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Near accidents and collisions between pedestrians and cyclists

Johannes Mesimäki[1*] and Juha Luoma[2]

Abstract

Cities throughout the world have increasingly promoted walking and cycling as healthy and sustainable modes of travel. However, collisions between pedestrians and cyclists have remained largely unstudied, and existing accident statistics suffer from underreporting. This study aimed to explore near accidents and collisions between pedestrians and cyclists, assess the frequency of near accidents, and evaluate pedestrians' and cyclists' sense of safety in traffic. An online survey was directed to inhabitants of Finnish cities with populations greater than 100,000, and the resulting data included 1046 respondents who walk and/or cycle regularly.

The main results show that near accidents between pedestrians and cyclists are around 50 times more frequent than collisions. Only 16 survey respondents had been involved in a collision during the 3-year period, whereas roughly a third had experienced at least one near accident. For both near accidents and collisions, the involved parties were usually travelling in the same direction. Most incidents occurred on pedestrian paths and shared pedestrian and bicycle paths. On shared pedestrian and bicycle paths separated by mode of transport, incidents were much rarer. Furthermore, sense of safety and willingness to walk and cycle were lower in environments where near accidents were more frequent.

These findings tentatively suggest that spatially separating modes of transport could improve people's sense of safety and prevent near accidents and collisions. Prevention of near accidents could increase the willingness to walk and cycle.

Keywords: Cycling, Walking, Perceived safety, Transport, Traffic, Accident

1 Introduction

Cities worldwide have increasingly promoted walking and cycling as healthy and sustainable modes of travel. While these modes are well suited for exercise and reducing greenhouse gas emissions [27, 32], their growing role raises the concern of pedestrian and cyclist safety. Despite this, collisions between pedestrians and cyclists have received limited academic attention [20, 35], even though they can lead to serious injuries and death [5, 11]. Consequently, this study aimed to gain insight on near accidents and collisions between pedestrians and cyclists, assess the frequency and distribution of near accidents, and evaluate pedestrians' and cyclists' sense of safety in traffic with an online survey.

Near accidents are similar to collisions but are generally more frequent [16, 33]. As such, the study of near accidents can provide a more substantial quantity of data for understanding collisions between pedestrians and cyclists, for which statistics are generally scarce [1, 23]. Increasing knowledge on both near accidents and collisions may thus contribute valuable information to accident prevention efforts, while shedding light on issues affecting pedestrians' and cyclists' sense of safety.

2 Literature review

O'Hern & Oxley [20] studied the frequency of pedestrian injuries caused by collisions with cyclists in Melbourne, Australia during 2006–2016 by analysing emergency department, hospital and police datasets. The 11-year

* Correspondence: johannes.mesimaki@vtt.fi
[1]VTT Technical Research Centre of Finland Ltd, P.O. Box 1000, 02044 VTT, Finland
Full list of author information is available at the end of the article

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period contained 183 emergency department presentations and 273 hospital admissions. A total of 6699 pedestrian hospital admissions occurred during the same period, 4136 of which involved a motor vehicle. The police dataset contained 155 collisions between pedestrians and cyclists, representing 1.2% of all pedestrian accidents in the dataset. Pedestrians over the age of 65 were overrepresented in each dataset compared to other age groups. The results suggest that pedestrian injuries in cyclist collisions are less frequent than pedestrian injuries in collisions involving a motor vehicle.

Poulos et al. [22] evaluated the frequency of cyclist accidents in Sydney, Australia. Study participants (n = 2038) kept a diary for 6 weeks documenting accidents and near accidents (near misses) they had experienced. Out of 198 recorded crashes, 5.0% involved pedestrians. Six of these occurred on shared pedestrian and bicycle paths. The overall crash rate for cyclists was 0.29 per 1000 cycled kilometres and 6.1 per 1000 cycled hours. The crash rate for cyclists riding on pedestrian paths was 26.4 per 1000 h, which was considerably greater than other road environments. For example, the risk was 8.8 on shared pedestrian and bicycle paths, 5.8 on cycle lanes and 4.7 on roads. In addition, cyclists older than 60 years of age had a significantly lower risk of experiencing a cyclist accident compared to those aged 25–59. Crash risk per 1000 cycled kilometres for the age group was 0.19, while the risk for cyclists aged 25–59 was 0.30. However, injuries resulting from cyclist accidents were generally more serious for those aged over 60. The authors suggest that this may explain why the elderly are often overrepresented in road safety studies based on injury statistics.

The near accident data from the diaries is discussed in Poulos et al. [23]. Their results show that 105.2 near accidents occurred per 1000 h of travel, and 5.0 occurred per 1000 km travelled. The ratio of near accidents to collisions involving motor vehicles was 49.3 to 1, and the ratio for near accidents involving pedestrians was 35.8 to 1. Near accidents between pedestrians and cyclists mainly occurred on the road (30.0%), shared paths (28.8%) and bicycle paths (21.3%), and were associated with pedestrian observation errors and unexpected manoeuvres as well as pedestrian misuse of shared or bicycle infrastructure.

De Rome et al. [7] studied the characteristics of cyclist accidents by interviewing 202 injured cyclists in 2009–2010 in the Australian Capital Territory. Only 6.4% of reported accidents involved pedestrians. Half of these were cyclist-pedestrian crashes and the rest were accidents in which the cyclist fell while overtaking a pedestrian. The study did not address pedestrian injuries.

Haworth et al. [15] studied the frequency of conflicts between pedestrians and cyclists by observing cyclists in the city centre of Brisbane, Australia in 2010 and 2012. The authors defined a conflict as a situation in which a crash between a pedestrian and cyclist would be inevitable without an evasive manoeuvre by one or both involved parties. Of 4495 observed cyclists, 48 conflicts between pedestrians and cyclists were recorded. Of these, 79.2% occurred on pedestrian paths and 20.8% occurred on roads. Among other factors, cycling on pedestrian paths was found to increase the odds of a pedestrian-cyclist conflict.

