95% confidence interval. Source: Grue et al. (2021) Figure 3.4.

Veisten et al. (2020) looked at a wider variety of issues related to using public transport than the Norwegian national travel survey 2018/19. The response alternatives in Veisten et al. included a mix of disabilities and more situation-specific problems, such as carrying luggage and non-physical problems such as cognitive and mental health issues. In this approach, a much larger proportion, i.e. about two out of ten, reported having problems using public transport (Table 1).

Table 1: Reported problems using public transport (N=2599) in response to the question 'Do any of the following make it difficult for you to use public transport?'. Source: Veisten et al. (2020) Table 3.10.

PROBLEM	PERCENTAGE
Impaired vision	1,3%
Asthma and allergies	2,9%
Impaired hearing	0,9%
Mental health issues	2,7%
Trouble walking or mobility impairment	2,7%
Pushing a pram or carrying heavy luggage	4,7%
Problems understanding timetables, route maps etc.	1,3%
Other	4,1%
None of the above	80,9%
Don't know/don't want to answer	2,2%

1.3 Measures and status

In 2009, Fearnley et al. conducted a study that was to have interesting implications for further work on universal design in public transport. Despite the fact that universal design is about accessibility for 'all' and 'as many as possible', the prevailing view was that universal design measures were primarily for people with special needs, such as wheelchair users. In Fearnley et al. (2009), public transport users in Oslo, Drammen and Kristiansand were asked about their perceptions of universal design measures in public transport. The results are presented in Figure 2.

'Despite some variation, the majority responded that they perceived the measures as quality improvements and not specifically targeted towards disabilities.'

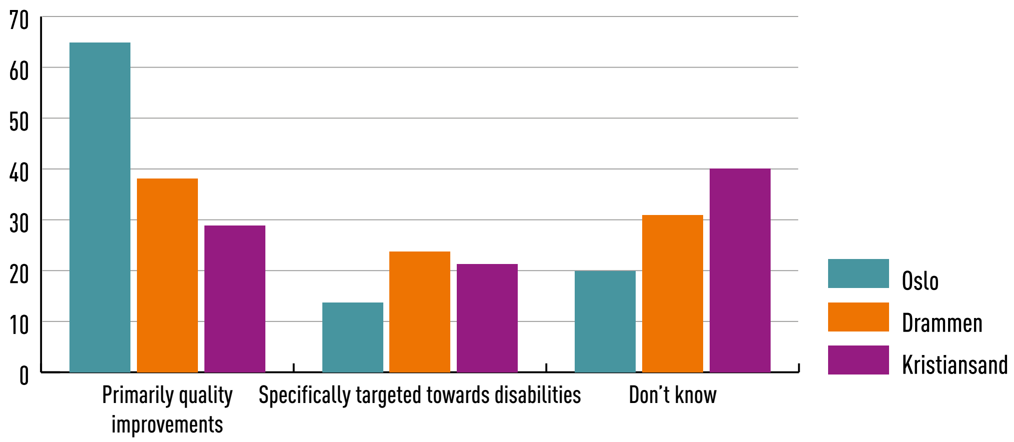


Figure 2: Breakdown of passengers' perceptions of universal design measures in public transport. Percentage. Source: Fearnley et al., 2009, Figure 4.7.

Just over ten years later, Veisten et al. (2020) carried out a similar exercise. First, they mapped whether accessibility measures make it easier to use public transport. Most general interventions relating to bus and tram stops (Figure 3) and most on-board measures (Figure 4) contribute to this.

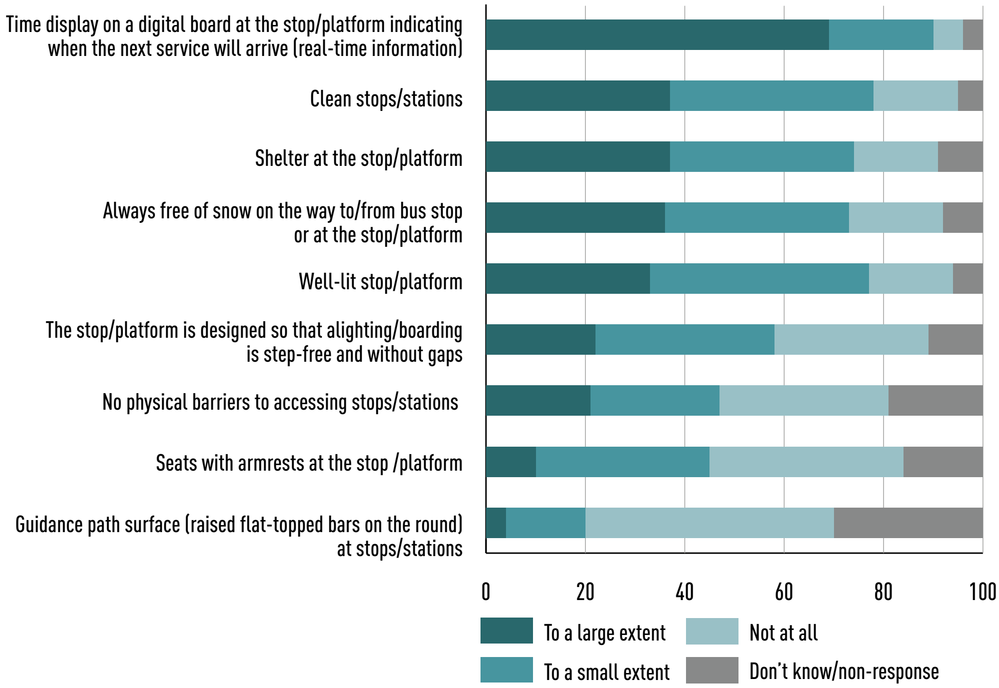


Figure 3: To what extent do you think that the following interventions at stops/stations make it easier for you to use public transport? (N=2599). Source: Veisten et al. 2020 Table 5.10. 'Don't know' and non-responses are not included.

