# The safety of elderly bicyclists

Lars Leden
Lars.Leden@vtt.fi

Charlotta Johansson
Charlotta.M.Johansson@ltu.se

*Architecture and Infrastructure*
*Luleå University of Technology, Sweden*

## Abstract

Demographic changes show that the absolute number and portion of the population in Europe that can be categorized as older or very old will continue to grow over the next several years. One aim should be to keep them active and healthy for as long a time as possible. Exercise, for example cycling, plays an important role in this context but data shows that the elderly bicyclists are overrepresented in crashes when compared with their exposure to traffic. Senior cyclists' needs and preferences should be a base for developing a safe and joyful cycling environment. This project uses in-depth crash data analysis, questionnaires with senior cyclists, and questionnaires with experts to identify potential for improving elderly bicycling.

Elderly bicyclists have a significantly higher risk than younger age groups. The consequences are significantly more severe for elderly bicyclists compared to other age groups and increase with vehicle speeds. Elderly bicyclists are significantly more involved in crashes when intending to turn left compared to other age groups. 22% of elderly in fatal crashes intend to turn left compared to 8% for adults and 14% for children.

As expected, elderly bicyclists are significantly more often impaired by bad sight and/or bad hearing as well as being impaired from taking medication in crashes compared to other age groups. Elderly bicyclists are less often in a hurry (5%) in crashes compared to other age groups (11%). Elderly bicyclists obey traffic rules no more and no less than other age groups. In darkness (incl. dawn and dusk), non-elderly adult bicyclists are significantly more often involved in crashes (37%) than elderly (11%).

The most stated safety-increasing measure according to the senior cyclists is construction of more cycle tracks. According to the expert questionnaire the most important preconditions were safety and a feeling of security when cycling, the existence of a network of roads for cycling including appropriate bike parking facilities and positive attitudes from users and non-users regarding travelling by bicycle. This is much in accordance with the opinions expressed by the senior cyclists.

*Key words: Elderly Bicyclists, Safety, Health.*

# Introduction

The older the person, the more fragile he/she is; Spolander (2004) concludes that a speed limit of 30 km/h per hour is too high for the elderly. Elderly pedestrians place themselves at greater risk when crossing streets with traffic in two directions as a result of wrongly estimating the time of arrival of moving vehicles, and/or the under-compensation of slower walking speeds (Oxley *et al*., 1997). It is not obvious to which extent this is valid to elderly bicyclists.

Demographic changes show that the absolute number and portion of the population in Europe that can be categorized as older or very old will continue to grow over the next several years. One aim should be to keep them active and healthy for as long a time as possible. Exercise, for example cycling, plays an important role in this context – it supports us to stay healthy in all phases of our lives. The health effects of cycling are well documented (Kraft, 2002; Manetta et al., 2005; Oja et al., 1998). The bicycle could become an ideal means of transportation for many senior citizens, in order to fulfill their individual needs of mobility, and to stay active and mobile at an older age provided that bicycling is safe. But data shows that the elderly bicyclists are overrepresented in crashes when compared with their exposure to traffic (Malak et al., 1990, Howarth et al., 1974, and Routledge et al., 1974, presented by Malak et al., 1990, Maring and Schagen, 1990, Oxley et al., 1997, and Thulin and Kronberg, 2000, Gustafsson and Thulin, 2003, MacGregor et al., 1999, Connely et al., 1998). Senior cyclists' needs and preferences should be a base for developing a safe and joyful cycling environment.

The aim with the study was to describe the (lack of) traffic safety of elderly bicyclists and explore the differences to younger age groups. The following five tools for idea generation were applied for identifying user's needs and developing countermeasures for safe and joyful cycling for senior citizens:

1. literature review
2. crash data analysis
3. questionnaires with senior cyclists
4. questionnaires with experts
5. an expert workshop with group discussions structured according to two different models.

The outcome of each tool is described below. The results of the literature review are presented as a part of the description of the outcomes of the four other tools. At the end of the paper the outcomes of the five tools are compared and discussed.

# Method and data description

### *Crash data analysis*

Three data sets were made available. The *first* data set is the Finnish road crash investigating teams' data (VALT data) from the years 1995-2005 which includes a detailed description of 459 fatalities involving a bicyclist in varying road environments. The data is classified into the age groups children (0-17 years), adults (18-64 years) and elderly (65 years and older). Altogether there are 256 bicyclists older than 64 years. Only a few bicyclists are 90 years old or older, see Table 1. Part of the presented analyses was presented in Johansson et al. (2004), using a smaller VALT data set with fatal injuries from 1995-2001. The present analyses focus on elderly bicyclists' safety.

Table 1. Ages of the elderly bicyclists in Finnish road crash investigating teams' data from the years 1995-2005.

| Age group | Frequency | Percent |
|---|---|---|
| 65-69 | 52 | 20,3 |
| 70-74 | 79 | 30,9 |
| 75-79 | 70 | 27,3 |
| 80-84 | 38 | 14,8 |
| 85-89 | 12 | 4,7 |
| 90-94 | 5 | 2,0 |
| 95-99 | 0 | 0,0 |
| Total | 256 | 100,0 |

The *second* data set includes Swedish travel surveys and self reported crash data from 1996-2000. This data have been compared with crash data from the Swedish Road Administration by Gustafsson and Thulin (2003), which makes it possible to calculate the risk of an accident, in terms of the number of crashes per traveled distance for different road user age, and type of environment. It made it also possible to calculate the consequence, defined as the number of fatally injured persons per number of injured persons. The travel surveys were based on a questionnaire sent daily to 65 randomly chosen people (different each day) aged between 1 to 84 years, and has been running since 1992. The study focused on pedestrians and bicyclists and their exposure and safety in traffic. The questionnaire were answered by 23 030 persons totally during the time period, and 2 957 of these had travelled by bike. The data was transformed to represent the total population of Sweden by gender and different age groups.