Several studies suggest that shared pedestrian and bicycle paths are relatively dangerous road environments [7, 22, 26]. In De Rome et al. [7], the second largest share of cyclist injury accidents, 36.1%, occurred on shared pedestrian and bicycle paths. Of these, 16.2% involved a pedestrian. Crash involvement per 1000 cyclists on shared paths was 11.8, while the figure was considerably lower for cycle lanes (5.8). Only one cyclist-pedestrian accident took place in another road environment. Most recorded accidents occurred while cycling among motor traffic (39.1%). These results differ from Canadian results reported by Cripton et al. [6], according to which injuries sustained from cyclist accidents on shared pedestrian and bicycle paths as well as pedestrian paths were more likely to require hospital transport than cyclist accidents on roads lacking cyclist infrastructure. However, the role of pedestrians in the study is unclear. In the study of Beck et al. [3] on cyclist accident characteristics, more accidents occurred on shared pedestrian and bicycle paths than exclusive bicycle paths, but only one cyclist accident involved a pedestrian.

Haworth & Schramm [14] studied cyclist injuries and travel behaviour in Queensland, Australia with a survey conducted in 2009–2010. The data contained 1179 self-reported cyclist accidents, most of which were single accidents (55.9%) or crashes with motor vehicles (27.2%). Cyclist-pedestrian accidents accounted for 18.1% of bicycle path accidents, 9.7% of footpath accidents, 1.3% of accidents on streets without bicycle lanes and 1.1% of highway accidents.

According to official Finnish traffic accident statistics, an average of 27 cyclist deaths and around 750 cyclist injuries, of which 51 were serious, occurred annually during 2014–2017 [29]. During the same period, an average of 31 pedestrian deaths and roughly 420 pedestrian injuries, of which 45 were serious, occurred annually. Fortunately, the number of deaths and accidents had dropped substantially over the last 10 years—cyclist deaths by about a third and accidents by about a fifth [9], while pedestrian deaths have halved and injuries have dropped by a third [10]. However, it is worth noting that hospital registry data contain an additional annual average of 215 serious cyclist injuries and 37 serious pedestrian injuries for the same period [30]. This

finding suggests that monitoring pedestrian and cyclist accidents with official statistics is challenging due to the large number of missing cases [1].

Pyyhtiä [24] assessed the sense of safety among 15–79-year-old residents in Helsinki, Finland, with a survey. Data was obtained for 4115 respondents from a sample of 7818 randomly selected residents. Of all respondents, 99 had experienced a pedestrian collision, 17% of which involved a cyclist. An additional 187 respondents had experienced a cyclist accident, of which 6% involved a pedestrian.

Hydén [16] argued that traffic conflicts become more frequent as their severity decreases, i.e. conflict frequency constitutes a continuum with near accidents and undisturbed passages occurring most frequently and accidents resulting in fatality or serious injury least frequently. Furthermore, Hydén [16] estimated that all serious conflicts, i.e. situations where a collision was narrowly evaded, are roughly 1000–30,000 times more frequent than all police reported injury accidents. As near accidents between pedestrians and cyclists appear to occur considerably more often than collisions, this type of relationship could also apply for cyclist-pedestrian interactions. Additionally, Hyden [16] and Svensson [33] suggested that due to their similarity, near accident data can supplement accident data when accidents are scarce. The notion finds further support for cyclist-pedestrian interactions from Poulos et al. [23], who showed that collisions and near accidents can have similar circumstances and support their consideration for informing accident prevention measures.

Collisions between pedestrians and cyclists can lead to serious injury and even death, with pedestrians usually more seriously injured [5, 12]. Generally, the most severe injuries in cyclist-pedestrian crashes occur as the pedestrian's head strikes the ground [11, 28]. This differs from accidents between pedestrians and motor vehicles, in which the most serious injuries occur upon impact with the vehicle [11, 20, 28]. Graw & König [11] determined that injuries to the pedestrian from handlebar impact are most likely to be minor. Additionally, they found that the cyclist's fall generally consists of a throw-off and slide, leading to a lower impact load on the head compared to the pedestrian. Furthermore, the elderly (65+) have the greatest risk of serious injury in cyclist-pedestrian accidents compared to other age groups [5, 20], and generally estimate the risk of traffic accidents to be greater than younger people (e.g. [25]).

Chong et al. [5] recommended a speed limit of 10 km/h for cyclists on shared pedestrian and bicycle paths to ensure pedestrian safety. The limit is justified with the notion that the kinetic energy differential between a car travelling at 60 km/h and a cyclist travelling at 10 km/h in the same direction does not differ significantly from the corresponding differential of a cyclist travelling at 30 km/h and a pedestrian travelling at 5 km/h [12]. However, Hatfield & Prabkahran [13] criticise the 10 km/h limit as too low for commuter cycling to be worthwhile. Furthermore, riding a bicycle below this speed can reduce bicycle stability [19], potentially increasing the risk falls causing personal injury [21].

Overall, collisions between pedestrians and cyclists appear to account for a relatively small proportion of all road traffic accidents. However, near accidents seem to be considerably more frequent than collisions. Furthermore, the results of previous studies have shown accumulations of accidents and higher crash involvement rates on shared pedestrian and bicycle paths. Collisions between pedestrians and cyclists may lead to serious injuries and death [5, 12], and pedestrians are generally injured more seriously than cyclists [11].

3 Method

The online survey was directed to inhabitants of Finnish cities with populations greater than 100,000 in June 2019. To be eligible for participation, respondents had to engage either in walking trips of at least 300 m once a month or more, or in bicycle trips during summer once a month or more.