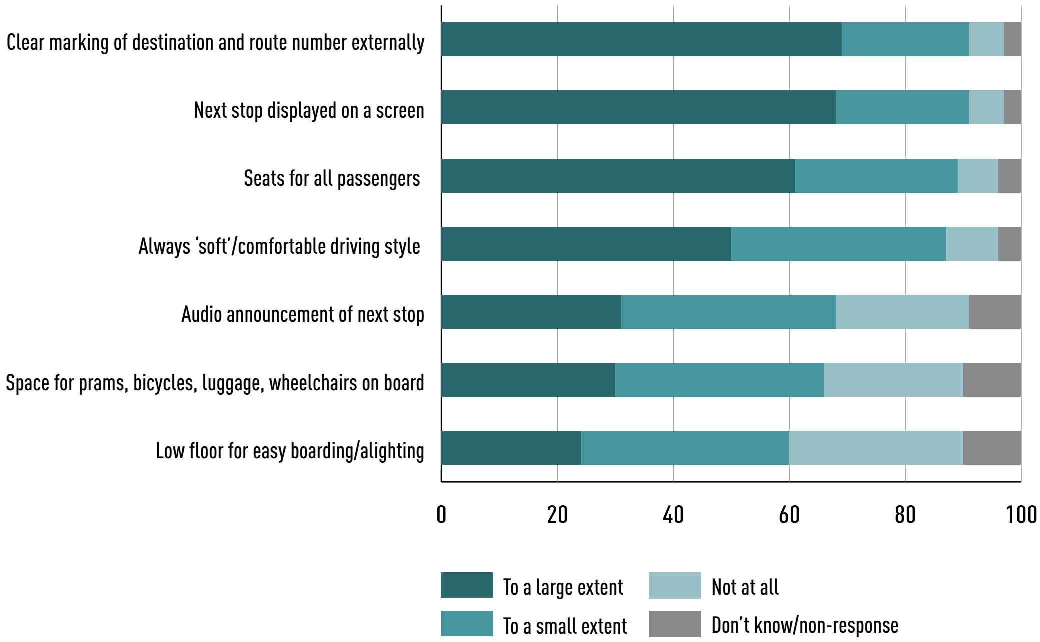


Figure 4: To what extent do vehicle/on-board measures simplify the use of public transport for you? (N=2599). Source: Veisten et al. (2020) Table 5.11. 'Don't know' and non-responses are not included.

Veisten et al. (2020) also asked a similar question regarding whether the measures mentioned were perceived as general quality improvements or as targeted towards specific user groups (Table 2).

Table 2: Are the measures mentioned general quality improvements or targeted towards specific user groups? (N=2599). Source: Veisten et al. (2020) Table 5.13.

	Primarily general quality improvements in public transport services	Targeted towards people with disabilities and passengers with special needs	Both	Don't know
General quality improvements or for special needs?	35%	18%	39%	8%

Almost 40% stated that they consider the measures to be both general quality improvements and targeted towards specific user groups. One-third regarded the measures as general quality improvements, while just under 20% considered them to be targeted towards specific user groups.

These findings have paved the way for innovative approaches to universal design:

Universal design does not have to be merely a minimum requirement for new-builds and upgrades. It can also be viewed as a tool to make public transport more appealing for everyone. Universal design measures can also, therefore, compete for investment and operating budgets on an equal footing with other public transport initiatives, such as improved service frequency.

This marked the beginning of valuation surveys that estimate the utility of universal design measures in public transport to passengers, measured in terms of willingness to pay. These valuations can in turn be used in cost-benefit analyses to calculate economic efficiency and to prioritise competing investment projects. We will take a closer look at this later in this chapter, but first we will demonstrate how the benefit of universal design is not limited to what can be measured and quantified.

2. Effects on quality of life

Freedom of mobility is essential for people to be able to work and study outside their own home and participate in various activities. Mobility is needed to engage in social activities with family and friends, participate in clubs, choirs, sports etc., as well as to carry out activities independently. Having the opportunity to travel is, *in itself,* an important aspect of quality of life because it allows people to be independent, reduces their reliance on others in their daily life, and provides greater flexibility in choosing when to participate in activities that people need and want to be a part of:

'Without the opportunity to travel, life would be quite dull. Isolating in every way. Anything is better than sitting at home staring at the wall' (in relation to people with a psychosocial disability having accessible public transport (Nielsen and Skollerud, 2018)

The UN defines 'freedom of mobility' as a human right, and universal design is therefore imperative for avoiding discrimination against individual groups and ensuring that everyone has equal opportunities to participate in society. An absence of freedom of mobility not only affects the individual but also has a bearing on society as a whole, as more people become dependent on disability benefit and the positive contribution they could have made is lost. In addition, the positive contribution of people's participation in society is lost.

A study by Hjorthol et al. (2013) gives an overview of aspects of walking that are not necessarily quantifiable in economic terms (Figure 5). Transport is essential for quality of life and for a social and active life (Table 3). Women place a higher value on these factors than men (Hjorthol, 2013; 2011).

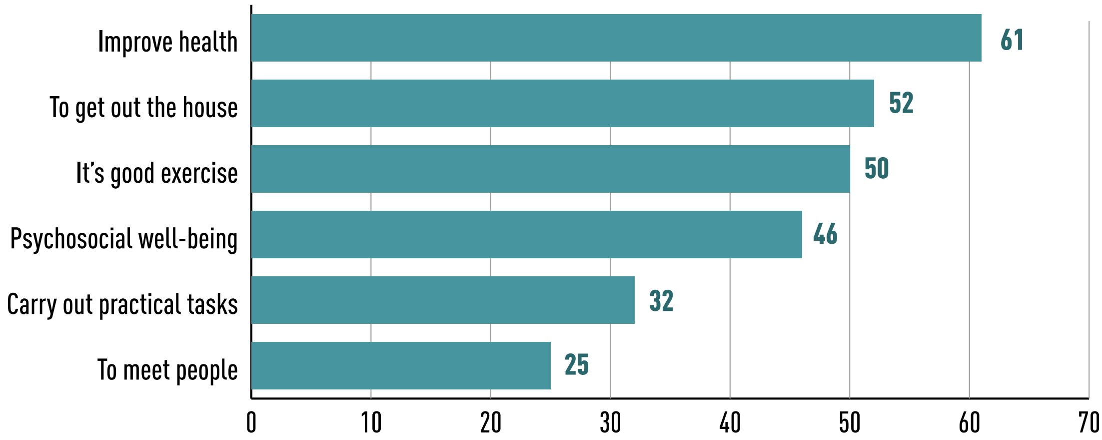


Figure 5: The main reasons for going for a walk. The percentage who answered 'Very important'. Kristiansand, 2012. Hjorthol et al., 2013.

Table 3 The percentage who say that the various statements apply, by gender. Norway 2010. Percentage. N=4020. Source: Hjorthol et al., 2011 Table 6.1.