The *third* data set includes 17 843 police reported fatalities and injuries with pedestrians and bicyclist in Finland during the years 1989-2002.

Different data sets were used, i.e. both Swedish and Finnish, because the available Swedish data contained too few observations to conduct quantitative studies. Finnish and Swedish conditions are regarded to be comparable. The Finnish VALT-data also contains a much higher level of detail in the description of the crash; better than what the Swedish data provides.

The aim of the crash data analysis is to find key parameters in crash data that are crucial (more common) in crashes when elderly (older than 64 years) as bicyclists are involved compared to other age groups.

How the risk of a fatal crash or an injury depends on the vulnerable road user's age was investigated for different circumstances. The following hypothesis regarding risk of fatal crash or injury dependent on the vulnerable road user's age was formulated:

1. Elderly bicyclists have higher risk than younger age groups.
2. The injuries are more severe when vehicle speeds are higher or the age of the involved bicyclist is higher
3. Elderly bicyclists is more often involved in fatal collisions outside built-up areas compared to other age groups.
4. In fatal collisions, elderly bicyclists is less often in a hurry compared to other age groups.
5. In collisions with fatal outcome on up-hill streets elderly are more often involved than others.
6. In collisions with fatal outcome in darkness elderly are more often involved than other age groups.
7. Elderly bicyclists are more often involved in crashes at intersections than other age groups.
8. Elderly bicyclists are more often involved in crashes when intending to turn left compared to other age groups.
9. Elderly bicyclists are more often involved in crashes with pedestrians and other bicyclists compared to other age groups.
10. Elderly bicyclists are more often involved in crashes when the road surface is damaged compared to other age groups.
11. In collisions with fatal outcome elderly bicyclists more often are impaired by health problems compared to other age groups.
12. In collisions with fatal outcome elderly bicyclists less often obey the rules compared to other age groups.

The selection of hypotheses to test were based on two different factors; firstly on findings from previous research concerning the safety of bicyclists in general, and the safety of children as bicyclists in particular (Johansson, Gårder and Leden, 2004), and from a brainstorming session with a group of researchers in the field of traffic safety discussing risk factors for elderly persons.

***Questionnaires***

Interviews with 31 bicyclists (15 men and 16 women), all members of the Cycling Promotion in Sweden (Cykelfrämjandet), were done as a pilot project to test and finalize a questionnaire about needs and safety of elderly bicyclists, see Leden and Risser (2007).

To gather more extensive knowledge about elderly bicyclists a questionnaire of five pages (see Leden, 2008, Appendix 4) was sent to 569 members of the Cycling Promotion in Sweden (Cykelfrämjandet) in June 2007. The sample was stratified to get better balance between regions and age groups. The mailing occurred in June 2007. Altogether 364 answers were received in due time, corresponding to a response frequency of 64%. However 13 persons answering were less than 65 years old, so answers were received from 351 members age 65+, corresponding to a response frequency of 61%, see Table 1. The answer frequency decreased with increasing age and was 61% in average. Seven respondents (2%) were 85+. The oldest one was 89 years. 40% of the respondents were female, but in the northern region the share was higher (52%).

When interpreting the results it should be remembered that the respondents are members of the Cycling Promotion in Sweden and have more experience in cycling and matters related to cycling, than people in general in Sweden and therefore not representative for all bicyclists of that age in Sweden. However having experienced respondents can of course be an advantage also when gathering background information to be used to develop a strategy and measures to obtain safe and joyful cycling for senior citizens. They are probably also healthier. The share that finds bad hearing a safety problem is small, only 9%, but increases somewhat after age 75.

Table 2. Number of received answers questionnaires.

| Region/Age | 65–74 | 75–84 | 85+ | Total | Answer frequency (%) |
|---|---|---|---|---|---|
| North | 56 | 16 | 1 | 73 | 65 |
| Middle | 69 | 73 | 4 | 146 | 55 |
| South | 99 | 21 | 2 | 130 | 69 |
| Total number answers | 224 | 118 | 7 | 349 | 54 |
| Answer frequency (%) | 65 | 58 | 30 | 61 | |

***Expert questionnaire***

An expert questionnaire was distributed during the Velo-city 2007 conference. All together, 14 experts answered. At the outset the experts were asked to describe, in their own words, the preconditions for using the bicycle as a means of transport.

## Results

### *Risk of elderly compared to younger age groups*

*Swedish travel surveys*

Swedish travel surveys and self reported crash data from 1996-2000 have been compared with crash data from the Swedish Road Administration (Gustafsson and Thulin, 2003). The data is used to calculate the risk for bicyclists of different ages as fatal or severely injured per million kilometers, see Table 3. Elderly, older than 64 years, always have the highest risk as cyclists and as pedestrians in urban traffic, and the consequences of the crashes are also always the highest. The latter is likely to be explained by the weaker bodies of the elderly.