The respondents were asked questions concerning near accidents and collisions between pedestrians and cyclists that they had experienced. Specifically, a collision referred to a situation in which a pedestrian and cyclist either crashed or collided with each other. A near accident referred to a situation in which at least one participant became frightened, was forced to evade or had to brake forcefully to avoid a collision. An underlying assumption was that near accidents and collisions are closely related phenomena. Although more accurately defined terms such as "conflict" exist to depict similar events [37], we use the term "near accident" as it allows for a somewhat broader interpretation.

The survey asked the respondents to provide details for a maximum of three collisions and two near accidents occurring in the previous 3 years. These details concerned, for example, road environment, accident type, factors related to involved parties and the consequences of collisions. Additionally, respondents answered questions related to their sense of safety in traffic and provided some demographic information.

At the time of data collection, Finnish traffic law [34] obliged pedestrians and cyclists to travel on paths provided for them if they were available. Such paths either a) separate pedestrians and cyclists from each other with lane markings, or b) require sharing the path. If no dedicated infrastructure exists, cyclists and pedestrians must travel along the side of the road. Only children under

the age of 12 may cycle on footpaths. Right-hand traffic applies to all road users except pedestrians.

Respondents were accessed through an online survey panel provided by Taloustutkimus Oy. When interpreting our results, it is important to consider the implications associated with such panels. As these panels consist of voluntary participants, they generally result in nonprobability samples that do not represent target populations accurately enough for broader inferences to be valid [4]. As the purpose of this study was to analyse the characteristics of near accidents and collisions as well as gain an approximate estimate of near accident frequency, it was not important for the survey to represent any particular groups with great accuracy. Nevertheless, it is essential to consider both the urban context of the target population and the sampling method when interpreting the results of this study.

4 Results

4.1 Characteristics of respondents

In total, we received 1046 survey responses. Over half of the respondents (61.8%) answered from both pedestrian and cyclist perspectives. Furthermore, 37.9% answered from a pedestrian perspective only, and 0.3% from a cyclist perspective only.

Of all respondents, 2.4% were aged 15–24, 30.0% were aged 25–49 and 67.7% were aged 50–79. In comparison with Finland's age and gender distribution, younger age groups (15–49) were slightly underrepresented and older age groups (59–79) slightly overrepresented, while the gender distribution was relatively similar (51.8% male and 48.2% female, compared to 49.9% and 50.1% [31]).

Most respondents (87.5%) reported walking trips of over 300 m several times a week or daily, and 34.5% reported cycling several times a week or daily during summer. The largest proportion of cyclist respondents (43.6%) cycled 201–1000 km per year, followed by respondents cycling under 200 km (34.7%), 1001–2000 km (14.0%) and over 2000 km (7.7%). Respondents appeared to walk slightly more and cycle slightly less than Finnish residents on average based on the 2016 National Travel Survey [8].

4.2 Frequency and characteristics of near accidents and collisions

A total of 354 respondents (33.8%) had experienced a near accident in the previous 3 years. Of these, 20.1% had experienced one near accident, 23.2% had experienced two, 11.0% had experienced three, and 45.8% had experienced more than three.

The data contained 21 collisions between pedestrians and cyclists. A total of 16 respondents (1.5%) had experienced one or more collisions. Pedestrians reported 18 collisions and cyclists reported three.

Based on the above results, and assuming that those reporting more than three near accidents had experienced no more than four, the respondents reported a total of 1001 cases: $[354 * (1 * 20.1\ \% + 2 * 23.2\ \% + 3 * 11.0\ \% + 4 * 45.8\%) = 1{,}001]$, where the total number of respondents who had experienced at least one near accident is 354, and the following proportions refer to the proportions of respondents who experienced one, two, three and more than three near accidents. Given that respondents reported 21 collisions, the number of near accidents is 47.7 times larger. As some respondents have probably experienced more than four near accidents, this ratio is almost certainly greater in reality. We can therefore assume that near accidents were approximately 50 times more frequent than collisions.

Respondents were asked to provide details of up to two near accidents, resulting in 637 detailed accounts. The majority (64.6%) of these cases were reported from a pedestrian's perspective, i.e. the respondent travelled on foot when involved the near accident. Furthermore, the oldest age group reported the most near accidents as pedestrians ($X^2(2) = 19.5$, $p < 0.001$): the proportion of pedestrians accounted for 79.6% for the age group 65–79, but 60.6% and 59.4% for the age groups 15–49 and 50–64, respectively. No corresponding effect was found for gender.

The reported near accidents most frequently occurred on shared pedestrian and bicycle paths (40.8%), followed by pedestrian paths (21.0%) (Fig. 1). Shared pedestrian and bicycle paths with separate lanes featured less than half the proportion of near accidents recorded on shared paths. It is important to note that these figures only show where reported near accidents occurred, and do not represent the risk of near accidents on the different road environments, as the exposure to near accidents is unknown.

Most collisions occurred on pedestrian paths ($n = 7$) and shared pedestrian and bicycle paths ($n = 6$), followed by pedestrian crossings ($n = 4$) and shared pedestrian and bicycle paths with separate lanes ($n = 3$). One collision occurred at a junction of a pedestrian and bicycle path.

In the most common near accident type (Fig. 2), both the pedestrian and cyclist were travelling in the same direction (43.6%). This was also the most common collision type ($n = 7$), followed by collisions in which both parties approached from opposite directions ($n = 5$) and collisions where both parties approached perpendicular to each other ($n = 5$). Two collisions involved a cyclist hitting a stationary pedestrian, and one collision occurred when the cyclist was turning. The event type distributions for near accidents and collisions are therefore relatively similar.