	Transport is necessary for me to have a social and active life	Knowing that transport is available or that I can get out when I need to is essential for my quality of life	I will feel old the day I can't go out on my own
All	*52*	*68*	*80*
Female	55	73	80
Male	49	63	81

Social networks and participation are crucial for both physical and mental health. Social isolation and loneliness – both perceived and actual isolation – are associated with premature mortality (Holt-Lundstad et al., 2015; House et al., 1988). In contrast, participation in social networks has a range of positive effects on health and health behaviour:

- Slower development of functional impairments, as social networks have a protective effect on the development of functional impairments[2] in older adults (Escobar-Bravo et al., 2011)
- Increased use of mental health services by people who are suicidal, which reduces the risk of suicide (Youn et al., 2020)
- Better mental health (Takagi et al., 2013; Kawachi & Berkman, 2001)
- Slowed development of dementia (Wang et al., 2002; Marseglia et al., 2019)
- Better self-reported health (Sirven & Debrand, 2008; Lee et al., 2008; Giles 2004)
- You can be a resource for others and give more back to society, such as helping sick friends or looking after grandchildren (Nordbakke et al., 2020)

2 Functional impairment is measured here in terms of ADL (activities of daily living) and IADL (instrumental activities of daily living) – the ability to take care of oneself – eating, personal hygiene, transportation etc.

Social participation is correlated with both quality of life and self-perceived health (Gilmour, 2012). Studies of older adults show that social participation can have a protective effect against loneliness associated with low wealth (Niedzwiedz et al., 2016) and that participation in organisations reduces mortality for men (Wilkins, 2003).

Being able to access transport is an essential prerequisite for participation. A longitudinal study in Ireland (Donoghue et al., 2019) of people over the age of 50 found that those who depend on others for transport have a lower quality of life, poorer mental health and less frequent participation in social activities. Those who had reduced their own driving in the past five years also had higher scores for depression and loneliness (ibid.).

'Those who depend on others for transport have a lower quality of life, poorer mental health and less frequent participation in social activities. Those who had reduced their own driving in the past five years also had higher scores for depression and loneliness.'

Another study shows that the reasons for non-participation in activities among older adults are linked to transport in 4% of cases for men and 11% for women (Gilmour, 2012). A quantitative study by Nordbakke (2016) showed that people with physical disabilities had fewer of their travel needs met than the general population. There are no corresponding studies for people with psychosocial disabilities, but research on travel behaviour indicates that this group also travels less frequently than others (Mackett, 2017). The Mental Health Action Group (2011) concluded that limited access to public transport leads to isolation and the exacerbation of symptoms, while good access is important for positive mental health. A smaller, qualitative study (Nielsen and Skollerud, 2018) also found that being able to travel was crucial for the informants' mental well-being.

Data collected in Veisten et al. (2020) shows that a much higher proportion of households with people who find it difficult to use public transport because of physical or mental health challenges have no access to a car (Table 4). In other words:

> *'people with physical and mental health challenges are more reliant on a universally designed public transport system for participating in activities outside their home. They also have significantly lower personal and household incomes than those without such challenges.'*

Table 4: Car ownership and income among people with and without physical/mental health challenges related to public transport. Source: Data in Veisten et al. (2020)

	Physical/mental health challenge		
	No	Yes	No. of respondents (N)
Household has car	68%	56%	2 599
Personal income	533 920	390 700	2 357
Household income	1 026 310	800 750	1 816

3. Demand[3]

Unfortunately, the research literature does not have clear answers as to whether or to what extent universal design affects the demand for public transport.

Within public transport analyses, a distinction is made between hard and soft quality factors. The division between them is not exact but must be interpreted based on purpose and context.

The *hard quality factors* are normally those that are easy to measure and quantify. They often form part of transport models and are considered to play a key role in demand, passenger costs, perceived travel burden and operator costs. Hard quality factors include ticket price, walking time, waiting time, travel time, service frequency (or headaway), and interchanges.

Soft quality factors meanwhile, encompass all other quality improvement measures, including comfort, low-entry and step-free boarding, availability of seats, travel and route information, facilities on-board and at stops, safety, cleanliness, driving style, etc. Many of the soft quality factors will help improve the universal design of public transport.

Compared to hard quality factors, the soft factors generally have a more limited effect on demand. This complicates the measuring of demand effects as these can easily be overshadowed by other factors that have a greater impact on passenger trends (such as unemployment, petrol prices and land use). Moreover, quality improvements are difficult to measure and quantify on a meaningful scale. As a result, both the improvements and their demand effects are difficult to map and measure.

3 The content of this section presents the main findings and text from Fearnley et al. (2015).

The most commonly reported demand effects of quality improvement measures are therefore based on less scientific approaches. For example, there are many anecdotal descriptions in industry journals along the lines of 'more accessible buses led to growth in passenger numbers'. Typically, they incorrectly attribute the entire change in demand after implementation of a quality improvement measure to this one measure. Other studies are based on self-reported changes in behaviour and attribute the entire demand effect to quality improvement measures without attempting to correct for effects of other factors that may be involved. Caution must therefore be exercised when considering such claims. Against this backdrop, Fearnley et al., (2009) found that about half of the respondents say they travel more often as a result of universal design measures in public transport.[4]

The most common alternative method for evaluating the demand effects of universal design is to assess passengers' willingness to pay (see the next chapter), so-called implicit demand calculations. The method is relatively simple:

If the willingness to pay for a universal design measure matches the willingness to pay for X minutes of travel time savings, it is assumed that the demand effect of the measure matches the demand effect of the same X minutes of reduced travel time. Thus, known demand effects of 'hard' quality factors (travel time in this instance) are leveraged and applied to 'soft' quality factors.

This method has numerous weaknesses and should be considered a 'last resort' in the absence of more insight (Fearnley et al., 2015). Nonetheless, Currie and Wallis (2008) synthesised a large number of studies and converted quality improvements into travel time savings and then into demand effects (patronage impacts).

Table 5 is from their study and gives an indication of the envisaged magnitude of the demand effects. Driver skills have a strong effect (0.68-1.02% demand effect), as does CCTV (video surveillance; 1.19%) and air conditioning (1.70%).

4 The measures include: clear signage; space for prams, bicycles and wheelchairs; low floor; stop announcements; as well as stops announced on the on-board display screen.

Table 5: Demand effects of soft quality factors based on travel time equivalents. Source: Currie and Wallis (2008, Table 2).