Independent of road user age, most bicyclists cross the street at sites not equipped with marked pedestrian or bicyclist crossings or signals, see Table 4 (based on data by Gustafsson and Thulin, 2003). The risk of injury and the consequence of the crashes are also the highest there. The risk of injury and the consequences of the crashes are always the highest for elderly bicyclists compared to other age groups independent of if there is a marked crossing or not. In the analysis above, speed limit and crossing-facility type were analyzed without consideration of each other. Co-variation may mean that isn't the isolated 'true' effect of either that is described above. Rather, it may be that most marked crosswalks are located in low-speed downtown areas whereas many pedestrian (and bicycle) crashes occur along outlying arterials where the spacing between crosswalks is much greater. Also, facilities such as crosswalks are often provided where pedestrian volumes are high, and high pedestrian volumes by themselves lower the risk that an individual pedestrian will be involved in a crash (Leden, 1997, Ekman, 1996).

Table 3. Risk of injury and fatal crash for bicyclists per million person kilometers and consequence of the crashes 1996-2000 (Gustafsson and Thulin, 2003).

| | Risk of injury | Risk of fatal or severe injury | Risk of fatal injury | Consequence |
|---|---|---|---|---|
| Urban traffic | | | | |
| 1-6 years | 1.219 | 0.179 | 0.007 | 0.006 |
| 7-14 years | 1.263 | 0.242 | 0.009 | 0.007 |
| 15-24 years | 1.394 | 0.238 | 0.005** | 0.004 |
| 25-44 years | 1.081 | 0.199** | 0.007** | 0.006 |
| 45-64 years | 1.221 | 0.283 | 0.015 | 0.012 |
| 65-84 years | 1.664 | 0.506** | 0.075* ** | 0.045 |
| 1-84 years | 1.244 | 0.255 | 0.014 | 0.011 |
| Non-urban traffic | | | | |
| 1-6 years | 0.261 | 0.058 | 0.000 | 0.000 |
| 7-14 years | 0.331 | 0.112 | 0.009** | 0.026 |
| 15-24 years | 0.282 | 0.084** | 0.012** | 0.041 |
| 25-44 years | 0.330 | 0.119 | 0.009** | 0.029 |
| 45-64 years | 0.321 | 0.141 | 0.028 | 0.086 |
| 65-84 years | 0.379 | 0.180* ** | 0.071* ** | 0.188 |
| 1-84 years | 0.325 | 0.125 | 0.023 | 0.071 |

**Significantly different than the expected value based on exposure and total no. of crashes (at 95% significance level) Poisson.*
***Significantly different than the expected value based on exposure and total no. of crashes (at 95% significance level) Normal distribution.*

Table 4. Exposure and risk of injury (injury, severe injury or fatal) and consequences in urban areas for bicyclists per million bicycle passages, 1996–2000 (Gustafsson and Thulin, 2003). (Crossings in a tunnel or on a bridge separated from the vehicle traffic is not included in the exposure presented in the table.)

| | No crossing facility | | | Marked crossing | | | Marked crossing with signal | | | Total no. |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | Expo-sure (%) | Risk of injury | Conse-quences | Expo-sure (%) | Risk of injury | Conse-quences | Expo-sure (%) | Risk of injury | Conse-quences | of million person passages |
| 1–6 years | *72* | 0.4387 | 0.0114 | *24* | 0.4350 | 0.0000 | *1* | 5.4278 * | 0.0000 | 89 |
| 7–14 years | *68* | 0.5813 | 0.0130 | *17* | 0.5839 | 0.0038 | *4* | 0.7550 | 0.0000 | 674 |
| 15–24 years | *58* | 0.4376 | 0.0040 | *21* | 0.5930 | 0.0000 | *14* | 0.3550 | 0.0205 | 1099 |
| 25–44 years | *56* | 0.3839 | 0.0039 | *21* | 0.4722 | 0.0065 | *15* | 0.2361 | 0.0179 | 1601 |
| 45–64 years | *65* | 0.3138 | 0.0166 | *17* | 0.7358 | 0.0060 | *11* | 0.2896 | 0.0086 | 1024 |
| 65–84 years | *59* | 0.9268* | 0.0683 | *19* | 1.6982* | 0.0538 | *13* | 0.4221 | 0.0435 | 238 |
| 1–84 years | 61 | 0.4339 | 0.0152 | 19 | 0.6239 | 0.0104 | *12* | 0.3178 | 0.0163 | 4725 |

* Significantly higher than the expected value based on exposure and total number of crashes (at 95% significance level).

The hypothesis no. 1 is supported; elderly bicyclists have higher risk than younger age groups. The consequences of the crashes were also the highest for elderly.

### *Severity of injuries dependent on vehicle speeds and age of the involved bicyclist*

*Finnish police reported data*

Table 5. Consequence for bicyclists by age and speed limits.

| Speed | Children | Adults | Elderly | All | All total |
|---|---|---|---|---|---|
| | On marked crossing at intersection, not turning vehicles | | | | |
| 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.021 |
| 40 | 0.000 | 0.012 | 0.050* | 0.014 | |
| 50 | 0.008 | 0.010 | 0.075* | 0.020 | |
| 60 | 0.032 | 0.023 | 0.125* | 0.043* | |
| | On marked crossings at intersections, turning vehicles | | | | |
| 30 | 0.000* | 0.062* | 0.000* | 0.035* | 0.018 |
| 40 | 0.000* | 0.010 | 0.046* | 0.014 | |
| 50 | 0.011 | 0.015 | 0.049* | 0.019 | |
| 60 | 0.000* | 0.000* | 0.045* | 0.006 | |
| | On marked crossing on link | | | | |
| 30 | 0.000* | 0.000* | 0.000* | 0.000* | 0.023 |
| 40 | 0.012 | 0.000* | 0.038 | 0.008 | |
| 50 | 0.002 | 0.015 | 0.085* | 0.024 | |
| 60 | 0.032 | 0.024 | 0.100 | 0.049* | |

*Significantly different than the average (at 95% significance level).