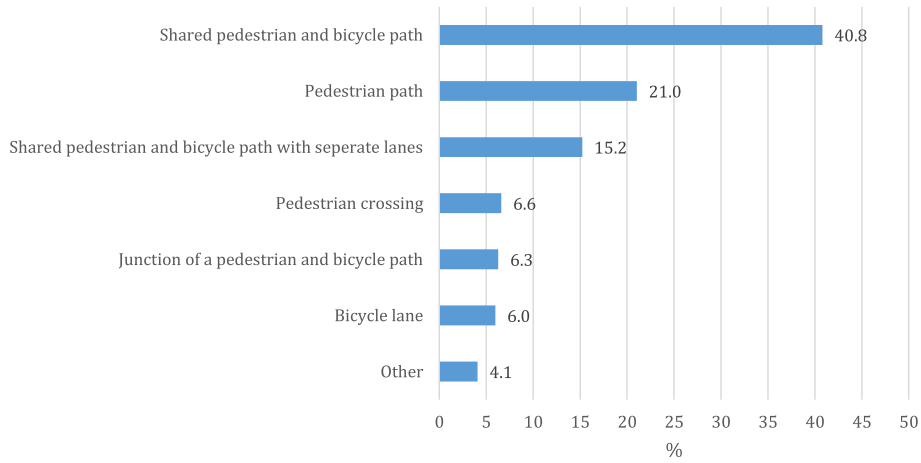

Fig. 1 Road environments of reported near accidents ($n = 637$)

Figure 3 shows the proportions of the four most common near accident types according to the four most common road environments. The distributions differed from each other significantly ($X^2(9) = 67.8$, $p < 0.001$). Events in which both parties were travelling in the same direction were most frequent on both types of shared pedestrian and bicycle paths (shared path 59.1% and shared path with separate lanes 40.9%) as well as pedestrian paths (57.4%). In contrast, the most frequent events on pedestrian crossings involved both parties travelling perpendicular to each other.

4.3 Factors contributing to near accidents and collisions

Table 1 lists the factors contributing to near accidents that relate to involved parties. Respondents were allowed to select more than one factor per near accident. The clear majority of factors concerned cyclists, which is likely due to pedestrians reporting around two-thirds of all near accidents.

Unexpected manoeuvres (33.5%), observation errors (27.4%) and mobile phone use (15.8%) emerged as the most frequently reported contributing factors related to pedestrians. These factors were frequently both self- and cyclist-reported. Excessive speed (38.4%), observation errors (18.7%) and rule violations (14.9%) were the most frequently reported contributing factors related to cyclists. These factors were also frequently both pedestrian- and cyclist-reported, but cyclists self-reported rule violations considerably less frequently. All "unsure", "do not know" and "other" answers were removed. A total of 145 such answers concerned pedestrians and 324 concerned cyclists.

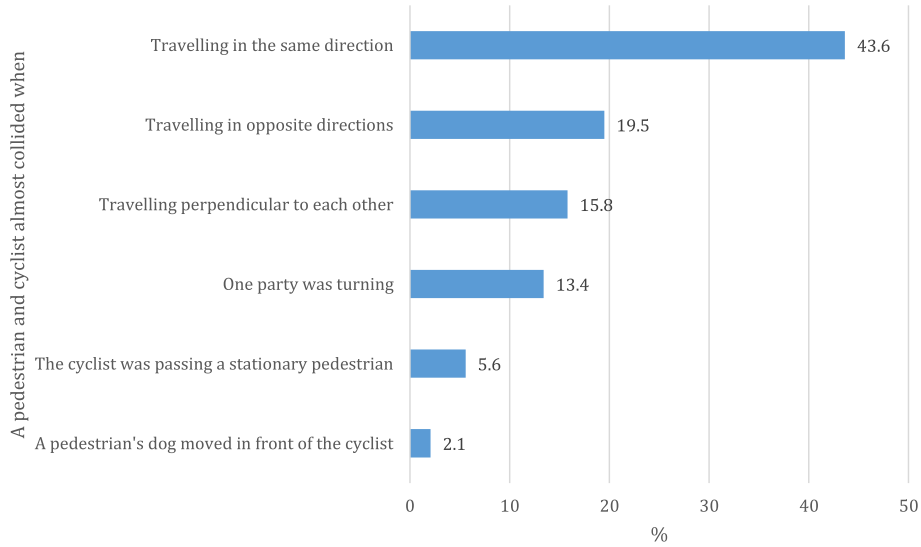

Fig. 2 Event description for reported near accidents ($n = 626$. 11 "other" answers excluded)

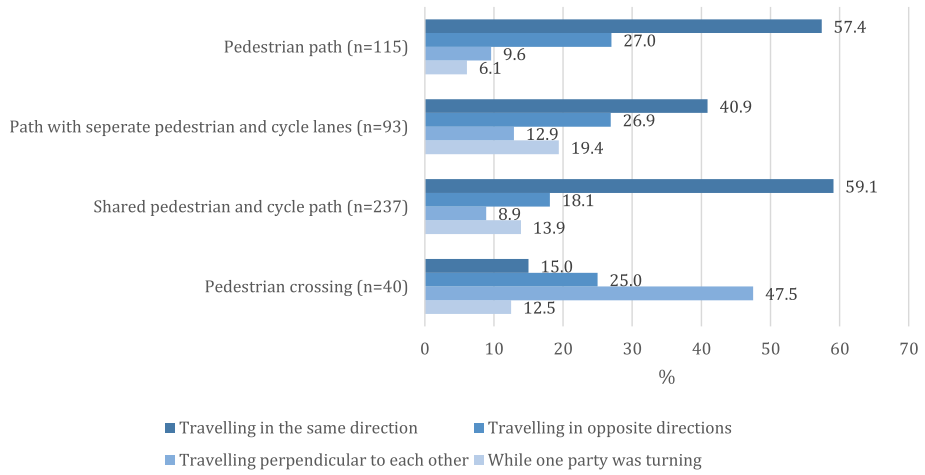

Fig. 3 Proportions of the most common near accident types according to the most common road environments

The most frequently reported factors concerning cyclists contributing to collisions were excessive speed ($n = 17$), observation errors ($n = 11$) and rule violations ($n = 11$), which were all reported by pedestrians. Of the eight factors concerning pedestrians, five were observation errors.

