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2018

Document Version:

Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):

Koglin, T., & Varhelyi, A. (2018). *What does maintenance of infrastructure mean for pedestrians and cyclists – A knowledge summary*. Lund University.

Total number of authors:

2

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What does maintenance of infrastructure mean for pedestrians and cyclists – A knowledge summary

TILL KOGLIN – ANDRÁS VÁRHELYI | LTH | LUND UNIVERSITY 2018



What does maintenance of infrastructure mean for pedestrians and cyclists – A knowledge summary

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CODEN:LUTVDG/(TVTT 3244)1-40/2018

Bulletin – Lund University

Department of Technology and Society, 309

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Keywords:

Pedestrian, Cyclist, Safety, Security, Accessibility, Infrastructure maintenance

Abstract:

This report summarises knowledge concerning the impact of the maintenance of bicycle and pedestrian infrastructure. The aim of the literature review was to compile existing knowledge on operation and maintenance of the transport infrastructure for pedestrians and cyclists, the highlight how operation and maintenance affect pedestrians and cyclists, in terms of accessibility, safety and security. The reviewed literature revealed a number of issues of relevance concerning the importance of maintenance of infrastructure for pedestrians and bicyclists. There are very few studies on vulnerable road users' ability to travel with the same transport quality as the other road users, especially in rural areas and in smaller cities. Furthermore, a change in attitude in decision makers and planners is needed to give walking and cycling a higher status. Moreover, studies analysed in this report have shown that the pedestrian infrastructure is not perceived to be as well developed as the one for motorised modes of transport. Moreover, it was found that walking and bicycling has to be treated as own and separate modes of transport and that there seems to be a lack of understanding of the user perspective of pedestrians and cyclists when it comes to maintenance.

Citering:

Koglin, T. & Várhelyi, A. (2018) *What does maintenance of infrastructure mean for pedestrians and cyclists – A knowledge summary*. Bulletin 309, Transport and Roads, Department of Technology and Society, Lund University, Lund

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Summary

This report summarises knowledge concerning the impact of the maintenance of bicycle and pedestrian infrastructure. The aim of the literature review was to compile existing knowledge on operation and maintenance of the transport infrastructure for pedestrians and cyclists, to highlight how operation and maintenance affect pedestrians and cyclists in terms of accessibility, safety and security. The aim was broken down into the following objectives:

- What issues of maintenance of the infrastructure affect experienced accessibility, safety and security of pedestrians and cyclists?
- How does maintenance of the infrastructure affect pedestrian and cyclist behaviour?
- How do planners and decision makers consider these issues?

A systematic literature was carried out in the Swedish National Library Catalog TRANSGUIDE, as well as in Web of Science and Scopus. The reviewed literature revealed a number of issues of relevance concerning the importance of maintenance of infrastructure for pedestrians and bicyclists. There are very few studies on vulnerable road users' ability to travel with the same transport quality as the other road users, especially in rural areas and in smaller cities. Furthermore, a change in attitude in decision makers and planners is needed to give walking and cycling a higher status. Moreover, studies analysed in this report have shown that the pedestrian infrastructure is not perceived to be as well developed as the one for motorised modes of transport. Pedestrians should be regarded as basic, and therefore there is a need to provide issues of consistently greater space and priority earlier in the planning process, and treat it as a separate mode of transport. The same need to promote pedestrians as a form of transport, and give it more attention in society to make walking to a standard with high status and take it as a guiding element in planning for cycling as well.

Moreover, it was found out that walking and bicycling has to be treated as own and separate modes of transport. Furthermore, there seems to be a lack of understanding of the user perspective of pedestrians and cyclists when it comes to maintenance, which results in more or less bad maintenance of the infrastructure for those modes of transport.

Sammanfattning

Denna rapport sammanfattar kunskap om effekterna av underhållet av cykel- och fotgängarinfrastruktur. Syftet med litteraturgranskningen var att sammanställa befintlig kunskap om drift och underhåll av transportinfrastrukturen för fotgängare och cyklister, att belysa hur drift och underhåll påverkar fotgängare och cyklister när det gäller tillgänglighet, säkerhet och trygghet. Syftet delades upp i följande mål:

- Vilka underhållsproblem av infrastrukturen påverkar upplevd tillgänglighet, säkerhet och trygghet för fotgängare och cyklister?
- Hur påverkar underhållet av infrastrukturen beteende av fotgängare och cyklister?
- Hur ser planerare och beslutsfattare på dessa frågor?

En systematisk litteratursökning utfördes i Nationalbibliotekskatalogen TRANSGUIDE, samt i Web of Science and Scopus. Den genomgångna litteraturen avslöjade ett antal frågor av relevans beträffande vikten av underhåll av infrastruktur för fotgängare och cyklister. Det finns få studier om oskyddade trafikanterns möjlighet att resa med samma transportkvalitet som för de andra trafikslagen, särskilt i landsbygdsområden och i mindre städer. Vidare behövs en förändring av attityd hos beslutsfattare och planerare för att ge gående och cyklande en högre status. Dessutom har studier som analyserats i denna rapport visat att fotgängarinfrastrukturen inte uppfattas vara lika välutvecklad som den för motoriserade transport. Fotgängare bör betraktas som grundläggande, och därför är det nödvändigt att ge frågan ett konsekvent större utrymme och prioritet tidigare i planeringsprocessen och behandla det som ett separat transportsätt. Samma behov av att främja fotgängare som en form av transport och ge det större uppmärksamhet i samhället för att gå till en standard med hög status och ta det som ett ledande element i planeringen för cyklande också. Dessutom upptäcktes att gående och cykling måste behandlas som egna och separata transportsätt. Vidare förefaller det finnas brist på förståelse för användarens perspektiv hos fotgängare och cyklister när det gäller underhåll, vilket resulterar i mer eller mindre dåligt underhåll av infrastrukturen för dessa transportsätt.

1 Introduction

Developing a sustainable transport system requires that the relative share of transport by cycling and walking increases (Banister 2008). For that to happen, it is important that the infrastructure experienced by cyclists and pedestrians is safe and accessible, i.e. well maintained for. Here, it is important to treat walking and cycling as a mode of transport, equal to the passenger car, and also include these modes in the planning processes. Traditionally, the car has been the main focus in transport planning, which has led to a marginalisation of cycling and walking in urban spaces and planning processes (Koglin and Rye, 2014; Lindelöw et al., 2016). For walking and cycling to increase it is important that the infrastructure works well for both cyclists and pedestrians and for that maintenance is one important aspect. In this report we comprise a summary of research concerning the maintenance of the infrastructure for cyclists and pedestrians in order to develop a better understanding what role the maintenance of pedestrian's and cyclists' infrastructure has for increasing those two modes.