In most of the different types of crashes the *consequences* (number of fatal crashes per sum of fatal and other crashes) increased with vehicle speed and the age of the vulnerable road user, see Table 5. The consequence of crashes at intersections was less serious when a turning vehicle was involved compared to if the vehicle was not turning.

*Swedish travel surveys*

For bicyclists aged 1-64, the risk is lower in 30-km/h zones compared to other urban areas; 0.65 bicyclists were fatally or severely injured per bicyclist-traveled kilometer compared to 1.06 in other urban areas. The risk in non-urban traffic was lower than in urban traffic which may seem surprising. A reason may be that bicyclists are better separated in non-urban traffic and cross side-streets much less frequently than in urban areas. For bicyclists older than 64, the risk was lower in 30 km/h zones than for other age groups. In other words, 30 km/h zones are especially safe for elderly bicyclists. The risk is higher in the other two types of environment for people older than 64 compared to younger bicyclists, see Table 6.

Table 6. Risk of injury or fatal crash for pedestrians per million person passages. Risk of injury or fatal crash for bicyclists per million person kilometers1996-2000 (Gustafsson and Thulin, 2003).

| | 30km/h -streets | Other urban traffic | Non-urban traffic |
|---|---|---|---|
| Total no. of fatal or severe injured bicyclists per million travelled kilometre. Average 0.73. | | | |
| 1-64 years | 0.65 | 1.06 | 0.32* |
| 65-84 years | 0.40 | 1.54* | 0.38 |

*Significantly different than the average based on exposure and total no. of crashes (at 95% significance level). Normal distribution.

*Finnish road crash investigating teams crash data*

Of all bicyclists that were fatally injured in Finland 1995-2001, 86 % were killed at vehicle speeds of 31 km/h or more, see Table 7. There is no significant difference with respect of the different age groups.

Table 7. No of bicyclists fatally injured vs. vehicle speeds.

| | Total no. of crashes | *31 km/h or more (%)* |
|---|---|---|
| Children | 57 | *93* |
| Adults | 106 | *83* |
| Elderly | 120 | *86* |
| Total | 283 | *86* |

The hypothesis no. 2 that the consequences of crashes increase with speed and age is supported.

### *Fatal collisions involving elderly bicyclists outside built-up areas*

Of the bicyclists that were fatally injured 1995-2005, there were a higher percentage of children that were killed outside built-up areas than of elderly. There is a significant difference (Ci2-test, df=2, $p<0.001$) with respect of the different age groups, but not the expected one, see Table 8. The hypothesis is not supported.

Table 8. Fatally injured bicyclists.

| | Total no. of crashes | *inside built-up areas (%)* | close to built-up area (%) | rural area (%) |
|---|---|---|---|---|
| Children | 85 | *33* | *11* | *56* |
| Adults | 165 | *59* | *11* | *30* |
| Elderly | 209 | *45* | *16* | *39* |
| Total | 459 | *48* | *13* | *39* |

### *Elderly bicyclists involved in fatal collisions not in a hurry*

*Finnish road crash investigating teams crash data*

Of the bicyclists that were fatally injured 1995-2001, there were a higher percentage of children that were in a hurry than among other age groups but the difference was not significant; see Table 9.

Table 9. Fatally injured bicyclists that were in a hurry.

| | No. of obs | | | |
|---|---|---|---|---|
| | Not hurry | Hurry | Total | *Hurry %* |
| Children | 28 | 6 | 34 | *18* |
| Adults | 49 | 4 | 53 | *8* |
| Elderly | 61 | 3 | 64 | *5* |
| Total | 138 | 13 | 151 | *9* |

### *Collisions with fatal outcome on hilly streets involving elderly bicyclists*

*Finnish road crash investigating teams crash data*

No significant differences were shown with respect to age in the number of bicyclists fatally injured at streets that had a down-hill grade. About one third of all the bicyclists (n=298) that were fatally injured were killed on down-hill streets. Of all bicyclists were 19 % fatally injured on up-hill streets. No significant difference with respect to age was shown.The hypothesis is not supported; elderly bicyclists were not significantly more involved in crashes on hilly streets than other bicyclists.

***Collisions with fatal outcome in darkness***

*Finnish road crash investigating teams crash data*

According to Table 10 children and elderly are more often involved in collisions with fatal outcome in daylight compared to other age groups. There is a significant difference with respect of the different age groups ($p<1.0$ e-9), but not clearly the expected one.

Table 10. Fatally injured bicyclists and daylight.

| | Total no. of crashes | *daylight (%)* |
|---|---|---|
| Children | 85 | *87* |
| Adults | 164 | *63* |
| Elderly | 207 | *89* |
| Total | 456 | *79* |

***Elderly bicyclists in crashes at intersections***

*Finnish police reported data*

The majority, about two thirds, of all bicyclist crashes at marked bicyclist crossings occur at intersections. Elderly bicyclists were not more often involved in crashes at intersections than other age groups. Significantly more of the child crashes occur at links though, compared with the older age groups. In most of the crashes, the involved vehicle was not turning. For cycling children the percentage crashing involving vehicles turning was 30% compared to 38% for elderly bicyclists. The hypothesis is not supported.