Respondents were asked whether environmental factors contributed to near accidents. Relative to the total number of near accident accounts ($n = 637$), the three most common factors were "unintuitive and complex infrastructure" (16.0%), "a nearby object reducing visibility" (9.7%) and "physical barriers" (8.8%). All other factors affected less than 6% of near accidents. Respondents were also asked whether a set of miscellaneous factors had contributed to near accidents. The three most common factors were "coincidence" (35.6%), "unexpected manoeuvres of a dog being walked" (16.8%) and "actions of other road users" (11.9%). All other factors affected less than 8% of near accidents in total.

Respondents were allowed to provide additional details concerning the near accidents they had experienced in an open-ended question. Most of these responses concerned the behaviour of pedestrians and cyclists. The most common issues concerning the behaviour of pedestrians were unexpected manoeuvres on shared pedestrian and bicycle paths, not walking on the right side of a shared path (although this is not legally required), travelling in large groups and unexpected manoeuvres of dogs being walked. The most common issues concerning cyclists related to adults cycling on pedestrian paths, failure to give way to pedestrians at pedestrian crossings and cycling between bus stops and buses. Furthermore, elderly respondents frequently mentioned difficulties evading cyclists on shared pedestrian and bicycle paths and thus feeling unsafe when using them.

Table 1 Factors contributing to near accidents related to involved parties. Respondents could select multiple factors ($n = 1550$)

Contributing factor	Related to the pedestrian				Related to the cyclist			
	Pedestrian-reported	Cyclist-reported	Total		Cyclist-reported	Pedestrian-reported	Total	
Observation error	82	72	154	27.4%	57	128	185	18.7%
Excessive speed	2	3	5	0.9%	47	332	379	38.4%
Unexpected manoeuvre	35	153	188	33.5%	24	86	110	11.1%
Mobile phone use	18	71	89	15.8%	11	47	58	5.9%
Headphone use	9	36	45	8.0%	8	37	45	4.6%
Rule violation	4	37	41	7.3%	9	138	147	14.9%
Intentional action	1	10	11	2.0%	4	44	48	4.9%
Intoxication	2	13	15	2.7%	0	6	6	0.6%
Lack of reflector or light	4	10	14	2.5%	3	7	10	1.0%
Total	157	405	562		163	825	988	

4.4 Sense of safety

Pedestrian and cyclist sense of safety in traffic was assessed by asking respondents how much they agreed with a set of statements, with options of agree/neutral/disagree. Respondents who walked trips of over 300 m at least once a month answered from a pedestrian's perspective, and respondents who cycled at least once a month during summer answered from a cyclist's perspective. Answering from both perspectives was possible, and all but three respondents who answered from a cyclist's perspective also answered from a pedestrian's perspective. Following the removal of "don't know" answers, the number of responses varied by item with 1025–1036 answers from a pedestrian's perspective and 633–643 answers from a cyclist's perspective.

Figure 4 shows that most respondents generally considered shared pedestrian and bicycle paths with separate lanes safe and were happy to walk and cycle on them. Respondents did not consider shared paths without separate lanes as safe, and willingness to travel on them was lower. Almost half of all pedestrian respondents agreed that cyclists are not considerate towards them in traffic but agreed that other pedestrians are. Moreover, cyclists agreed that other cyclists are considerate towards them but disagreed that pedestrians are as considerate.

Figure 5 shows responses to the five statements concerning sense of safety in traffic which differed significantly by age group. Other statements did not differ significantly by age. Responses from pedestrian and cyclist perspectives were combined, and after removing "don't know" answers, the number of responses varied by item with 1658–1676 per statement. The statement "Cyclists are generally considerate toward pedestrians" was only asked from a pedestrian perspective and thus received 1035 responses. The results show that younger respondents agreed with each statement more frequently than older respondents.

4.5 Prevention of near accidents and collisions

Finally, respondents were given an opportunity in an open-ended question to suggest how near accidents and collisions could be prevented. The resulting qualitative answers ($n = 670$) were categorised, and Fig. 6 presents the 10 most common suggestions. The most frequent suggestion was lower cyclist speed (19.3%), followed by the greater provision of separated pedestrian and bicycle lanes (17.0%) and greater overall attentiveness in traffic (16.9%). Other frequently suggested proposals included use of bicycle bell (12.1%) and additional public education on traffic rules (10.7%).