'Soft' bus improvement		Valuation[a] (in-vehicle time minutes)	Notes	Estimated patronage impact (%)[b]
Boarding	No step	0.1	Difference between two and no steps	0.17[c]
	No pass show	0.1	Two stream boarding, no show pass vs single file past driver	0.17
Driver	Attitude	0.4	Very polite helpful cheerful well presented vs businesslike and not very helpful	0.68
	Ride	0.6	Very smooth compared to jerky	1.02
Cleanliness	Litter	0.4	No litter compared to lots of litter	0.68
	Windows	0.3	Clean windows, no etchings compared with dirty windows and etchings	0.51
	Graffiti	0.2	No graffiti compared with lots	0.34
	Exterior	0.1	Completely very clean compared to some very dirty areas	0.17
	Interior	0.3		0.51
Facilities	Clock	0.1	Clearly visible digital clock with correct time vs no clock	0.17
	CCTV	0.7	CCTV, recorded, visible to driver plus driver panic alarm compared to no CCTV	1.19
Information	External	0.2	Large route number and destination sign front, side and rear plus line diagram on side vs small signs	0.34
	Interior	0.2	Easy to read route no. and diagram compared to none	0.34
	Info of next stop	0.2	Electronic next stop sign and announcements vs no information	0.34
Seating	Type/layout	0.1	Individual shaped seats with headrests all facing forward vs basic double bench some backwards	0.17
	Tip-up	0.1	Tip up sets in standing/wheelchair area compared with all standing area in central aisle	0.17
Comfort	Legroom	0.2	Space for small luggage vs restricted legroom and no space for small luggage	0.34
	Ventilation	0.1	Push open windows giving more ventilation vs slide opening windows	0.17
		1.0	Air conditioning	1.70

a Based on Australian Transport Council, 2006.

b Assumes a 20 min bus journey with 5 min access/egress walk, 5 min wait, a $1.50 fare and a value of time of $Aust 10.00/h (2006). This makes a weighted generalised cost of 59 min. Forecasts are made by applying a generalised cost elasticity of –1.0 to the change each soft factor has on this base generalised time. These assumptions are based on (Booz Allen Hamilton, 2000b, Australian Transport Council, 2006).

c The 0.17% impact of a 'no step' bus is small compared to estimates of the impact of low floor vehicles (Balcombe et al, 2004; 5% and TAS Partnership, 2002; 3–9%). We conclude that this is a 'low' estimate or that it concerns only the implementation of a step and not the provision of an entirely new low floor vehicle.

In summary, the knowledge about how universal design affects the demand for public transport is almost non-existent or, at best, poorly substantiated. This is partly because the demand effects are so small that they are difficult to distinguish from natural demand fluctuations and the effects of external factors such as petrol prices and employment levels. It is also partly because there have been few scientific studies of the correlations.

4. Willingness to pay

4.1 Measures to increase universal design can reduce travel inconvenience

Although it is difficult to calculate the demand effects of universal design in public transport, it is possible to measure the utility of such improvements to passengers.

People are willing to pay for transport because it enables them to engage in activities (such as work, school, shopping, leisure activities, visiting friends, etc.). If part of the inconvenience of travelling is reduced or eliminated, the expectation is that people will be more satisfied with public transport and may even want to travel more.

In the information box below, a simplified example is given of how a trade-off between two scenarios can provide information about willingness to pay – travel time savings in this context.

Box 1: Deducing the value of time based on a trade-off

WHAT DO YOU CHOOSE?

Journey A
- Price NOK 10
- 20 minutes

Journey B
- Price NOK 14
- 15 minutes

A person who prefers Journey B makes a trade-off that suggests a 5-minute time saving is worth paying NOK 4 more. Thus, for that person the time saving is worth at least NOK 0.80 per minute.

Willingness to pay does not entail passengers actually paying more to achieve better quality or avoid poorer quality. It is an expression of how much the passenger thinks a trade-off between various travel factors is worth.

When people state their willingness to pay for universal design measures, it indicates that the travel inconvenience will be reduced if the measure is implemented. The time spent travelling and waiting/transferring may also be considered less of an inconvenience with the measure than without it.

Some people will want an improvement to be implemented throughout the entire journey from start to finish, so that all public transport stops and vehicles, and the entire access road etc. have sufficient accessibility. Improvements to only one part of the journey chain (see Øksenholt and Krogstad, 2022) may not be enough for these passengers to perceive increased utility for the entire journey.

Willingness to pay is linked to a person's ability to pay. Their preferences for specific goods and services guide their willingness to pay, but their ability to pay also matters. For many goods, there will be a positive correlation between income and willingness to pay. As shown in the previous chapter, people with disabilities have relatively lower incomes. They may be willing to pay more for (the utility derived from) specific universal design measures, as documented in Fearnley et al. (2009), but the income distribution has a moderating effect.

4.2 Estimated valuations of universal design measures

In the autumn of 2018 and summer of 2019, surveys were conducted of public transport passengers in Oslo, Trondheim and other parts of Norway. The respondents considered various (levels of) measures related to accessibility and universal design. The valuations were derived from so-called choice experiments, where respondents chose between sets of two alternative public transport journeys with different levels of quality, as well as different travel/waiting times and in some cases different ticket prices – similar to the example in Box 1 (see Table 6).

Table 6: Example of a choice presented in the survey on quality factors in public transport.

QUALITY	ALTERNATIVE A	ALTERNATIVE B
Shelter at the stop	No roof over the stop	Small shelter – roof and back wall
Seating at the stop	Large bench with armrests	No seating
Cleanliness (washed/litter removed) at the stop	Often dirty/with litter	Usually clean
Maintenance of stop	Damaged/worn out items are repaired/replaced within one week	Damaged/worn out items are repaired/replaced, but it takes a few weeks
Waiting time at the stop	7 minutes	13 minutes
Ticket price	NOK 30	NOK 24

Each respondent was given six such pairwise choices, with slightly different descriptions of the various qualities, different waiting times and different ticket prices. The choices of alternatives enable estimating the trade-offs between the components (attributes) in the choice experiment. The trade-off between a change in the level of one quality factor and a change in ticket price gives the monetary value of the change in the quality factor.

For further details, refer to Veisten et al. (2020). Figure 6 is a summary of some of the valuation estimates.