1.1 Background

1.1.1 Pedestrians' and cyclists' accidents problems

Fall accidents involve major socioeconomic costs. Yearly, on average nearly 2000 single casualty accidents are reported in the Swedish Traffic Accident Data Acquisition (STRADA) data base. The casualties in outdoors predominantly occur on a slippery surface and elderly and women are overrepresented in the accident statistics. There are large variations between the municipalities, where some municipalities have none or just a few reported accidents, while others have up to 40 reported accidents per 10,000 inhabitants during the winter period (NTF, 2013). The society's costs for fall accidents in snowy and icy conditions are at least twice as high as the cost of winter road maintenance in Sweden (NTF, 2013). There are probably good opportunities for socio-economic savings by improved prevention of casualties in snowy and icy conditions. Prioritizing walking and cycling areas in winter road maintenance seems to be beneficial both with regard to injury reductions and with regard to costs for healthcare and sick leave due to injuries from slip accidents. However, a major difficulty in preventive work is that winter road maintenance costs mainly affect the budget of municipalities and property owners while the damage costs mainly affect county councils and regions.

About one third of the road users enrolled in hospitals in Sweden are cyclists and the majority of them have been injured in a single accident, that is to say an accident that is not due to a collision with another road user. Of all cyclists seeking emergency care, eight out of ten have been injured in a single accident and from the severely injured, seven out of ten have been injured in a single accident (Niska et al., 2013). Analysing the Swedish Transport Administration's in-depth studies of fatalities and healthcare reporting in the STRADA accident database, Niska et al. (2013), found that 27 % of severely injured cyclists in single accidents could be related to road operation and maintenance, 20 % to road design, 27 % to cyclists' interaction with their bike, 15 % to cyclist behaviour and state and 11 % to interaction with other road users. Older age groups occur in both fatality accidents and severe accidents to a greater extent than younger - more than 40 % among the killed and severely injured in bicycle accidents were 65 years of age or older.

Niska and Eriksson (2013) claim that about 90 % of all accidents, where cyclists were severely injured in Sweden, occurred in urban areas. Eight out of ten were injured in a single accident, just over one of ten in a collision with a motor vehicle. Of the killed cyclists 69 % died of collision with motor vehicles. In about half of all single casualties, which account for about 80% of all bicycle accidents, road environment factors contributed to the accident (Niska and Sjögren, 2007). The largest contributory factor to single bicycle accidents is slippery surfaces, mainly caused by ice and snow (Niska, 2010). Important countermeasures include improved winter maintenance, removal of loose gravel and adjustment of curbs, followed by separated cycle tracks, safe bicycle transfers and removal of fixed objects on and adjacent to the cycle tracks.

Sakshaug et al. (2013) found that attention to the fact that it is slippery, careful walk does not seem to be enough to avoid falls due to snowy and icy conditions. A certain amount of insecurity generally leads to more attention and thus better road safety. Sakshaug et al. (2013) claim that this also applies to fall crashes due to uneven coating. However, their study suggests that the correlation of snow and ice crashes is somewhat different. This seems to be due to the fact that the risk of ice on the footpath, especially in slope, is underestimated by younger pedestrians while the elderly are more careful when it is slippery. Partly, it seems that pedestrians, nevertheless looking carefully do not notice the danger in the form of ice under the snow. Field studies show that, with the exception of some older people, there are very few who took take a detour to go on a bare ground instead of on an ice-covered surface. Many do not seem to take

the risk of a fall accident very seriously. A few places that become extra slippery make many people slip. If these spots could be corrected at once, many fall accidents could be prevented.

Summarising accident studies in Sweden, Arvidsson (2016) concluded that in 38 % of reported accidents between 2008 and 2015 (82,559), the accident occurred on a sidewalk. The most common reasons for a person had hurt him/herself was that the surface was uneven, presence of holes and pits or level differences. The reduction in the number of level differences in the urban environment, such as sidewalks at transitional points, could reduce the number of falls for pedestrians. Friction requirements for various types of pavements on sidewalks and footpaths should also be reviewed.

Eriksson and Sörensen (2015) studied the importance of winter weather for pedestrians to be injured in single fall casualties using data from Swedish emergency hospitals and from the Transport administration's weather information system. The results show that more than 10 times more pedestrians are injured in single accidents due to slippery surface in urban areas compared to outside urban areas. Female pedestrians are injured to a greater degree than men. Women are also more seriously injured. Men have a higher proportion of slip accidents due to snow and/or ice, compared to other types of accidents, in relation to the distribution of accident types for women. Instead, women have a higher proportion of injury in case of other accident causes (e.g. uneven ground, tripping).

A scoping review of literature on pedestrian falls published between 1995 and 2015 (Schepers, et al., 2017) shows that more walking is related to a lower risk of pedestrian falls. Older people, especially older women, have a higher risk of (injurious) pedestrian fall. Outdoor fall victims have equally good or better health characteristics and scores on balance tests compared to those who have not experienced such falls. Road factors such as uneven surfaces, busy junctions, stairs, and slippery surfaces seem to play an important role in pedestrian falls. Pedestrian falls victims are generally in good health (apart from normal age-related problems) but at risk due to road factors. The conclusion and recommendation of the study was that the road system should be adapted to human capabilities and limitations including those of pedestrians. Measures such as preventing uneven surfaces and good winter maintenance seem to be effective. Also more quantitative research on road factors to inform design guidelines and standards for public space authorities was proposed.

1.1.2 Pedestrians' and cyclists' needs and conditions

Rosenkvist, et al. (2013) conducting a survey among people aged 65+ years in Malmö, Sweden and found that the cycling was perceived as something positive; exercise, air, freedom, etc. Around the age of 75 years, the percentage of those cycling significantly decreased. What made people stop cycling was both their own health and the traffic environment that felt dangerous. It was concluded that through measures in the environment more elderly people could be able to cycle further over the years.

Lundgren and Aylward (2015) conducted a survey of the elderly's experience of fall crashes on snow and ice with the purpose of highlighting the elderly's experience of winter road maintenance and any restrictions that may arise in everyday mobility for older people winter time. Half of all respondents had fallen over snow or ice, about two thirds of which had fallen more than once. Of those who fell 10 % have been so badly injured that they have had to seek care at a health centre or emergency department. Twenty nine percent have ever avoided going out because of the risk of slipping and 12 % say they avoid going out at least once a year. Twenty percent have had the help of relatives to transport themselves because of the hail, one or more times in the past five years. Twelve percent need at least once every winter to take an alternative route to, for example, public transport or the deal due to the risk of slipping. Of those who have a service, half indicate that they use the service more often winter time due to the risk of slipping. Almost half (47 %) often use slip protection when it's low and one third think winter road maintenance is insufficient in the areas where they usually go. The use of anti-slip protection is evenly distributed between the sexes, i.e. there is no clear difference depending on whether the respondent is male or female. But even though more men than women have slipped, more women than men have been injured to such an extent that it required care. More women than men say that they did not go out because of the risk of slipping and more women than men say they have taken an alternative route because of the risk of slipping. The result thus suggests that women experience a greater restriction of their mobility in winter than men do. An alternative explanation could be that men seek care to lower extent and/or do not want to admit that they avoid going when it is slippery outside.