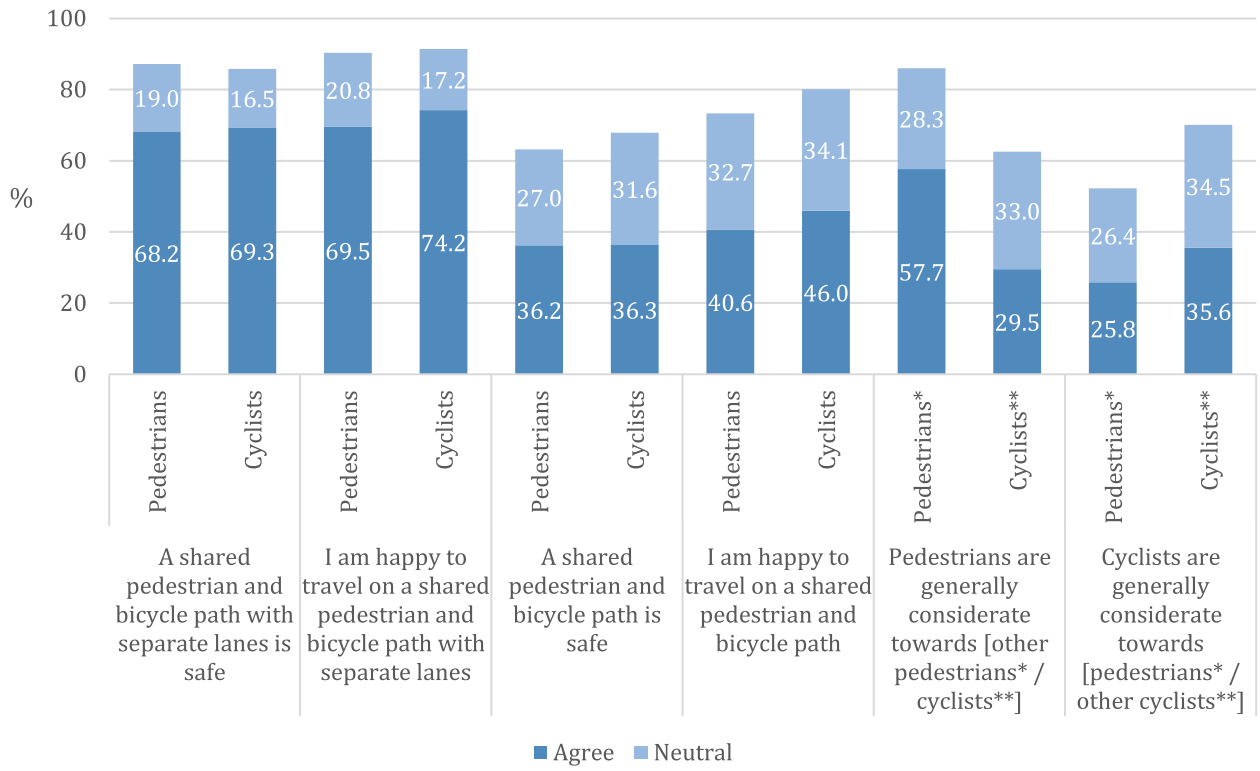

Fig. 4 Responses to statements concerning sense of safety ($n = 1025–1036$ per statement for pedestrians and 633–643 for cyclists)

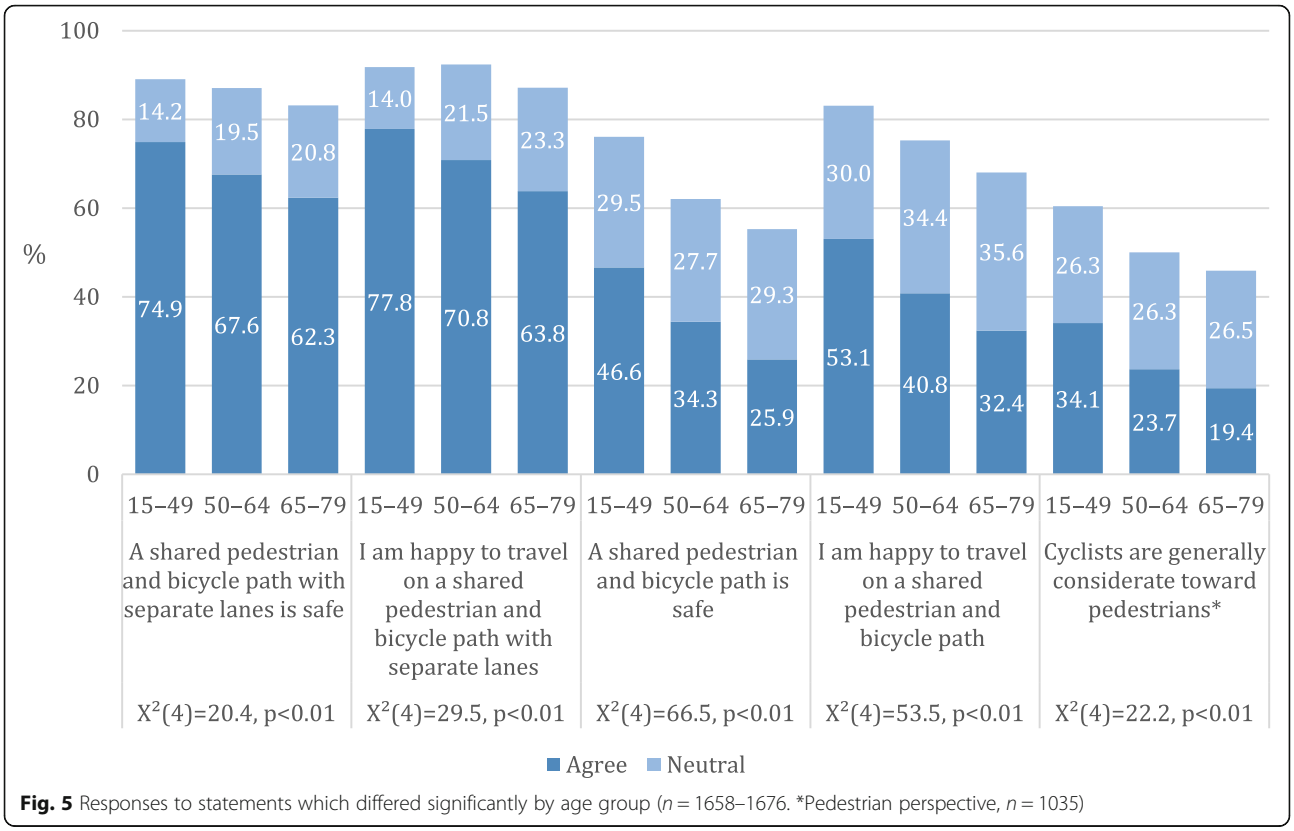

Fig. 5 Responses to statements which differed significantly by age group ($n = 1658–1676$. *Pedestrian perspective, $n = 1035$)

5 Discussion

The purpose of this study was to explore near accidents and collisions between pedestrians and cyclists, assess the frequency and distribution of near accidents and evaluate pedestrians' and cyclists' sense of safety in traffic. To achieve this, the experiences of 1046 survey respondents from Finnish cities with populations greater than 100,000 were analysed.