***Elderly bicyclists involved in crashes when intending to turn left***

*Finnish road crash investigating teams' crash data*

22% of elderly intend to turn left in fatal crashes compared to 8% for adults and 14% for children, see Table 11. The hypothesis is supported, elderly bicyclists were more often involved in crashes when intending to turn left compared to other age groups ($p<0.01$). Goldenbeld (1992) found similar results, that elderly bicyclists often have problems at intersections and especially when turning left.

Table11. Bicyclists fatally injured when intending to turn left.

| | intending to turn left | |
|---|---|---|
| | N | (%) |
| Children | 12 | *14* |
| Adults | 13 | *8* |
| Elderly | 45 | *22* |
| Total | 70 | *15* |

### *Elderly bicyclists involved in crashes with pedestrians and other bicyclists*

Based on Finnish road crash investigating teams crash data, elderly bicyclists were not involved more often in crashes with other unprotected road users, see table 12. The hypothesis is not supported.

Table 12. Fatally injured bicyclists.

| | Total | % single | Counterpart | | | |
|---|---|---|---|---|---|---|
| | | | % pedestrian | % bicyclists | % mc/moped | % Heavy/pick-up |
| Children | 85 | *2* | *0* | *5* | *0* | *34* |
| Adults | 165 | *18* | *2* | *5* | *1* | *33* |
| Elderly | 209 | *5* | *0* | *2* | *3* | *28* |
| Total | 459 | *9* | *1* | *3* | *2* | *31* |

### *Elderly in crashes when the road surface was damaged*

Based on Finnish road crash investigating teams crash data, elderly bicyclists were not involved more often in crashes caused by damaged road surface, see table 13. The hypothesis is not supported.

Table 13. Fatally injured bicyclists.

| | Total no. of crashes | *Damaged road surface (%)* |
|---|---|---|
| Children | 71 | *10* |
| Adults | 148 | *12* |
| Elderly | 187 | *7* |
| Total | 406 | *9* |

### *Elderly bicyclists that are impaired by health problems*

*Finnish road crash investigating teams' crash data*
The share of bicyclists with hearing and/or sight problems in fatal crashes for the data set covering Finnish road crash investigating teams' crash data based on the years 1995-2005 could be compared to those shares for the total population. However we did not have access to that data of the total population with impaired hearing or sight, or the exposure for these groups, but it seems as if the shares of those involved may be similar to the shares for the whole population. Impact by medicine is judged by the investigation team, see Table 14. The hypothesis is supported.

Table 14. Bicyclists fatally injured with bad hearing or sigh, or medicine.

| | Bad Sight | | Bad Hearing | | By medicine | |
|---|---|---|---|---|---|---|
| | N | (%) | N | (%) | N | (%) |
| Children | 59 | *2* | 26 | *0* | 49 | *10* |
| Adults | 108 | *3* | 57 | *9* | 82 | *45* |
| Elderly | 151 | *13* | 58 | *47* | 116 | *59* |
| Total | 318 | *7* | 141 | *23* | 247 | *45* |

***Elderly bicyclists obeying the traffic rules***

*Finnish road crash investigating teams' crash data*

The share of elderly bicyclists which has not obeyed the rules were similar to other adult bicyclists, in total about 80 % did not obey traffic rules when involved in an accident.

Impact by alcohol was judged by the investigation team. Other adult bicyclists were more often affected by alcohol than elderly bicyclists, see Table 15. There is a significant difference with respect of the different age groups ($p<0.001$).

Table 15. Bicyclists fatally injured when impaired by alcohol.

| | Total no. of crashes | *Impact by alcohol (%)* |
|---|---|---|
| Children | 82 | *79* |
| Adults | 163 | *94* |
| Elderly | 199 | *81* |
| Total | 444 | *86* |

***Questionnaires***

43% of the respondents use a bike daily and 50% a few times a week, see Table 16.

Table 16. How often respondents used a bike. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| Daily | *45* | *41* | *42* | *42* | *50* | *43* |
| A few times a week | *47* | *53* | *48* | *54* | *50* | *50* |
| Once a week | *4* | *3* | *3* | *2* | *0* | *3* |
| Other | *4* | *4* | *8* | *2* | *0* | *5* |
| Total number | 144 | 79 | 77 | 41 | 6 | 347 |

Almost all respondents cycle in the spring, summer and autumn, but only 40% do it in the wintertime see table 17. Only 12% cycle during the winter in northern Sweden, whereas 35% do it in the middle, and 61% in the southern region.

Table 17. The share of elderly cycling in different seasons of the year (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| Season | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| Autumn | *92* | *92* | *88* | *90* | *86* | *91* |
| Winter | *43* | *34* | *39* | *36* | *57* | *40* |
| Spring | *97* | *99* | *95* | *95* | *86* | *96* |
| Summer | *100* | *99* | *97* | *98* | *100* | *99* |
| Total number | 146 | 79 | 77 | 42 | 7 | 351 |

The foremost reason that elderly ride bicycles is to get exercise, which 94% of the respondents state as a reason, see Table 15. Other often stated reasons are: because it is joyful (84%), because it gives freedom (73%), because it is easy (72%), and because it is easy to park (66%). The only reason which got a response below 50% that is included in the list of the questionnaire is "because cycling is fast". Furthermore, only 58% find cycling cheap. *Note* that on this and several other questions, respondents are allowed to give several answers.

The elderly use a bike most often during trips to the store. About 76% usually use a bike for such trips, see Table 18. Almost two thirds use a bike also when visiting friends and a little more than half use a bike during trips to the library, swimming-hall or similar destinations. Fewer use a bike during vacation. A big share of the respondents also checked off the alternative 'other', and the majority of these people meant bike usage for exercise and excursions.