Wennberg et al. (2009) examined older peoples' needs as pedestrians and their perceptions of the outdoor environment. The results show that older people consider accessibility/usability issues as very important and that the importance depends on such individual background variables as age, sex, occurrence of functional limitations, use of mobility devices, and

dependence on walking as transport mode. In bare-ground conditions, physical barriers are more important for the oldest old (80+) and for older people with functional limitations or mobility devices. However, orderliness-related issues (e.g. cyclists in pedestrian areas, lighting, and litter/graffiti) are equally important regardless of the background variables. In snow/ice conditions, ice prevention is considered more important than snow removal. Snow removal on a detailed level (e.g. removal of heaps of snow on pavements and at zebra crossings) is emphasised.

A literature study on the situation of pedestrians and cyclists in rural areas (Rosander and Johansson, 2012) concluded that the understanding of the problem of unprotected road users in the current environment is relatively high. One trend that can be distinguished is that the studies often deal with the issues individually and focus primarily on planning, safety and security and not so much on accessibility. There is a wide range of studies on the ability of unprotected road users to travel with the same type of transport quality as other road users, especially in rural areas or in small towns. The overall conclusion is that there is a lack of studies that take a holistic approach of the unprotected road users' situation in the transport environment.

The findings above highlight the extent of pedestrians' and bicyclist's safety, security and accessibility problems connected with maintenance of the infrastructure. More knowledge is needed on how pedestrians and cyclists experience accessibility, safety and security, how maintenance of the infrastructure affect their behaviour and how planners and decision makers consider these issues.

1.2 Aim

The aim of the literature review was to compile existing knowledge on operation and maintenance of the transport infrastructure for pedestrians and cyclists, to highlight how operation and maintenance affect pedestrians and cyclists, in terms of accessibility, safety and security. The aim was broken down into the following objectives:

- What issues of maintenance of the infrastructure affect experienced accessibility, safety and security of pedestrians and cyclists?
- How does maintenance of the infrastructure status affect pedestrian and cyclist behaviour?
- How do planners and decision makers consider these issues?

2 Method

A literature search was conducted in the Swedish National Library Catalog TRANSGUIDE, as well as in Web of Science and Scopus.

Search in TRANSGUIDE

A literature search in the Swedish National Library Catalog TRANSGUIDE was conducted at the end of August 2017. The TRANSGUIDE database contains over 140,000 references to Nordic and English-language publications. The literature is in the areas of traffic, road users, vehicles, transport and infrastructure.

The keywords were as follows:

- pedestrian, walking, cyclist, cycle, bicycle, bike, unprotected road user, vulnerable road user, VRU, old* OR elder* OR senior OR disab* OR impair* OR handicap* OR mobility
- security, safety, accessibility, level of service, needs, attitude, satisfaction, experience, behaviour, AND mobility OR availability OR usability OR assessment OR evaluation
- operation, maintenance, condition, AND snow* OR ice OR icy

The search string including the above keywords was as follows:

(pedestrian? OR walk? OR ?cycl? OR bike? OR unprotected OR vulnerable OR VRU OR old? OR elder? OR senior OR disab? OR impair? OR handicap? OR mobility) AND (security OR safety OR accessibility OR level of service OR mobility OR availability OR need? OR usability OR assessment OR evaluation OR attitude? OR satisfaction OR experience OR behavio?) AND (operation OR maintenance OR condition OR snow? OR ice OR icy) NOT (railway OR maritime OR life-cycle OR energy OR highway OR ?signal? OR ?vehic? OR Motorcycle OR material? OR crash? OR model? OR emission? OR concrete)

The publication period was limited to 2007-2017. The search gave 62 hits, of which 52 were less or not relevant at all.

Search in Web of Science

The second literature search was made in the interdisciplinary database Web of Science Core Collection, which is a collection of databases / citation indexes with bibliographic information and citation data. In this search, the four citation indexes for journals and the two indexes for conferences have been searched. Altogether, there are just over 12,000 journals and 148,000 conference pressures indexed in the requested indexes. More information about the Web of Science can be found here:

https://images.webofknowledge.com/WOKRS5251R3/help/WOS/hp_database.html#dsy367-TRS_science_citation (Generally about WoS)

<http://ip-science.thomsonreuters.com/mjl/> (search about indexed journal articles)

<https://clarivate.com/essays/journal-selection-process/> (WoS selection process)

Generally about the search strategy

Block search has been used, which means that every aspect of the search query is initially treated separately in the search. Based on a single keyword search, scanned hits and keyword lists search for additional synonyms and related terms that are added to the search string. When saturation occurs (same terms return, no new terms appear), the completed search blocks are combined to the final search query.

The search was conducted on 27th of September 2017.

Search nr	Search string	Limitations	Hits
1	TS=((road* OR street* OR pavement* OR sidewalk* OR footway*) NEAR/3 (maintenance* OR maintain* OR administer* OR manag* OR condition* OR repair* OR operation* OR winter OR snow* OR ice OR icy OR sand* OR salt* OR sweep* OR plow*)) OR "winter maintenance*" OR "snow remov*" OR "snow clear*")	-	16012
2	TS=(pedestrian* OR walking OR walker* OR *wheelchair* OR "*wheel chair*" OR "mobility aid*" OR "mobility device*" OR "mobility tool*" OR amd* OR *cyclist* OR cycling* OR bicycl* OR bike* OR biking OR "cycle transport*" OR "vulnerable road user*" OR vru)	-	390491
3	TS=(experience* OR view* OR perception* OR perceive* OR perspective* OR satisf* OR attitude* OR interview* OR survey* OR questionnaire* OR behavio* OR choice* OR (decision* NEAR/1 mak*) OR preference* OR psycholog*)	-	8320958
4	#1 AND #2 AND #3	Timespan: 2007-2017	275

The number of hits was 275, which, after exclusion of non-relevant scientific fields (computer science, mathematics, etc.) was limited to 152 titles. After reviewing these titles, it was found that 27 publications seemed relevant, the abstract of which was examined. After reading the abstracts, 18 pcs were found relevant.

Search in Scopus

The third literature search was made in the interdisciplinary database Scopus. Scopus contains bibliographic information and citation data for approximately 23,000 serial titles (magazines and conferences) and for over 150,000 books. More information about Scopus is available here:

The search was conducted on 27th of September 2017.

Search nr	Search string	Limitations	Hits
1	TITLE-ABS-KEY (((road* OR street* OR pavement* OR sidewalk* OR footway*) W/3 (maintenance* OR maintain* OR administer* OR manag* OR condition* OR repair* OR operation* OR winter OR snow* OR ice OR icy OR sand* OR salt* OR sweep* OR plow*)) OR "winter maintenance*" OR "snow remov*" OR "snow clear*")	-	30 915
2	TITLE-ABS-KEY (pedestrian* OR walking OR walker* OR *wheelchair* OR "*wheel chair*" OR "mobility aid*" OR "mobility device*" OR "mobility tool*" OR amd* OR *cyclist* OR cycling* OR bicycl* OR bike* OR biking OR "cycle transport*" OR "vulnerable road user*" OR vru)	-	462 458
3	TITLE-ABS-KEY (experience* OR view* OR perception* OR perceive* OR perspective* OR satisf* OR attitude* OR interview* OR survey* OR questionnaire* OR behavio* OR choice* OR (decision* W/1 mak*) OR preference* OR psycholog*)	-	13 022 859
4	#1 AND #2 AND #3	PUBYEAR 2007-2018	403

The number of hits was 403, which, after exclusion of non-relevant scientific fields (computer science, mathematics, etc.) was limited to 36 publications. After reading the abstracts, 6 pcs were found relevant. Two of these publications overlap with hits in the Web of Science Core Collection.