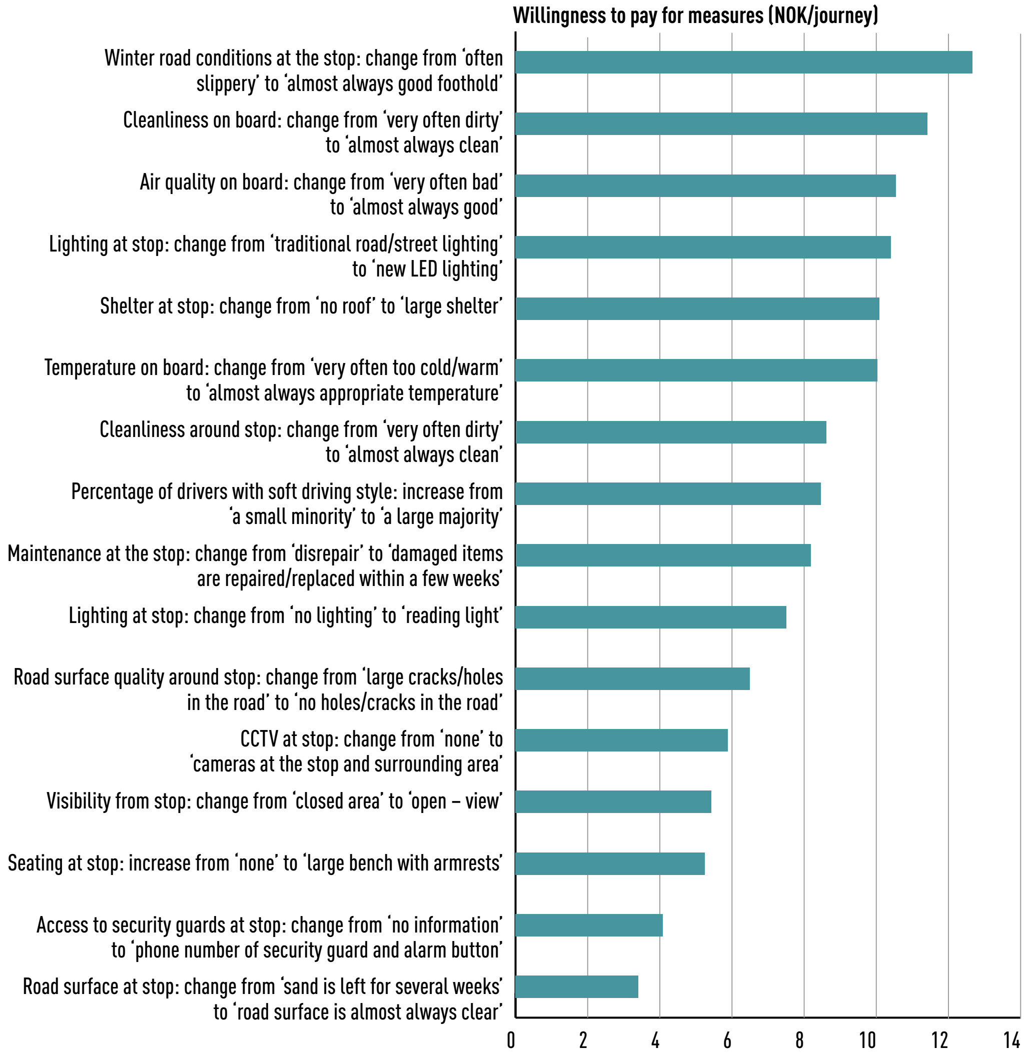


Figure 6: Extra willingness to pay per journey for comfort and universal design measures on board and at the stop/station – from the lowest quality level to the highest level (of three specified quality levels).

Most of the valued measures/quality factors in Figure 6 are physical installations or technologies.

'Measures on board achieved a consistently high willingness to pay.'

Measures on board achieved a consistently high willingness to pay. There are general standards for the temperature on board public transport vehicles (adjusted for seasonal/day-night variations, i.e. implicitly in line with passengers' clothing). Most people would probably prefer that the temperature on board is not 'very high' on cold days and not 'very low' on hot days. Air quality and cleanliness on board also have a relatively high value. On public transport, the functionality of a vehicle can depend on the driver operating it as intended. 'Soft driving style' was specified under driver quality, which also achieved a high willingness to pay.

Shelter in waiting areas (stops/stations), and cleanliness/maintenance of these areas are relatively highly valued by public transport passengers. Bench seating in waiting areas can be more crucial for certain groups.

The level of safety and security measures in waiting areas is also more crucial for some groups than others. Both increased visibility from the stop and CCTV at/around stops/stations obtained moderately high values. Good lighting at stops may or may not be related to security, but it was relatively highly valued.

For the information measures at stops/stations, the valuation estimates were somewhat lower, but it was apparent that visible real-time information was relatively highly valued. For some passengers, having more access to information both before and during the journey may be more crucial.

'In terms of the conditions to/from stops/stations, it was reduced slipperiness that was most valued.'

In terms of the conditions to/from stops/stations, it was reduced slipperiness that was most valued. This is not particularly surprising given the mobility limitations and hazards that icy roads cause for many people. Veisten et al. (2019) calculated that halving the scope of slippery winter roads in Oslo would reduce the annual number of pedestrian falls resulting in injuries by roughly 20%. Lighting on the roads to/from stops is also valued relatively highly. The estimates for improved road maintenance were also relatively high. The willingness to pay for faster removal of gravel/sand from the road indicates that leaving it on the road for a while is not critical for many passengers.

Veisten et al. (2020) point out that estimated willingness to pay obtained via questionnaires may be subject to hypothetical exaggeration as there are no direct consequences for people choosing more expensive alternatives with higher comfort levels in the pairwise choices. Nevertheless, it is possible that respondents believed that their answers could have an impact and might influence the decision-makers. If this is the case, respondents might have thought that choosing more expensive alternatives could lead to measures being implemented, even if it meant higher ticket prices.

It will also generally be the case that the implementation of one measure could affect the willingness to pay for another. For example, an individual's budget constraints will reduce their willingness to pay for new measures, given that they have to pay higher ticket prices for each new measure. None of the respondents gave a valuation for all of the measures; they chose between paired alternatives in two rounds, each consisting of four measures. The valuations can be described as follows: the estimated willingness to pay for a measure is valid if this measure is among the first measures to be implemented. For subsequent measures, it is expected that the willingness to pay will be lower than what is shown in Figure 6.