Table 18. Reasons why the elderly bike. Share of answers (%).

| | *Share* |
|---|---|
| Easy | *72* |
| Exercise | *94* |
| Cheap | *58* |
| Joyful | *84* |
| Environmentally friendly | *69* |
| Fast | *48* |
| Easy to park | *66* |
| Gives freedom and independence | *73* |
| Other | *19* |
| Total number | 351 |

Table 19. Share of the elderly that state that they usually choose
to go by bike to a certain destination (%).

| | *Share* |
|---|---|
| Store | *76* |
| Friends | *60* |
| Library, swimming-hall or similar | *55* |
| During vacation | *39* |
| Other: exercise | *16* |
| Other: excursion | *5* |
| Other | *18* |
| Total number | 351 |

The foremost reason that the elderly leave their bikes at home and use another means of transportation is related to bad road conditions during the winter (which is the reason too that so many do not bike at all during the winter): slipperiness (81%), insufficient snow removal (79%) and snowfall (77%), see Table 20.

Table 20. Circumstances for leaving the bike at home. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| Rain | *27* | *37* | *40* | *40* | *57* | *34* |
| Darkness | *32* | *42* | *49* | *38* | *57* | *39* |
| Wind | *22* | *23* | *19* | *26* | *43* | *23* |
| Snowfall | *74* | *85* | *74* | *76* | *71* | *77* |
| Temperature below zero degrees Celsius | *42* | *56* | *52* | *57* | *43* | *49* |
| Slipperiness | *81* | *84* | *82* | *79* | *57* | *81* |
| Insufficient snow removal | *79* | *85* | *79* | *67* | *86* | *79* |
| For ex. Saturday night (feels unsafe) | *16* | *18* | *25* | *19* | *0* | *19* |
| Rush hour | *16* | *18* | *16* | *14* | *14* | *16* |
| Other | *7* | *3* | *3* | *2* | *14* | *5* |
| None of these are crucial | *8* | *6* | *5* | *12* | *0* | *7* |
| Total number | 146 | 79 | 77 | 42 | 7 | 351 |

Temperatures below zero Celsius restrain about half of the elderly from cycling; also rain, darkness and wind restrain from cycle. All reasons expect 'wind' and 'insufficient snow removal' are stated as reasons for leaving their bike at home considerably more often by elderly in northern Sweden than in the two other regions.

Also, long distances are a reason that elderly choose not to use a bike. Some leave their bikes at home when the distance in one direction is more than 6–10 kilometres. Two thirds (65%) of the respondents do not like biking if the (one-way) distance is above 15 kilometres, see Table 21, and only 17% find distances longer than 20 kilometres a suitable distance, whereas a small share are willing to bike quite a bit further. There are no big differences between genders and age groups, except that that the share that bike only up to 5 kilometres increases with age.

Table 21. How far away a destination needs to be for the elderly to abstain from using a bike. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| km | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| 0–5 | *11* | *12* | *16* | *21* | *29* | *14* |
| 6–10 | *38* | *42* | *38* | *29* | *0* | *37* |
| 11–15 | *13* | *15* | *16* | *5* | *29* | *14* |
| 16–20 | *23* | *15* | *18* | *11* | *29* | *19* |
| 21–30 | *5* | *8* | *9* | *13* | *14* | *8* |
| 31–40 | *7* | *3* | *3* | *8* | *0* | *5* |
| 41–50 | *1* | *1* | *1* | *8* | *0* | *2* |
| 51– | *2* | *4* | *0* | *5* | *0* | *2* |
| Total number | 142 | 74 | 71 | 38 | 7 | 332 |

Almost all (94%) of the elderly stated that they usually bike on paths or use cycle tracks. The share that usually bike on cycle tracks decreases somewhat the smaller the municipality is.

Table 22. Road types on which the elderly usually bike. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| Smaller roads | *90* | *89* | *86* | *81* | *57* | *87* |
| Cycle tracks | *93* | *96* | *96* | *90* | *86* | *94* |
| Mixed traffic | *72* | *58* | *57* | *64* | *57* | *64* |
| Side walks | *18* | *11* | *9* | *7* | *0* | *14* |
| Other | *6* | *8* | *9* | *5* | *0* | *7* |
| Total number | 146 | 79 | 77 | 42 | 7 | 351 |

About 87% stated that they usually bike also on smaller roads. The share that bikes on roads decreases in the older age groups. About two thirds of all respondents bike in mixed traffic. The share that stated that they usually bike in mixed traffic is somewhat higher in the age group 65–69 than in the other age groups and lower among those who live in rural areas than in other municipality sizes. Only 14% usually bike on the sidewalk, and that share decreases with age.

The most common sites or manoeuvres the elderly avoid are roundabouts, left turns and crossing streets without a cycle crossing, see Table 23. Also according to the analysis of Finnish in-depth crash data left-turns were hazardous to the elderly cyclists. Especially the oldest respondents state that they avoid roundabouts. Also cycle tracks with moped traffic are avoided by many. The most common reason that the elderly avoid any site or maneuver is that they feel insecure. Many choose to walk their bike, when they perceive something dangerous such as drivers of cars that do not stop or take cyclists into consideration and cars and mopeds that are driven too fast. 41% of the respondents do not avoid any site or manoeuvre.