3 Experienced Accessibility, Safety and Security

A survey with the aim of gaining knowledge about the travel habits of residents and their experience of safety and security in small towns and villages in northern Sweden was conducted by Rosander and Johansson (2011). The results showed that almost half of the respondents believed that the road through their town was unsafe, especially during winter conditions or in darkness, and especially when traveling as a pedestrian or cyclist. Many cyclists and pedestrians answered that they were worried about an accident and one of the most common views was that the space on the road was too narrow.

Arnehed and Johansson (2012), in a survey on pedestrians' and cyclists' experienced accessibility, safety and security along major roads in Sweden found that respondents generally expressed anxiety for their safety and security. Those who were most satisfied were those who lived and travelled along a road where their path was separated from motorised traffic with railing. Those who were most concerned were those who lived along road where the separation only consisted of painted lines on the road surface. Also, darkness created more insecurity. The largest percentage of people who felt insecure, in both daylight and darkness, concerned walking and cycling areas, only separated with a painted line.

Customer surveys, carried out in 100 municipalities in Sweden in the spring of 2013, on how citizens perceive the municipality's service in terms of streets, parks, water/sewage and waste disposal (Bylund and Lille, 2010) showed that 61 % of the responding residents in all municipalities thought that the snow removal on the major streets was well maintained and 48 % thought it was well maintained on the street where they lived. The residents generally found that snow removal was better done on major streets of the municipality than of the street where they lived. Nine percent thought that the municipality should salt more on the streets. Twenty two percent wanted to salt fewer streets and 29 % thought that salt should not be used at all. Men thought to a greater extent than women that salt should not be used at all.

A Dutch study (Wijlhuizen, De Jong and Hopman-Rock, 2007) aimed at testing the assumption that the level of outdoor physical activity mediates the relationship between fear of falling and actual outdoor falls. A prospective follow-up study of 10 months was conducted in three municipalities in the Netherlands. The participants were 1752 people aged 65 and older, living independently. The results showed that people with a high fear of falling were more often low to moderately active compared to people who had no such fears and were more often very

active. Fear of falling was not associated with outdoor falls, but it was when taking the level of physical activity into account. Outdoor physical activity mediated the relationship between fear of falling and actual outdoor falls. This implies that the incidence of falls as an outcome in studies did not adequately represent the impact of risk factors for falls and that the level of physical activity should be taken into account.

Rantakokko et al. (2009) studied which individual characteristics and environmental factors correlated with fear of moving outdoors and whether fear of moving outdoors predicted development of mobility limitation. Seven hundred twenty-seven community-living people aged 75 to 81 were interviewed at baseline, of whom 314 took part in a 3.5-year follow-up study. The results showed, that at baseline, 65 % of the women and 29 % of the men reported fear of moving outdoors. Poor socioeconomic status, musculoskeletal diseases, slow walking speed, and the presence of poor street conditions, hills in the nearby environment, and noisy traffic correlated with fear of moving outdoors. At the first 6-month follow-up, participants with fear of moving outdoors had more than four times the adjusted risk of developing difficulties in walking 0.5 km and a three times greater adjusted risk for developing difficulty in walking 2 km compared with those without fear. The difference in the prevalence of walking difficulties remained statistically significant over the 3.5-year follow-up. The conclusions from the study were that fear of moving outdoors was common in older adults and increased the risk of developing self-reported difficulties in walking 0.5 km and 2 km. The study concluded that knowledge about individual and environmental factors underlying fear of moving outdoors and finding ways to alleviate fear of moving outdoors are important for community planning and prevention of disability.

Focus group discussions with various categories of pedestrians were conducted in Luleå, Västerås and Älmhult in Sweden with the purpose of describing pedestrians' situation in some urban environments (Berglund, et al., 2011). The findings indicated that the life situation affected what was important when or if walking. Nice nature was generally considered to be the best of walking environments in all places. The interviewed youngsters mainly walked for utility reasons - to and from school, exercise, bus, or train, but also to hang out. Recreational interest and social interactions seemed to affect young people's walking habits more than the place itself. The interviewed seniors walked both for utility reasons and for recreation. The health status of seniors was of great importance. For the seniors, even surface and good road maintenance, as well as proximity to social services were particularly important. For working

people factors such as time, efficiency, proximity to the home, the quality of the surroundings, the basis and security are important aspects. Overall, the participants were satisfied with their walking environment. For the seniors, the biggest problems were snow removal wintertime and uneven walking surfaces that gave water accumulations and risk for stumbling. Also, tunnels under the road/railway were seen as a problem. Misplaced walking tunnels appeared to be a common problem in residential areas. Seniors experienced cyclists to pass in the wrong direction and cyclists not heard but suddenly appearing on the combined pedestrian/cycle path as a problem (Berglund, et al., 2011).

Ullberg, et al. (2013) conducted a survey in five Swedish towns (Båstad, Luleå, Västerås, Älmhult and Östersund) among citizens of age 16 to 84 with the aim to capture walking habits and views on good and less good walking environments. Between 24 % and 44 % of the respondents went to and from work/school/education on foot at least once a week. The respondents were relatively pleased with the space available for walking but they were not as happy with the lighting. About 40 % stated that they chose to always or often go where they saw or met other people. People actively chose beautiful surroundings when they went for exercise or recreation, compared to what they thought about the environment where they travel on foot in everyday life.

Björklund et al. (2014) conducted a focus group interview with ten participants consisting of four men and six women between the ages of 18 and 75, with the purpose of finding out which factors are important for pedestrians when choosing a walking route. The results showed that individuals did not seem to prefer separated walking and cycling paths. Most important seemed to be that the walk took place on a walkway of some kind and not along the roadside with motor vehicles. The view seemed to be of importance when people chose which way to go. Other roadway attributes, such as maintenance, closeness to road with motor vehicles and type of intersection did not seem to have as much importance.

A knowledge overview (Niska and Sjögren, 2007) showed that road surface condition was of significant importance for cyclists' perception of the cycling friendliness of a bicycle path. Cyclists preferred a smooth road surface, well cleaned with satisfactory friction and they were significantly more sensitive to road surface defects than motorists were. Even a slight irregularity or a slippery spot may be experienced as unpleasant.

The inclination to cycle is affected by - in addition to the wish for exercise - several factors (Lindelöw, 2009). Experienced obstacles to cycling are bad weather, altitude differences,

quality of the cycle infrastructure, long distances and poor safety (Eriksson, 2009). Karlsson (2000) also showed that wind, precipitation, snow and temperature were important factors for bicycle exposure. A survey (Bergström and Magnusson, 2003) showed that there was a great potential to influence cycling in winter through better winter road maintenance: snow removal proved to be the most important maintenance measure. Slipperiness was not considered as important for the choice of means of transport, but it was important to take care of it for safety reasons.