5. Economic efficiency

Economic efficiency is a key part of the decision-making basis for major investments, particularly for investment projects in the National Transport Plan (NTP; Ministry of Transport, 2021). Economic efficiency is calculated in a cost-benefit analysis, which entails quantifying and synthesising all the effects of a project – benefits and costs – and weighing these up against the budgeted cost. In simple terms, we can say that if the benefits outweigh the disadvantages and costs, the measure improves social welfare.

In this context, utility (or benefit) refers to factors such as reduced travel times, smaller queues/less congestion and reduced risk of accidents. The willingness of passengers to pay for universal design measures, as documented above, is a utility factor that can be included in a cost-benefit analysis.

'In this context, utility (or benefit) refers to factors such as reduced travel times, smaller queues/less congestion and reduced risk of accidents.'

In concrete terms, this means, for example, that upgrading a stop from no seating to large benches with armrests gives a passenger benefit of NOK 5.25 per passenger (see Figure 6). If 2,000 passengers use this stop every year, the annual passenger benefit is NOK 10,500. Any disadvantages for others (which in practice is zero) are deducted from this amount. Furthermore, the proposed bench will have a lifespan of several years. Therefore, future years' benefit and potential future disadvantages must be added together to calculate a net benefit in today's currency (present value of benefit). The cost will consist of an investment cost and any annual maintenance costs.

If the net benefit exceeds the budgeted cost and the tax cost,[5] the measure is considered to improve social welfare.

This example is a simplified description of calculations involved in cost-benefit analyses. For further details, see the manuals from the Norwegian Public Roads Administration (2021) Impact assessments. Manual V712 and the Norwegian Railway Directorate Guide to socioeconomic analyses in the railway sector (2018) (both in Norwegian only).

The benefit-cost ratio is the most suitable way of ranking and prioritising competing projects. This ratio shows the net benefit of a measure for each budgeted krone (Norwegian currency) it costs. If the ratio is positive, the measure is viable. A benefit-cost ratio of 0.3 means that society gains NOK 0.30 for every krone spent on the measure, in addition to the money invested. The project with the best benefit-cost ratio should, all else being equal, be given the highest priority.

Based on the aforementioned key finding that universal design measures in public transport are considered a quality improvement for everyone, as well as the estimate of passengers' willingness to pay for such measures, the Institute of Transport Economics has developed several simplified calculation tools for cost-benefit analyses that are well-suited for universal design measures. The most important tools in this context are as follows:

The cost-benefit tool for smaller public transport measures at stops and in vehicles. This includes shelters, seating at stops, accessible passenger information, lighting, snow and ice removal, etc.

Cost-benefit calculation tool for the operation and maintenance of pedestrian and bicycle facilities, including measures related to lighting, road surface standards, winter operation and cleanliness.

These online tools make it very easy to perform cost-benefit analyses. Typically, as in the example of the bench at a stop, it is only information about the costs and the number of users that is needed per year. The tool takes care of the rest:

- It calculates user benefit,
- benefits/disadvantages to others, and
- benefit/cost for operators and for society over the analysis period (which is currently set at 40 years).
- The tool also calculates costs and taxes over the analysis period.

The net present value of the measure is the sum of benefits minus the sum of disadvantages and costs. If the net present value is positive, the measure improves social welfare.

5 The tax cost is often referred to as the shadow price of public funds. This represents society's efficiency loss associated with financing projects through taxation and is routinely set at 20%. (Thus, it is not the actual expenditure but rather the societal 'cost' (efficiency loss) incurred when raising funds through taxes to cover the expenditure.) If the proposed bench costs NOK 5,000 and is financed from public budgets, the tax cost at 20% will amount to NOK 1,000, which is added to the budgeted cost.

When it is not possible to access all the figures required for using these tools, there is a handy feature that helps with this. Figure 7 is a screenshot of this feature.

Imagine that you are thinking about installing seating at a stop and have a good idea of the costs (which are input as NOK 10,000 for installation and NOK 1,000 for annual operating and maintenance), but you are uncertain about the number of passengers who will benefit from the measure. The graph helps you with this. In this example, the graph shows that the measure is welfare improving if the annual number of users of the stop exceeds approximately 550 – or an average of 1.5 passengers per day. Even with minimal knowledge about the stop, in most cases, you can quickly assess whether the usage of the stop makes the measure viable. Corresponding graphs can be created for the other input data, such as installation costs and annual operating and maintenance costs.

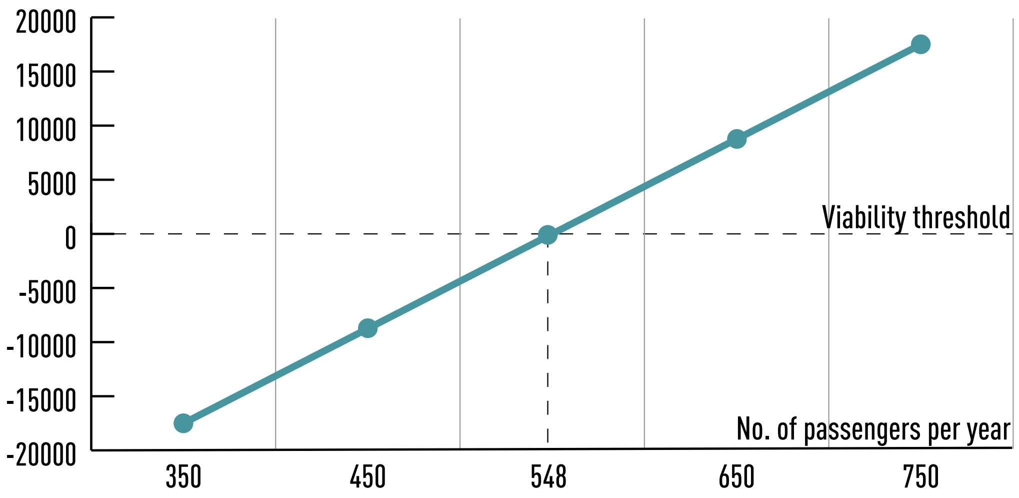


Figure 7: Screenshot of the tool for calculating social welfare in public transport. The graph shows how the benefit of the measure depends on a selected input variable – in this case the number of passengers per year.

Hagen and Odeck (2007), and subsequently Odeck et al. (2010), demonstrated that this type of calculation tool can be used to document the overall value to society of universal design measures in public transport. As in the example of seating at a stop, a vast number of bus stops will have usage patterns that suggest a high value to society. The benefit-cost ratio can easily reach double figures, meaning that society gains more than ten times the value of what the measure costs.