On average, respondents walked slightly more often, cycled slightly less often and travelled somewhat greater distances compared to the 2016 National Travel Survey results [8]. However, the results of the National Travel

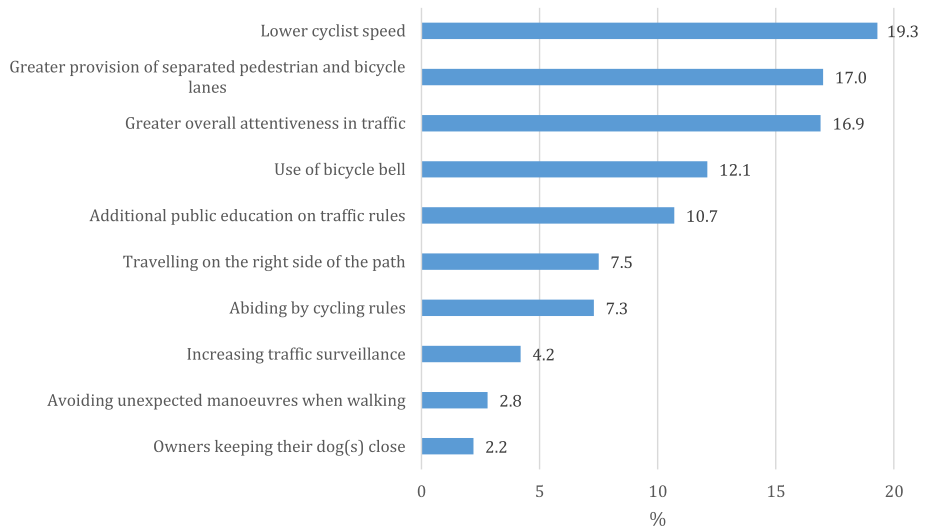

Fig. 6 Ten most frequent suggestions regarding the reduction of pedestrian-cyclist collisions and near accidents ($n = 670$)

Survey cover the entire country, not just cities. Furthermore, the National Travel Survey contains a large proportion of walking trips of less than 1 km, reducing average trip length. It is also likely that those who travel longer distances were more motivated to participate in the survey.

Only 16 respondents (1.5%) had experienced a collision between a pedestrian and cyclist during the previous 3 years. This resulted in detailed accounts of 21 collisions, of which 18 were reported from a pedestrian perspective and 3 from a cyclist perspective. The main findings concerning collisions are similar to the results of Pyyhtiä's [24] survey directed to residents of Helsinki, Finland. If we examine the results for just 1 year and assume equal sample sizes, the results of this survey would contain seven collisions, of which pedestrians reported six and cyclists one. The corresponding figures for Pyyhtiä's [24] survey would be six collisions, of which pedestrians reported four and cyclists two. When accounting for the random variance associated with traffic accidents, the differences between the results can be considered small. Additionally, the results are in line with other studies showing that collisions between pedestrians and cyclists are rare relative to other accident types [20, 22, 36].

Out of all reported collisions, 15 resulted in the respondent sustaining an injury. However, only two respondents sought medical attention as a result and only three respondents reported the collision to the police. This finding supports those of Kautiala & Seimelä [17] and Airaksinen et al. [1], who discovered that Finnish traffic accident statistics concerning pedestrians and cyclists suffer from incomplete coverage.

The survey data contains a considerably greater number of near accidents compared to collisions. A total of 33.8% of respondents had experienced at least one near accident in the previous 3 years, resulting in detailed accounts of 637 near accidents. Almost half of the respondents who reported a near accident had experienced more than three. Unsurprisingly, respondents who cycled the greatest number of annual kilometres had mainly experienced three or more near accidents. These results complement Aldred & Crosweller [2], who found that near accidents occur almost daily for UK cyclists travelling large numbers of annual kilometres. Respective information concerning pedestrians is unavailable.

Near accidents appear to occur often, while actual collisions are rare. According to our data, approximately 50 near accidents occurred for every collision. This ratio is almost certainly greater in reality, as respondents likely remember collisions better than near accidents, and some respondents undoubtedly experienced more than four near accidents. The ratio of cyclist-pedestrian near accidents to collisions calculated by Poulos et al. [23] was 35.8 to 1, but participants in the study only reported the three most serious near accidents per day, potentially leading to a bias favouring the reporting of interactions with motor vehicles. Regardless, both our ratio of 50 near accidents per collision and the ratio of Poulos et al. [23] support the notion that near accidents occur much more frequently than collisions. These findings are also in line with Hydén [16] and Svensson [33], who proposed that less severe conflicts are more frequent than severe conflicts.

The majority of both near accidents and collisions occurred on shared pedestrian and bicycle paths as well as pedestrian paths. On shared paths with separate lanes, considerably fewer near accidents and collisions were recorded. The finding is similar to previous studies where collisions and near accidents between pedestrians and cyclists accumulated on shared spaces [3, 6, 7, 22]. Additionally, Haworth et al. [15] found that cycling on pedestrian paths increased the odds of a conflict between pedestrians and cyclists, while De Rome et al. [7] and Poulos et al. [22] calculated higher overall crash involvement rates for shared paths compared to cycle lanes. Unlike in the study by Haworth and Schramm [14], the survey results contained no collisions and only a few near accidents on cycle lanes. However, this is likely due to the low provision of dedicated cycle lanes in Finland.