Kröyer, Eriksson and Forsman (2017) investigated the relationship between cycling and weather conditions in Sweden and found that higher air temperature, no precipitation, increased sunshine and low wind speed correlated with higher cycling exposure. The winter season, October-April accounted for between 40-60 % of the cycling volume of the summer season, so there is a great potential to extend the summer season by moving the transition periods through better winter road maintenance for cyclists.

Focus group meetings with cyclists in Sweden revealed that concerning safety - besides other road users and geometric design - shortcomings in maintenance appeared to have the greatest importance (Niska, 2010). Maintenance was significant for the decision to cycle, mainly in the winter, but this mainly applied for those people's decision who cycled daily. Maintenance of high standard has an immediate effect on accessibility during short periods and it is of importance to retain the daily bikers (Niska, 2010). Dozza and Werneke (2014) collected naturalistic cycling data from 16 bicyclists to estimate risk while cycling and found poor maintenance of the road to increase the risk tenfold.

4 The importance of the built environment and its maintenance for road user behaviour

Faskunger (2007) studied the impact of the built environment on people's physical activity and found that: people living in "walkable" residential areas were more physically active compared to residents in other areas. Walking and cycling-friendly cities and towns also contribute to better social health with increased social contacts and increased social capital or citizenship. Proximity and high availability of services, facilities, parks and green spaces, gyms, walkways, meeting places, etc. are extremely important for bringing about changes in the population's patterns of movement, especially when it comes to encouraging everyday activities such as walking or cycling to settle matters. The more supportive environments, places and facilities there are in an area, the higher the likelihood that those living in the area are regularly physically active (Faskunger, 2007).

Built environment characteristics that hinder a physically active lifestyle are poor lighting, long distance to targets, inadequate infrastructure for active transport, high traffic volume and high speed of motor vehicles. Issues, preventing elderly from being outdoors are often uneven surface on sidewalks, high traffic volume, noise, air pollution, isolated places, lack of benches to rest, poor maintenance of sidewalks and cycle paths, and worries about violence (Faskunger, 2007). The security issue is of great importance to people's physical activity, especially for women, children, the elderly and the disabled. Measures to improve security through the built environment are, for example, better lighting, creating sight lines, building traffic-separated walking and cycling routes, as well as taking measures to reduce traffic speed (Faskunger, 2007).

Jägerbrand (2011) studied how much of street lighting is lost on walking and cycling routes due to shade of trees. The results show that all types of protruding, shady vegetation at pedestrian and cycle paths have a potentially blocking effect on illuminance. Such protruding vegetation can cause a reduction of illumination levels by between 27-77 % and all investigated shaded road sections therefore ended up in a lower lighting class compared to their original class. Accordingly, current Swedish guidelines for free height over walking and cycling paths do not appear to be sufficient to prevent shadow effects of trees at night.

Shay et al. (2009) examined associations between pedestrian facilities and walking behaviour of Montgomery County, USA and found that crossing aids and good sidewalk conditions were associated with walk trips more than were other pedestrian facilities. The conclusion from the study was that travellers may respond to environmental features closer to their residence more strongly than to more distant environmental qualities.

Lu (2010) explored assisted living residents' walking behaviour, locations where residents prefer to walk, and walking environments in and around assisted living facilities in a major city in Texas. The results indicate that (a) residents were walking both indoors and outdoors for exercise or other purposes (e.g., going to destinations); (b) assisted living facility planning and design details such as neighbourhood sidewalk conditions, facility site selection, availability of seating, walking path configuration, amount of shading along the path, presence of handrails, existence of signage, etc. - may influence residents' walking behaviour; and (c) current assisted living facilities need improvement in all aspects to make their environments more walkable for residents.

Rantakokko et al. (2010) examined the association between barriers in the outdoor environment and perceived quality of life in old age and to assess whether fear of moving outdoors and unmet physical activity needs contribute to this association. Face-to-face home-interviews with 589 community-dwelling people aged 75 to 81 were made. Quality of life was found to be worse among those who reported more barriers in their outdoor environment, experienced fear of moving outdoors or unmet physical activity needs, and also had slower walking speed and more chronic diseases. Terrain, traffic and distances influenced quality of life through fear of moving outdoors or unmet physical activity needs, whereas distances had a direct association with quality of life.

Wallmann et al. (2012) conducted a cross-sectional survey with inhabitants of urban and rural areas in the western part of Germany on the association between physical activity and variables of the perceived environment. The findings showed associations between physical activity and access to destinations, well-maintained sidewalks, seeing physically active people in the neighbourhood and neighbourhood safety.

Rosenberg et al. (2013) conducted in-depth interviews with 35 adults over the age of 50, who used an assistive device and lived in Washington, USA. Participants were on average of 67 years of age and predominantly used canes, walkers, or wheelchairs. Key themes pertained to sidewalk availability and condition, ramp availability, hills, aesthetics, lighting, weather,

presence and features of crosswalks, availability of resting places and shelter on streets, smooth walking paths, safety, and traffic on roads. It was found that a variety of built environment barriers and facilitators to neighbourhood-based activity existed for midlife and older adults with mobility disabilities. The conclusion from the study was that the quality of neighbourhood environments for an aging population that uses assistive devices is important to foster independence and health.

Stamps (2013) carried out experiments with various stimuli involving 112 participants to obtain ratings of perceived threat, perceived walkability, and perceived enclosure for different types of surfaces: pavement, grass, sand, and rocks. It was found that perceived walkability and type of surface underfoot were highly correlated. Environments in which the surface were difficult to walk over were perceived as being more enclosing and more threatening than surfaces that were easy to walk over.

Annear et al. (2014) explored the evidence for environmental influences on older adult health and activity participation. The findings show that reported environmental influences on activity participation included climate, level of pollution, street lighting, traffic conditions, accessibility, appropriateness of services and facilities, aesthetics, pedestrian infrastructure, community life, socio-economic conditions, exposure to antisocial behaviour, social network participation, environmental degradation, level of urbanism, exposure to natural settings and familiarity with local environment.

Kwarteng et al. (2014) assessed relationships between neighbourhood environments and physical activity and the extent to which these associations varied by demographic characteristics or perceptions of the physical and social environment in low-to-moderate income neighbourhoods in Detroit, Michigan. The findings suggest that sidewalk improvements and reductions in physical disorder in urban communities may promote greater equity in physical activity.

Adams et al. (2016) examined the associations of perceptions of the environment in the workplace 'neighbourhood' and commuter walking. Respondents were significantly more likely to walk for their daily commute if they reported there to be convenient walking routes, suitable pavements, maintained pavements or convenient public transport. It was concluded that improving and maintaining the walking environment around existing workplaces and ensuring infrastructure around new workplaces designed to support commuter walking should be considered a priority area for investment.