As mentioned at the beginning of this section, projects in the National Transport Plan (NTP) are subject to cost-benefit analysis. In the current NTP (Samferdselsdepartementet, 2021 Table 10.2), the net present benefit of prioritised investments is NOK -52.7 billion. The measured value to society is thus significantly *lower* than the cost.[6] In other words, the NTP includes many non-viable projects. In comparison, universal design measures often demonstrate excellent benefits to cost ratios. Shifting the focus away from large national infrastructure projects in the NTP towards smaller, local universal design measures would therefore likely result in a major socioeconomic gain.

6 The explanation given is as follows: 'This is because, when prioritising, the government has also attached importance to other considerations.' (Page 162).

Fearnley (2018) commented on this as follows:

'Measured in terms of net present benefit per krone spent on a measure (benefit-cost ratio), a shelter, a bench, or good lighting at a bus stop, for example, will easily outperform any NTP measure. By a good margin.'

It could be questioned whether it is right to rank universal design measures against completely different types of projects, such as NTP projects. In many ways, universal design is a basic requirement and a right. Unfortunately, the reality is somewhat different: in practice, there is not enough money to meet all important needs. Universal design is primarily a requirement for new-builds and major upgrades. In addition to universal design measures being funded from earmarked budgets, they can also be prioritised in competition with other worthwhile projects, based on estimated benefits and cost benefit analyses. As we have demonstrated, universal design measures are highly competitive in relation to projects covered by other budget items and can yield far greater benefits than most other investment projects in the transport sector. Measuring the overall value to society can therefore have a potentially significant impact on the work with universal design in the sector.

6. Concluding remarks

We can assume that between 10% and 20% of the population experience some kind of difficulty when travelling, whether it is situation-specific (like carrying luggage or pushing a pram) or in relation to something more permanent. This therefore affects a significant number of people.

'Between 10% and 20% of the population experience some kind of difficulty when travelling.'

Measures to make public transport, outdoor spaces and footways more universally designed and accessible have direct effects and benefits for users. The service becomes accessible, and people experience freedom of movement and the opportunity to participate in society. Universal design also has more indirect effects. For example, independence and mobility lead to better mental and physical health, reduced loneliness, improved quality of life and the possibility to serve as a resource for others.

Many measures to make transport systems more accessible for people who experience various difficulties are considered quality improvements by other passengers. Universal design measures can therefore also be viewed as general quality improvements. All passengers benefit from universal design measures because the services are regarded as more intuitive, safe, comfortable, flexible and easy to use. This benefit has been quantified in valuation surveys and is not insignificant. There are many examples where the passenger benefit of universal design measures far exceeds the cost of implementing them – they are therefore welfare improving. This is true even though it is challenging to quantify demand gains from such measures.

> ‘There are many examples where the passenger benefit of universal design far exceeds the cost of implementing them – they are therefore welfare improving.’

There is still much research to be done on universal design. For example, there is a lack of knowledge about universal design and micromobility (such as electric bicycles and scooters) and cars. Additionally, the bulk of the existing literature on the needs of different groups primarily focuses on people with visual, hearing and mobility impairments. More knowledge is needed about other groups, such as those with allergies, cognitive challenges, gastrointestinal conditions and mental health problems.

7. Suggestions for further reading

Odeck, J., Hagen, T., Fearnley, N., 2010. Economic appraisal of universal design in transport: Experiences from Norway. *Research in Transportation Economics*,

Veisten, K., Flügel, S., Halse, A.H., Fearnley, N., Sundfør, H.B., Hulleberg, N., Jordbakke, G.N., 2020. *Public transport passengers' valuation of universal design and comfort*. TØI rapport 1757/2020

ITF 2018. *The Economic Benefits of Improved Accessibility to Transport Systems*. Roundtable report, OECD / International Transport Forum

Statens vegvesen, 2021. *Konsekvensanalyser. Håndbok V712*.

Aarhaug, J., Elvebakk, B., 2012. *Enhanced accessibility in public transport: A before-and-after study*. TØI-rapport 1235/2012

References

Currie, G., Wallis, I., 2008. Effective Ways to Grow Urban Bus Markets – A Synthesis of Evidence. *Journal of Transport Geography* 16, pp 419–429, https://doi.org/10.1016/j.jtrangeo.2008.04.007

Donoghue O. A., McGarrigle C. A., Kenny R. A. (2019) Who's in the driver's seat? Impact on social participation and psychosocial wellbeing in adults aged 50 and over, *Transportation Research Part F: Traffic Psychology and Behaviour,* Volume 64, 522-531, https://doi.org/10.1016/j.trf.2019.06.010

EEA, 2011. *Europaparlements- og rådsforordning (EU) nr. 181/2011 av 16. februar 2011 om passasjerers rettigheter ved buss- og turvogntransport og om endring av forordning (EF) nr. 2006/2004*, https://lovdata.no/static/NLX3/32011r0181.pdf

Escobar-Bravo MÁ, Puga-González D, Martín-Baranera M. Protective effects of social networks on disability among older adults in Spain. Archives of Gerontology and Geriatrics. 2012 Jan-Feb;54(1):109-116. https://doi.org/10.1016/j.archger.2011.01.008.

Fearnley, N., 2006. Public transport subsidies in the UK: evidence of distributional effects. *World Transport Policy & Practice*, vol 12(1) 2006. Eco-Logica

Fearnley, N., Flügel, S., Killi, M., Leiren, M.D., Skollerud, K.H., Nossum,Å., Aarhaug, J., 2009. *Passengers' valuation of measures for universal design of public transport*. TØI-rapport 1039/2009

Fearnley, N., 2018. *Sjekk samfunnsnytten av enkle kollektivtiltak*. Samferdsel, 24.05.2018

Fearnley, N., Aarhaug, J. 2019. Subsidising urban and sub-urban transport – distributional impacts, *European Transport Research Review*, https://doi.org/10.1186/s12544-019-0386-0

Fearnley, N., Aarhaug, J., Flügel, S., Eliasson, J., Madslien, A., 2015. *Measuring the patronage impact of soft quality improvements in urban public transport* . TØI-rapport 1408/2015

Giles LC, Metcalf PA, Glonek GF, Luszcz MA, Andrews GR. The effects of social networks on disability in older Australians. *Journal of Aging and Health*. 2004; 16(4):517-538, https://doi.org/10.1177/0898264304265778