The above suggests that road user separation may have benefits for safety compared to space sharing, especially if environments with frequent near accidents potentially feature frequent collisions, as the relationship between traffic conflict severity and frequency suggests [16, 33]. However, it is acknowledged that our results only show where reported near accidents and collisions accumulated, and do not represent near accident or collision risks by road environment. Our results are thus preliminary, and research on such risks between pedestrians and cyclists by road environment is recommended to further inform accident prevention efforts.

Events in which both road users were travelling in the same direction were most frequent on pedestrian paths, shared pedestrian and bicycle paths and shared paths with separate lanes. It is likely that most or all of these events involved the cyclist approaching the pedestrian. The frequent reporting of excessive cyclist speed, pedestrian and cyclist observation errors and unexpected pedestrian manoeuvres may explain why this event type was so frequent in shared road environments.

The lowest number of near accidents occurred on pedestrian crossings, most of which involved road users approaching perpendicular to each other. This result is unsurprising, as pedestrian crossings often connect to roads where an encounter with a forward-travelling pedestrian or cyclist is probable. Connection points between pedestrian crossings and pedestrian and bicycle paths

are therefore potentially dangerous sites for near accidents and collisions, where the involved parties approach perpendicular to each other.

Respondents were asked to report factors that they felt contributed to collisions and near accidents. The most frequently reported factors concerning cyclists were "excessive speed", "observation error" and "rule violation". The respective factors concerning pedestrians were "unexpected manoeuvre", "observation error" and "mobile phone use". The distribution of factors contributing to collisions mirrored the distribution for near accidents, with observation errors, excessive cyclist speed and rule violations reported most frequently. The finding further supports similarity between collisions and near accidents. Poulos et al. [23] also found that pedestrian observation errors and unexpected manoeuvres were frequent circumstances associated with near accidents between pedestrians and cyclists. However, that study considered cyclist perspectives only.

Respondents did not report factors related to their own behaviour nearly as often as they reported factors related to the other involved party. The low number of self-directed factors may indicate that respondents did not feel they contributed to events, were unable to estimate the effect of their behaviour, or did not want to disclose their behaviour. It is important to note that respondents were only able to deduce contributing factors based on their own experience. Therefore, the information concerning these factors is somewhat biased.

The most frequently reported contributing environmental factor was "unintuitive and complex infrastructure". Less frequently reported factors included "feature by the road obstructing visibility" and "obstruction on the road or lane". Furthermore, in response to a question concerning miscellaneous contributing factors, disruption caused by dogs being walked and their leashes were frequently reported. Ker et al. [18] made a similar finding, in which dogs off leash and dogs too far away from their owners contributed to near accident occurrence.

Respondents felt that users of the same travel mode are generally considerate towards each other, but users of different modes are less considerate. Cyclists also considered shared pedestrian and bicycle paths to be slightly safer than pedestrians did. These findings are unsurprising, as pedestrians are potentially the most vulnerable road users when pedestrians and cyclists share the same space [11, 12]. These findings suggest a lack of rapport between pedestrians and cyclists.

Respondents felt that road types separating pedestrians and cyclists from each other were safer than shared paths, and willingness to ride or walk on them was greater. However, older respondents considered both less safe and were less willing to travel on them than younger respondents. The lower perceived safety of older respondents may be related to their greater vulnerability in collisions between pedestrians and cyclists [5, 20, 22]. Additionally, younger people generally estimate traffic accident risks to be lower than the elderly (e.g. [25]).

This study was subject to a number of limitations. As the data is based on the experiences of survey respondents, the disclosed information is likely to be incomplete and its subjectivity must be considered when interpreting the results. For example, respondents may not have remembered all near accidents that occurred to them in the previous 3 years. Additionally, a considerably greater number of factors contributing to collisions and near accidents were attributed to other involved parties instead of respondents themselves, demonstrating some degree of bias. Respondents also appeared to encounter difficulty identifying contributing factors related to the surrounding road environment. Finally, the study focused only on inhabitants of relatively large cities and not on all pedestrians and cyclists.

6 Conclusion

Near accidents seem to occur considerably more often than actual collisions, with at least 50 near accidents occurring for every collision. Shared pedestrian and bicycle paths appear to be more dangerous than shared paths with separate lanes. Moreover, pedestrians and cyclists felt less safe on shared pedestrian and bicycle paths and were less happy to ride or walk on them compared to paths separating road users from each other. Respondents generally felt that lower cyclist speeds, prevention of unexpected pedestrian manoeuvres, greater overall focus on traffic and better adherence to traffic rules could reduce the risk of near accidents. However, as speeds below 10 km/h may have counter-productive effects due to greater riding instability [19] and associated fall and injury risk [21], the safety effects concerning cyclist speed remains uncertain and inconclusive. Finally, future research on the risk of near accidents and collisions between pedestrians and cyclists on different road environments is recommended.

7 Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12544-021-00497-z.

Additional file 1.

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Authors' contributions

Johannes Mesimäki: Lead author of manuscript and data-analysis. Juha Luoma: Second author, research design, guidance and reviewing. The authors read and approved the final manuscript.

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Availability of data and materials

Data for this research is unavailable.

Declarations

Competing interests

None.

Author details

[1]VTT Technical Research Centre of Finland Ltd, P.O. Box 1000, 02044 VTT, Finland. [2]Independent Research Scientist, Ulvilantie 19 g 4, 00350 Helsinki, Finland.

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