Aldred et al. (2017) made a systematic review of stated preference studies examining the extent to which cycle infrastructure preferences vary by gender and by age. A few of the studies covered preferred winter maintenance methods and attitudes to cycle track lighting. It was found that women reported stronger preferences than men for greater separation from motor traffic. Also, a few studies suggest that women may be more likely to be affected by winter conditions, hills, and personal safety concerns. One of the conclusions from the review was that, in low-cycling countries seeking to increase cycling, focus should be on the stronger preferences of under-represented groups as a necessary element of universal design for cycling.

Perez et al. (2017) analysed levels of physical activity of 436 Latinas in San Diego, California and found significant positive associations, among others, between having destinations within walking distance from home and transportation. Also, significant interactions were found of income with aesthetics and sidewalk maintenance. A significant positive association between better perceived sidewalk maintenance and leisure-time physical activity was found among those with a higher household income.

Forsman, Gustafsson and Werner (2011) analysed travel surveys in Sweden with the aim of highlighting cyclist and pedestrian traffic on a general level, and to what extent cycling and walking were combined with other modes of travel within the same journey and, on the other hand, how cycling and walking were distributed in different traffic environments. The results showed that cycling was included as at least one of the modes of travel in 13 % of all work trips. In terms of walking trips, the corresponding figure was 33 %. For cycling, it was apparent that the proportion of work trips by bicycle was significantly higher in summer than in winter. The average walking distance was slightly longer in winter than in summer. However, for trips that were combined with other modes of transport, the percentage was slightly higher in summer than in winter. Some differences were found between men and women, both in terms of cycling and walking. In terms of bicycle, the proportion of bicycle trips was higher among women than men, but the average bicycle distance was longer for men. For walking trips, both the proportion of travel and average travel length were longer for women than for men.

Antonakos (1994) studied cyclists' opinions on environmental design issues and examined the influence of personal characteristics, travel resources, and travel constraints on cyclists' environmental preferences, evaluations of cycling conditions, and decisions to bicycle for transportation. Age was positively correlated with preference for on-road facilities, with importance placed on surface quality and scenery. Age was negatively correlated with

preference for bike paths separated from the roadway. Safety, scenery and terrain were more important to women on average than to men. Cycling experience was negatively correlated with preference for off-road facilities and concerns about safety, traffic and terrain.

A survey by Ward Thompson et al. (2012) in locations across England, Wales and Scotland showed outdoor activity predicted by having a clean, nuisance-free local park, attractive, barrier-free routes to it and other natural environments nearby. Being able to park one's car outside the house also predicted time outdoors.

A literature review by Jonsson and Svensson (2012) points out that the bicycle should be treated as a vehicle. If the conditions for cycling on a road are bad, people simply choose not to cycle there. The same applies to the use of bus stops on major roads. If the bus stop is difficult to access or otherwise not inviting, one can choose not to use the bus stop and travel by own car instead. Road safety and safety are factors that are highlighted as important to consider, both when it comes to cycling and walking on a country road as when waiting for a bus at a bus stop on a major road.

A study in the Netherlands, analysing bicycle use in almost 60 towns concluded that good cycling conditions lead to higher bicycle use and vice versa: towns with many cyclists have more effective bicycle policies - a self-reinforcing process. Small towns may relatively easily gain by improving competitiveness of bicycles in comparison to cars. Major cities face the challenge of making cycling more attractive: better circulation, less traffic obstacles and less noise (CROW, 2017).

A paper by Rietveld and Daniel (2004) analyses to what extent municipality policies matter in explaining variations in bicycle use between countries and cities. It appears that most of the inter-municipality variation in bicycle use is related to physical aspects such as altitude differences and city size, and features of the population (share of youngsters). Differences in ethnic composition also appear to matter. Important policy-related variables are: the number of stops cyclists have to make on their routes; hindrances in road use; and safety of cyclists. In addition, the relative position of bicycles with respect to cars (speed, parking costs) also appears to matter. These results shed light on various components of the cyclists' generalised costs, such as those related to accidents and physical efforts that are not usually considered.

5 Planers' and decision makers' view on the issue

Johansson, et al. (2012) conducting interviews with traffic and community planners in Swedish municipalities found that the concepts of travel choice - route selection - built environment have proven to be central for pedestrians. Society needs to provide more space for pedestrian issues and create the image that walking traffic is a norm, thereby giving it higher status. There is lack of data describing and quantifying walking, and there is a lack of methods for measuring walking.

Wennberg (2009) examined the implementation process in municipal planning, and effects of measures taken, to achieve barrier-free outdoor environments. The findings show a large variation in the implementation process concerning accessibility among Swedish municipalities. Removal of physical barriers the year round have potential for encouraging walking in old age, especially among older people with functional limitations and mobility devices. A travel-chain perspective on accessibility is essential though involving removal of physical barriers from indoor to outdoor environments, from one transport mode to another, from public to residential areas. Older peoples' needs as pedestrians are not completely fulfilled by current legislative directives on accessibility, which calls for a focus on other issues as well, e.g. problems with bicycles and cyclists on pavements and footpaths as well as the need for benches to rest on. There is a need for improved ice prevention and snow removal. In addition, safety/security-related issues are important, however, barrier-free environments are to be considered as a basic precondition for peoples' ability to use an environment at all.

According to road maintenance administrators the most difficult conditions to manage in cycleway maintenance is thawing and freezing, resulting in slush followed by icy ruts and slipperiness (Niska, 2010). Wiklund and Malmberg (2012) studied written winter road maintenance agreements in 13 Swedish municipalities and found that the requirements for snow removal often are very general and in many cases, there is no specific description of how snow removal at pedestrian crossings should be performed. The most common functional requirements are that pedestrian crossings should be kept free from snow leys to ensure good visibility and that there should be no snow strings or ramps that limit the ability of disabled people to walk. However, only a couple of municipalities have chosen to define what is considered to be an acceptable height of the resulting snow ley. As regards accessibility for the disabled, there are no examples of what is considered acceptable heights. All municipalities

have defined the starting criteria for the start of snow removal in the terms of the contract, but since snow is a weather phenomenon that can have many different characteristics, it is difficult to define starting criteria solely on the basis of the amount of snow. A large part of the municipality's actual functional requirements are instead communicated through verbal agreements rather than in written agreements. This makes the routines very vulnerable and there is a high risk that important knowledge is not managed and gets lost. Unclear and overly general functional requirements leave a large margin of interpretation and are likely to be perceived differently by clients and performers, thus leading to misunderstandings and uncertainties about how and when the snow removal is to be carried out. The agreements between the municipality and the contractor, therefore require consensus and good communication in order for the snow removal to work as the municipality wishes. The ability to ensure good snow removal through fines seems to be most formal in the agreements rather than actually being issued when snow removal has not been carried out in accordance with the stated functional requirements. A review of planning and design guidelines (Gustafsson, Wiklund and Archer, 2011) revealed that there are many different standards for what is seen as good quality and standard bicycle infrastructure in Sweden.