Table 23. Sites or manoeuvres the respondents avoid. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| No | *47* | *44* | *32* | *29* | *43* | *41* |
| Do not know | *3* | *8* | *5* | *5* | *0* | *5* |
| Roundabouts | *20* | *19* | *29* | *29* | *29* | *23* |
| Left turn | *18* | *16* | *19* | *24* | *0* | *19* |
| Crossing streets without cycle crossing | *14* | *27* | *18* | *12* | *29* | *18* |
| Crossing streets with cycle crossing | *8* | *10* | *7* | *10* | *14* | *8* |
| Cycle track with mopeds | *14* | *9* | *13* | *12* | *0* | *12* |
| Crossing streets at a traffic signal | *2* | *1* | *3* | *2* | *14* | *2* |
| Other | *5* | *3* | *8* | *10* | *0* | *6* |
| Total number | 146 | 79 | 77 | 42 | 7 | 351 |

According to the elderly, the biggest safety problems are potholes, slipperiness and insufficient snow removal; 76, 74 and 70% of the respondents have referred to these factors as safety problems, see Table 24. However, according to the analysis of the Finnish in-depth crash data, elderly bicyclists are not over-involved in crashes where the road surface was damaged. Major problems are also curb stones and cars going too fast.

Table 24. Safety problems. Share of answers (%).

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 65–69 | 70–74 | 75–79 | 80–84 | 85+ | Total |
| Potholes | *75* | *73* | *79* | *76* | *71* | *76* |
| High curb stones | *61* | *66* | *49* | *62* | *86* | *60* |
| Slipperiness | *75* | *77* | *69* | *76* | *57* | *74* |
| Insufficient snow removal | *71* | *65* | *73* | *67* | *71* | *70* |
| Bad hearing | *8* | *4* | *12* | *12* | *14* | *9* |
| Functions of the bikes | *8* | *10* | *10* | *14* | *29* | *10* |
| Hindrances | *17* | *16* | *22* | *19* | *29* | *19* |
| Missing road lighting | *28* | *24* | *25* | *17* | *29* | *25* |
| Cars driving too fast | *57* | *54* | *45* | *50* | *14* | *52* |
| Bad sight | *4* | *3* | *5* | *5* | *14* | *4* |
| Medication | *3* | *0* | *0* | *2* | *0* | *2* |
| Other | *13* | *14* | *13* | *14* | *29* | *14* |
| Total number | 146 | 79 | 77 | 42 | 7 | 351 |

What the elderly say would increase their biking is linked to what they say is important for increased traffic safety. Increased safety would lead to increased biking among the elderly. Requests dealing with the physical design of roads are especially a demand for more and better cycle tracks. Communication between road users expressed as more and better consideration are also perceived to increase their feeling of security and thereby increase their biking, see Table 25. More cycle tracks is the most stated alternative both on the question about what would increase the biking of the elderly and on the question about what would increase traffic safety. Other safety-increasing factors that would increase biking are better maintenance of cycle tracks, road users taking each other into better consideration, and removal of mopeds from cycle tracks.

Table 25. Factors that would increase biking among the elderly. Share of answers (%).

| | Gender | | |
|---|---|---|---|
| | Women | Men | Total |
| More cycle tracks | *13* | *12* | *13* |
| Better cycle tracks | *4* | *4* | *4* |
| Maintenance of cycle tracks | *3* | *2* | *3* |
| Possibility to bring the bike onto buss/train | *12* | *4* | *7* |
| Health | *5* | *5* | *5* |
| Better weather | *2* | *4* | *3* |
| Better bike parking facilities | *2* | *3* | *3* |
| Motivation | *1* | *3* | *2* |
| More time | *1* | *2* | *2* |
| Consideration between road users | *1* | *1* | *1* |
| No mopeds on cycle tracks | *1* | *0* | *1* |
| Other | *16* | *18* | *17* |
| Already bike often | *9* | *6* | *7* |
| Total number | 140 | 209 | 351 |

***Expert questionnaire***

The experts were asked to describe the preconditions for using the bicycle as a means of transport. The most common preconditions mentioned were:

• Safety and a feeling of security when cycling
• The existence of a network of roads for cycling including appropriate bike parking facilities
• Positive attitudes from users and non-users.

This is much in accordance with the opinions expressed by the senior cyclists. Some experts stressed the importance of an urban policy for cycle mobility. Reasonable physical and mental abilities of the cyclists were also considered as important preconditions. According to the experts, the most important needs concerning infrastructure for senior citizens are comfortable, wide bike paths or cycle streets away from main streets, with good directional signage. High curb stones and steep gradients should be avoided. An electric motor could be useful up-hills. Many experts mentioned the importance of detectors well in advance of signalized intersections to give cyclists the possibility to get a green light without having to slow down or dismount their bicycles.

Low motor vehicle speeds achieved by Intelligent Speed Adaptation (ISA) or by other means was by many considered as a prerequisite for safety. Other suggestions to increase safety include warning signals or warning lights to warn cyclists of approaching motor vehicles or vice versa at intersections. Such warning devices could also be useful when a motor vehicle is approaching a bike from behind (or a bike is approaching a pedestrian, but then the sound has to be .gentle. so that pedestrians are not scared). ITS can be used to get better guidance for and visibility of bicyclists at night time, for example through led-lights in the pavements or by increasing the intensity of street lighting at times when cycle traffic is present.
With respect to suggestions to improve the design and equipment of the bike itself, an upright seating position and a low bike frame making it easy to climb on and off the bike was stressed. Some equipment facilitating turning left would be useful as many senior citizens

have a stiff neck and bad balance. A rear-view mirror could help, as stated by senior cyclists, but improvements are also possible by designing the infrastructure, so that it becomes unnecessary to merge with motor vehicles when turning left. As mentioned above, cycle tracks are an efficient means to increase safety for elderly bicyclists, as they reduce accidents with left-turning bicyclists (Jensen, 2006).