Gilmour (2012) Social participation and the health and well-being of Canadian seniors. Statistics Canada. *Health Reports*, Vol. 23. (4). https://www. researchgate.net/profile/Heather_Gilmour/publication/232607486_Social_participation_and_the_health_and_well-being_of_Canadian_seniors/links/09e415086d6c6ca8c4000000.pdf

Grue, B., Landa-Mata, I., Flotve, B.L., 2021. *The Norwegian national travel survey 2018/19 – key results*. TØI-rapport 1835/2021, toi.no/getfile.php?mmfileid=71405

Hagen, T., Odeck, J., 2007. *Svært lønnsomt å investere i universell utforming*. Samferdsel nr. 9/2007

Holt-Lunstad J, Smith TB, Baker M, Harris T, Stephenson D. Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspect Psychol Sci* 2015; 10: 227–37, https://doi.org/10.1177/1745691614568352

House JS, Landis KR, Umberson D. Social relations-hips and health. *Science* 1988; 241: 540–5, https://doi.org/10.1126/science.3399889

Kawachi , I. Berkman, LF, 2001. Social ties and mental health. J Urban Health. 2001, 78: 458-467. 10.1093/jurban/78.3.458, https://doi.org/10.1093/jurban/78.3.458

Lee HY, Jang SN, Lee S, Cho SI, Park EO. The relationship between social participation and self-rated health by sex and age: a cross-sectional survey. Int J Nurs Stud. 2008 Jul;45(7):1042-54, https://doi.org/10.1016/j.ijnurstu.2007.05.007

Mackett, R. (2017). *Building confidence: Improving Accessibility for people with mental impairments*. Downloaded June 2020 https://www.gov.uk/government/publications/exploring-the-barri-ers-to-travel-for-people-with-mental-impairments

Marseglia A, Wang HX, Rizzuto D, Fratiglioni L, Xu W., 2019. Participating in Mental, Social, and Physical Leisure Activities and Having a Rich Social Network Reduce the Incidence of Diabetes-Related Dementia in a Cohort of Swedish Older Adults. *Diabetes Care*, 42(2):232-239, https://doi.org/10.2337/dc18-1428

Mental Health Action Group (2011). *Mental Health & Public Transport.* Downloaded June 2020: http://www.derbyshiremind.org.uk/pdf/MHPublicTransportReport.pdf

Ministry of Children and Equality, 2017. *Lov om likestilling og forbud mot diskriminering (likestillings- og diskrimineringsloven)*. https://lovdata.no/dokument/NL/lov/2017-06-16-51

Ministry of Transport, 2021. Meld. St. 20 (2020–2021) *Nasjonal transportplan 2022–2033*, https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/nasjonal-transportplan

Niedzwiedz C. L, Elizabeth A. Richardson, Helena Tunstall, Niamh K. Shortt, Richard J. Mitchell, Jamie R. Pearce. (2016) The relationship between wealth and loneliness among older people across Europe: Is social participation protective? *Preventive Medicine*, https://doi.org/10.1016/j.ypmed.2016.07.016

Nielsen A.F. & Skollerud K.H. (2018). *Universal design of transportation systems for people with mental impairments*. TØI rapport 1615/2018

Nordbakke, S., Phillips, R., Skollerud, K., Milch, V., 2020. The health effects of a new mobility solution for older people in Oslo, TØI-rapport 1810/2020

Nordbakke S. & Skollerud. K.H. (2016). *Transport, unmet activity needs, and wellbeing among people with physical disabilities*. TØI rapport 1465/2016

Norges Handikapforbund (2001) *Tilgjengelighet til offentlig transport*. En eksempelsamling fra Norges Handikapforbund

Norwegian Public Roads Administration, 2021. *Konsekvensanalyser. Håndbok V712*. https://www.vegvesen.no/fag/veg-og-gate/plan-legging-prosjektering-og-grunnerverv/planlegging/grunnlagsdata/konsekvensanalyser

Odeck, J., Hagen, T., Fearnley, N., 2010. Economic appraisal of universal design in transport: Experiences from Norway. *Research in Transportation Economics*, https://doi.org/10.1016/j. retrec.2010.07.038

Railway Directorate, 2018. *Veileder i samfunnsøkonomiske analyser i jernbanesektoren*, https:// www.jernbanedirektoratet.no/no/strategi-er-og-utredninger/analyse-og-metodeutvikling/samfunnsokonomiske-analyser-og-transportanalyser

Sirven N, Debrand T. 2008. Social participation and healthy ageing: an international comparison using SHARE data. *Soc Sci Med*. 2008 Dec; 67(12):2017-26, https://doi.org/10.1016/j.socscimed.2008.09.056

Takagi, D., Kondo, K. & Kawachi, I. Social participation and mental health: moderating effects of gender, social role and rurality. *BMC Public Health* 13, 701 (2013). https://doi.org/10.1186/1471-2458-13-701

UN, 2007. Convention On The Rights Of Persons With Disabilities (CRPD).

Veisten, K., Flügel, S., Halse, A.H., Fearnley, N., Sundfør, H.B., Hulleberg, N., Jordbakke, G.N., 2020. Public transport passengers' valuation of universal design and comfort . TØI rapport 1757/2020

Veisten, K., Fearnley, N., Elvik, R., 2019. Economic analysis of measures for improved operation and maintenance for cycling and walking . TØI-rapport 1690/2019

Wang HX, Karp A, Winblad B, Fratiglioni L. Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: a longitudinal study from the Kungsholmen project. *Am J Epidemiol*., https://doi.org/10.1093/aje/155.12.1081

Wilkins K. (2003) Social support and mortality in seniors. *Health Reports* 2003; 14(3): 21-34

Youn, H.M., Kang, S.H., Jang, SI. mfl. 2020 Association between social participation and mental health consultation in individuals with suicidal ideation: a cross-sectional study. *BMC Psychiatry* 20, 305 (2020). https://doi.org/10.1186/s12888-020-02724-8

Øksenholt, K.V., Fearnley, N., 2022. Inclusive mobility. Article 1 in this article collection https:// www.toi.no/uu-artikkelserie

Øksenholt, K.V., Krogstad, J.R., 2022. How can we ensure universal design of journey chains in a system with complex laws, regulations and responsibilities? Article 5 in this artcile collection https://www.toi.no/uu-artikkelserie