Koglin (2013), studying cyclists' experiences through surveys in Stockholm and Copenhagen found that cyclists in Copenhagen had a more positive view on planning, infrastructure, etc. than cyclists in Stockholm. It seemed that the perception of decision makers and politicians on the outcome of their decisions did not correspond to cyclists' experiences. For example, in Copenhagen - a city that clearly prioritizes cycling - still motor traffic created the biggest problems for cyclists. Neither Copenhagen nor Stockholm have managed to break free from the dominance of the motorised transport to create a truly sustainable traffic system.

Niska, Johansson and Caesar (2013) conducted interviews with municipal operating and planning staff, expert seminars and a survey of all municipalities in Sweden with the purpose of identifying the difficulties in managing and maintaining traffic safety and accessibility measures and finding possible solutions to the problems. The conclusion from the study was that there was reason to review the detailed design of all pedestrian crossings from an operational and maintenance perspective. The difficulty lies in finding a balance between different goals and interests such as road safety, accessibility and aesthetics as well as practical maintenance and costs. What is available to everyone under bare surface conditions is not available to everyone in the winter. All use of tiles and stones increases the need for

maintenance. Tactile tiles are extra problematic as they are difficult to clean. The directional edges for visually impaired and the 0.9 to 1 meter wide ramp to zero level, which are designed to make it easier for people with disabilities to cross a street are design details that are the biggest problem for winter maintenance. The possibility of using smaller vehicles during snow removal has been investigated, but with the conclusion that there is currently no alternative. In order to maintain accessibility and road safety in all circumstances, operational issues need to be considered in the planning and design phase, and operating procedures and methods need to be adapted to the new design features. More detailed descriptions on procurement and better follow-up are needed.

Rosander and Johansson (2013) conducted a review of some of the most common planning models and methods used in traffic measures in Sweden with the overall aim to investigate how the demands of pedestrians and cyclists can be considered. It was unclear whether pedestrians and cyclists were considered in particular, or at all in the planning models. In addition to developing the assessments in socioeconomic calculations in order to better take into account the benefits of walking and cycling, increased awareness is needed to make clearer priorities for non-quantifiable effects in assessments. This is especially true of accessibility, giving everyone a basic accessibility with good quality.

Interviews with officials in 13 Swedish municipalities (Niska, 2006), showed that the municipalities largely follow standard requirements for construction of bicycle infrastructure, but have their own operating and maintenance guidelines, where cycling routes are often prioritized. The lack of resources is considered to be the biggest obstacle to offering a good standard. The majority of the interviewees consider winter road maintenance the hardest part of operation and maintenance of cycle paths. The need for an even surface standard is also highlighted, given the cyclists' sensitivity to irregularities. The public is seen as a resource in detecting deficiencies. The most common notifications, related to the operation and maintenance of cycle paths are broken glass and slipperiness.

Nilsson, et al. (2013) studied how Swedish municipalities can work more systematically with planning and design for pedestrians and found that there is a gap between the vision and what one actually plans for in society and how society is developing. The questions are not clearly visible in the planning process and detailed knowledge about the claimant's claims is still missing. Security, safety and road maintenance are important for all motives to walk (to work / school and other goals, for exercise and recreation or for social reasons), whereas accessibility,

directness, surface smoothness and the environment play a significant role for different persons. This does not mean planning separate networks for different groups, such as working people have an interest in combined exercise and recruitment, but taking into account the motives that need to be met in different parts of the urban area. Lack of lighting is a barrier to several groups of night time and lack of winter road maintenance and uneven surfaces, a barrier to, above all, the elderly. One of the most important results was the lack of data describing and quantifying behavior as a mode of transport. In the municipalities, work is seen as a continuous process, although often a forgotten mode of transport. Traditionally, the car has been the focus of planning. Society needs to provide more space for pedestrian issues and create a picture of the fact that walking traffic is fundamental and thus gives higher status. Walking should be treated as a separate transport mode and come in at an early stage. There is a need for support to prioritize walking and making sure not to lose the walking issue in the regular planning process.

Grönvall, Johansson and Niska (2013) identified a number of conflicts between safety and accessibility versus operation and maintenance: a) street environment furnishing that complicates snow removal and cleaning; b) design and details of surface layers, curb and elevations that make it difficult for snow removal and cleaning; (c) rate-damping design that impairs operation. The conclusion was that most of the identified conflicts still have a need to study more closely. Several of the identified conflicts require that different areas of interest be given the opportunity to jointly develop design requirements that work for all parties. There is a need to invite expertise in different focus areas and, in cooperation with the group, develop appropriate design and method proposals.

An expert workshop with the purpose of discussing various proposals for cycling and walking measures on major roads (Jonsson et al., 2013) concluded that detailed design of any chosen solution was considered to be very important. Small details can make the facility difficult to use, thus creating unnecessary problems. Factors often mentioned were the presence of lighting, separation, and dimensions of the facility. Overall, lighting was always considered a relevant measure, whether traveling along or across a road was discussed. Also, safety and security were considered important. Understanding within the groups was, however, that cost considerations sometimes had to allow lower degrees of separation were also considered useful but in turn demanded low speeds. The dimensions of the infrastructure were considered important, a cycle path or walkway must be dimensioned so that road users can fit even when they have to interact with each other.

A survey, including interviews, focus group studies and follow-up studies with stakeholders in carried out in Sweden (Gruhs, et al., 2011) showed that there were a number of conflicts between safety and accessibility versus operation and maintenance. Nevertheless, conflicts have only been described to a limited extent in research literature and planning documents. No literature has specifically studied the conflicts between safety and accessibility versus operation and maintenance. However, the questions are referred to as needs or wishes in different contexts.

With regard to accessibility for people with disabilities, there are detailed guidelines from the Swedish National Board of Housing, Building and Planning - BOVERKET (2003, 2004) where several of the design requirements are governed. Accessibility and traffic safety are addressed in a series of reports aimed at traffic planners, but the operational aspects are mentioned extremely sparsely in this literature. In the operating literature, it is primarily focused on operating methods at large and the problems that arise due to different types of detail design are not highlighted. The lack of research literature in this area indicates that it is important to develop better knowledge of the conflicts and possible solutions. The interviews also show that the conflicts between safety and accessibility versus operation and maintenance exist, but there have not been many systematic, practical studies or attempts to resolve the conflicts. The following conflicts could be identified:

- Furnishing a street environment that aggravates snow removal and cleaning
- Design and details of surface layers, curb and elevations that make snow removal and cleaning difficult
- Property owners responsibility for accessibility and safety
- Street sections in residential areas, speed-damping design that make operation difficult.

The municipalities do not have policies for many areas that concern pedestrians' safety work, such as speed-reducing bumps, crossing points, pedestrian areas, coatings, maintenance and top shifts. If there were written guidelines, it would be easier to implement actions, and make follow-ups and evaluations. An area where most municipalities want better resources is to correct the surface coating.