Almost all experts suggested a digital map for on-line route guidance when cycling and also for trip planning before the trip starts. On-line devices like Personal Digital Assistants (PDAs) could also be used, for example, to get local weather information or to find time tables for public transport and especially to see whether it is allowed to bring the bike on the tram or bus. A special design of the devices making it easy for elderly to use them was considered crucial. The following automatic types of equipment for bikes were considered important to test and further develop:

- automatic locking and opening at a distance by using the key as for cars
- automatic gears
- automatic turning on and off of bicycle lamps (with power supply from a reliable dynamo)
- automatic elevating of the saddle after mounting.

Also Spolander (2007) suggests a lower more upright riding position and automatic gear changing. Further he gives a list of components which can be improved ergonomically and functionally, and concludes that a design which give better comfort also seems to give better safety.

## Concluding discussion

Elderly, older than 64 years, always have the highest risk as cyclists and as pedestrians in urban traffic, and the consequences of the crashes are also always the highest.  The latter is likely to be explained by the weaker bodies of the elderly.The most stated safety-increasing measure according to the senior cyclists is construction of more cycle tracks. According to the expert questionnaire the most important preconditions were safety and a feeling of security when cycling, the existence of a network of roads for cycling including appropriate bike parking facilities and positive attitudes from users and non-users regarding travelling by bicycle. This is much in accordance with the opinions expressed by the senior cyclists. The above stated suggestions to improve the infrastructure to support travelling by bicycle, together with crossing facilities physically designed to allow vehicle speeds not higher than 30 km/h, would likely improve the possibility for elderly persons to travel safely by bicycle to a higher extent.

## References

Connely, M.L., Conaglen, H.M., Parson, B.S., Isler, R.B., 1998. Child Pedestrians Crossing Gap Thresholds. Accident Analysis and Prevention. Vol. 30, No. 4, pp.443-453.

Ekman, L., 1996. On the Treatment of Flow in Traffic Safety Analysis: A Non-Parametric Approach Applied on Vulnerable Road Users. Department of Traffic Planning and Engineering, University of Lund, Bulletin 136, Lund, Sweden.

Goldenbeld, C. (1992). Ongevallen van oudere fietsers in 1991 [Accidents of older cyclists in 1991]. R-92-71. SWOV Institute for Road Safety Research. The Netherlands.

Gustafsson, S., Thulin, H., 2003. Gående och cyklister, exponering och skaderisker i olika trafikantmiljöer för olika åldersgrupper. VTI meddelande 928.2003.

Jensen, S. U. (2006). Personal information.

Johansson, C., Gårder, P. and Leden, L. (2004). Towards a safe environment for children and elderly as pedestrians and cyclists- A synthesis based on an analysis of in-depth studies of fatalities, police-reported crashes and including video recordings of behaviour. Nottingham, ICPTT-conference 5-9 Sept in Nottingham, Great Britain.

Kraft, K. S. (2002). Report on blood pressure control and on the diagnostic value of bicycle exercise in elderly people. Medizinische Poliklinik, Bonn, Germany.

Leden, L., 1997. Pedestrian Risk Decreases with Pedestrian Flow and Increases with Vehicle Flow - A Case Study presented at The International Cooperation on Theories and Concepts in Traffic Safety (ICTCT) November 5-7, 1997 in Lund.

Leden, L. and Risser, R. (2007). Safe and joyful cycling for senior citizens. Velo-city 2007.

Leden, L., 2008. Safe and joyful cycling for senior citizens. Espoo 2008. VTT WORKING PAPERS 92. http://pure.ltu.se/ws/fbspretrieve/2071496

MacGregor, C., Smiley, A., Dunk, W., 1999. Identifying Gaps in Child Pedestrian Safety. Comparing What Children Do with What Parents Teach. Transportation research record 1674. Paper no. 99-0724.

Malek, M., Guyer, B., Lescohier, I., 1990. The Epidemiology and Prevention of Child Pedestrian Injury. Accident Analysis and Prevention. 1990 Aug. Vol22 (4):pp.301-313.

Manetta, J., Brun, J.-F., Prefaut, C. and Mercier, J. (2005). Substrate oxidation during exercise at moderate and hard intensity in middle-aged and young athletes vs. sedentary men. Metabolism Clinical and experimental, Vol. 54, pp. 1411–1419.

Maring, W. and van Schagen, I. (1990). Age dependents of attitudes and knowledge in cyclists. Accident Analysis and Prevention, Vol. 22, No. 2, pp 127–136.

Oja, P., Vuori, I. and Paronen, O. (1998). Daily walking and cycling to work: Their utility as health-enhancing physical activity. UKK Institute for Health Promotion Research, Tampere, Finland.

Oxley, J., Fildes, B., Ihsen, E., Charlton, J., Day, R., 1997. Differences in Traffic Judgements Between Young and Old Adult Pedestrians. Accident Analysis and Prevention. Vol.29, No. 6, pp. 836.847.

Spolander, K. (2007). Better cycles. an analysis of the needs and requirements of older cyclists. Vinnova report VR 2007:17. Available at: http://www.vinnova.se/upload/EPiStorePDF/vr-07-17.pdf

Thulin, H., Kronberg, H., 2000.Gående och cyklister. Exponering och skaderisker i olika trafikmiljöer för olika åldersgrupper. VTI meddelande 886.2000.