Telephone interviews with municipal officials working on traffic planning, operation and maintenance (Spolander, Gustafsson and Frodlund, 2014) found that the municipalities' focus on pedestrians seems to be relatively new. There is a great need to develop working methods for pedestrian traffic. It is unusual for municipalities to collect continuous data on pedestrian traffic, how it evolves and where conflict points exist. Pedestrian safety goals are rarely

formulated. The organization of work seems to be undeveloped. Pedestrian traffic safety is fragmented in many areas such as accessibility work, operation and maintenance, school roads. Collision accidents and single fall accidents are often handled by different departments and by different persons. Mostly, there is no designated overall responsibility for programs for pedestrian safety, traffic plans and budget. Only in a few municipalities there is a person who is particularly responsible for the coordination of pedestrian issues.

Massart (2016), after a market survey for different types of measurement equipment, put forward an approach to develop an evaluation method for footways, based on a network analysis. Additional information (complaints/defects) is obtained from users, through a smartphone app. The basic idea is that a main inspection is done by the manager at least once a year. An operator travels on a footway with a wheelchair, which is the most "sensitive" type of footway user. This wheelchair is equipped with sensors (of a smartphone) and a skid resistance-measuring device. Three parameters (comfort/longitudinal unevenness in the direction of travel, gradient in the direction of travel, and cross fall) can be measured in one run, and a skid resistance measurement is made in each section of the network. In total, the method provides four technical indicators and feedback from the user. All this information will help the road manager to maintain the footway network.

6 Costs and benefits

It is economically profitable to invest in the infrastructure to facilitate active transport (Faskunger, 2007). Even the most costly investments in infrastructure for bicycle traffic are profitable, as research has shown that costs for chronic diseases (healthcare costs and reduced productivity) decrease for a local community. However, a strong commitment to pedestrian and bicycle traffic is required, so that more people can choose this active means of transport.

Hedström (2013) studying cost aspects of walking and cycling solutions along major roads, as well as operations and maintenance in Sweden, found that the costs of construction, operation and maintenance of walking and cycling solutions along and across major roads, is that these are often not separately reported, but are included in the total road project. In order to increase the possibility of creating attractive and cost effective walking and cycling solutions, continued knowledge building should include focus on how walking and cycling objects are handled in the initial planning process. It is also important to make systematic follow-up of completed walking and cycling objects along major roads to get a better idea of the costs of installation, operation and maintenance.

Corazza et al. (2016) elaborated an evaluation index for sidewalk conditions as a part of an efficient set-up of a Sidewalk Management System. The study relies on surveys, as well as the classification and analysis of sidewalk distresses. The authors adapted an index already standardized for roads and airports: the Pavement Condition Index (PCI). PCI has been modified to consider the specific types on the sidewalks studied within this paper. To validate the method, a pilot case study of a residential district in Rome, Italy, was carried out with promising results, however, more tests and amendments of the method are needed in order to give a useful tool for developing more accurate maintenance programs.

Bird (2008) put forward a model that enables transport authorities to compare the costs of different maintenance regimes with the benefits of accidents prevented. Factors influencing the number of accidents, including pedestrian age, defect size and footway construction were examined, and statistics of accidents requiring hospital treatment and the results of medical research into walking was analysed. For a given footway network and maintenance regime, the likely number of accidents and their cost could be calculated.

7 Discussion and Conclusions

The reviewed literature revealed a number of issues of relevance concerning the importance of maintenance of infrastructure for pedestrians and bicyclists. There are very few studies on vulnerable road users' ability to travel with the same transport quality as the other road users, especially in rural areas and in smaller cities. Furthermore, a change in attitude in decision makers and planners is needed to give walking and cycling a higher status. Moreover, studies analysed in this report have shown that the pedestrian infrastructure is not perceived to be as well developed as the one for motorised modes of transport. Pedestrians should be regarded as basic, and therefore there is a need to provide issues of consistently greater space and priority earlier in the planning process, and treat it as a separate mode of transport. The same need to promote pedestrians as a form of transport, and give it more attention in society to make walking to a standard with high status and take it as a guiding element in planning for cycling as well.

In terms of planning for walking and cycling, it is also important to calculate and measure those modes correctly and evaluate the socio-economic aspects. Studies have pointed out the need to develop economic calculations, which better take into account the overall aspects and impacts of walking and cycling in rural areas, but also in general. In order to do this, it may even be possible to use new forms of modelling and calculation that prioritise also the invisible effects and benefits of walking and cycling. This is especially important when following up the Swedish accessibility goals (providing all basic accessibility with good quality and user-friendliness) and contributing to development opportunities across the country. One problem, however, is that there is a lack of reliable data concerning walking and cycling in Sweden. Here, it is important to stress that collected data highlight the cyclists and pedestrian perspective in order to develop that focus within transport planning.

The bicycle should be treated as a vehicle and infrastructure planners must be aware of the assumptions a cyclist has. This includes planning separately for walking and cycling in which both modes should be treated as such. This is also important when it comes to maintenance of the infrastructure for cycling and walking. Studies, analysed here, have shown that there is a lack of maintenance of cycling and pedestrian infrastructure and that requirements are not always fulfilled. This might have to do with, at least in certain cases, that the road authorities does not have the resources to operate existing infrastructure in a good way. Additional measures for providing for pedestrians will increase the cost of both facilities and maintenance.

This may create a problem when currently there are insufficient resources to implement and maintain existing infrastructure of walking and cycling. Thus, there is a need to prioritise of available resources for the construction and operation of the infrastructure for walking and cycling.

Furthermore, there seems to be a lack of understanding of the user perspective of pedestrians and cyclists when it comes to maintenance, which results in more or less bad maintenance of the infrastructure for those modes of transport. Knowledge about individual and environmental factors underlying fear of moving outdoors and finding ways to alleviate fear of moving outdoors are important for community planning and prevention of disability.

No literature has specifically studied the conflicts between safety and accessibility versus operation and maintenance. However, the questions are referred to as needs or wishes in different contexts. The lack of research literature in this area indicates that it is important to develop better knowledge of the conflicts and possible solutions.

Pedestrian safety goals are rarely formulated. The organization of work seems to be undeveloped. Pedestrian traffic safety is fragmented in many areas such as accessibility work, operation and maintenance, school roads. Collision accidents and single fall accidents are often handled by different departments and by different persons. Mostly, there is no designated overall responsibility for programs for pedestrian safety, traffic plans and budget. Only in a few municipalities there is a person who is particularly responsible for the coordination of pedestrian issues.

7.1 Conclusions

Overall it can be concluded that planners and decision makers do not have a clear view on how to plan and maintain infrastructure for pedestrians and cyclists. Moreover, poor infrastructure and/or poorly maintained infrastructure for pedestrians and cyclists influences the experience negatively and leads to the sense that pedestrians and cyclists are not prioritised.

More concretely it can be said that:

- Residents' knowledge and opinions about their own city should be taken into consideration in future discussions and in planning improvement measures.
- Walking and cycling as a mode of transport should be a normative element in planning.

- Conflicts between safety and accessibility versus operation and maintenance have to be studied more closely.
- Continued knowledge building should include focus on how walking and cycling objects are handled in the initial planning process. It is also important to make systematic follow-up of completed walking and cycling objects along major roads to get a better idea of the costs of installation, operation and maintenance.

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