"Environmental Engineering" 10th International Conference
Vilnius Gediminas Technical University
Lithuania, 27–28 April 2017
http://enviro.vgtu.lt

eISSN 2029-7092 / eISBN 978-609-476-044-0

Article ID: enviro.2017.112
DOI: https://doi.org/10.3846/enviro.2017.112

Identification of Risk Factors for Collisions Involving Cyclists Based on Gdansk Example

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Abstract. The role of pedestrian and bicycle traffic in Poland has growing trend. The comprehensive traffic study, conducted in Gdansk in 2016, has confirmed the increase in the number of cyclists and their share in the modal split. Therefore, it is particularly important to ensure the safety of this group of unprotected road users. Only in 2015 on the roads of Gdansk occurred 93 accidents (excluding collisions) involving cyclists. As a result, 101 people were injured, including nine seriously and 3 people killed. The study aim was to identify risk factors for collisions involving cyclists based on data of accidents reported to the police. The following factors were analysed: the conditions for the drivers on the road (speed limits of, surface conditions), conditions for cyclists (cycling infrastructure, traffic management), external conditions (time of the year, time of the day, weather conditions), conditions organizational (type of intersection, traffic light) as well as the social aspects – the behaviour of all users.

Keywords: vulnerable road users, risk factors, cycle infrastructure.

Conference topic: Sustainable urban development.

Introduction

Increasing the role of active forms of mobility, including walking and cycling, is one of the tool recommended by the European Union (European Commission 2011, 2007) to balance the development of the transport system in cities. Increasing the proportion of walking and cycling in the modal split of cities is aimed at reducing emission of pollutants, including carbon dioxide, reducing congestion and improving health of residents. Realizing the common objectives of the United Europe, individual countries, regions and cities undertake local activities (educational, promotional, investing, legislative) to promote cycling and walking.

As a result of actions undertaken, as well as growing environmental awareness of society and a trend for healthy lifestyle popularization, the number of cyclists and pedestrians is systematically growing. With increasing role of active forms of mobility, there is a growing need to ensure safety of unprotected road users, such as cyclists and pedestrians. Police statistics show that they are the most vulnerable to the consequences of road accidents, including injuries and death.

In this article, we analysed the data from road accidents (without collision) in Gdansk involving cyclists occurring in 2006–2015. Based on the data obtained from the Registration System of Accidents and Collisions (SEWiK) and knowledge on the cycling infrastructure of Gdansk, classification of factors affecting the reported events according to the degree of significance, was performed.

Safety of cyclists in Gdansk

In Gdansk, the number of accidents involving cyclists is much higher in comparison to most cities of the European Union. Safety of cyclists in Gdansk reflects national trends (Fig. 1). Analysing the change in the number of accidents involving cyclists in the country during subsequent years (Fig. 2) and in Gdansk (Fig. 3), we can observe a significant increase in the number of accidents after 2011 relative to previous years. This trend has been observed in Belgium, Finland, Austria and the Czech Republic (Fig. 1). After 2010, the trend at the city scale deviates from the nationwide trend. During the last five years in Poland, the number of accidents involving cyclists is increasing, despite the general improvement of safety on Polish roads. In Poland, in 2010–2015 the number of road accidents decreased by 15%, the number of victims by 19% and the number of fatalities by as much as 25%. At the same time, the number of accidents involving cyclists increased by 18.3%, the number of victims by nearly 17% and the number of fatalities by 7%. While at the scale of Gdansk, after 2011 we can observe a slight but systematic reduction in the number of accidents involving cyclists.

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Only in 2014, one reported 3 accidents more in comparison to the previous year. Analysing the level of safety of cyclists, we should consider not only the number of accidents, but also the level of bicycle traffic and the proportion of biking trips in the modal split, which is still reduced in Polish cities (1–10%). According to the calculations provided by the authors of the "Strategy of transport and mobility for Gdansk Metropolitan Area" who referred the number of accidents with cyclists to a relatively small proportion of cycling in traveling, cycling belongs to a type of trip characterized by the highest risk (Michalski *et al.* 2015). An indicator demonstrating the level of safety is the number of fatalities among cyclists per million residents. At the scale of Poland, in 2015 this rate accounted for 7.8 (15.8 in 2005) fatalities per million residents and for Gdansk it accounted for 6.5. Accordingly at that time, the average for the EU-14 countries was 4.0.

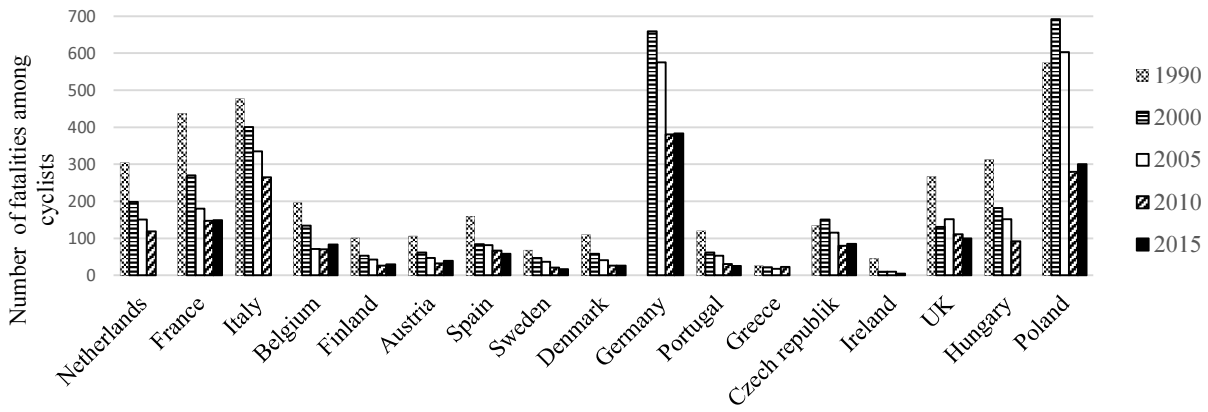

Fig. 1. The number of fatalities among cyclists in selected countries in years 1990–2015
Source: own study based on OECD 2016

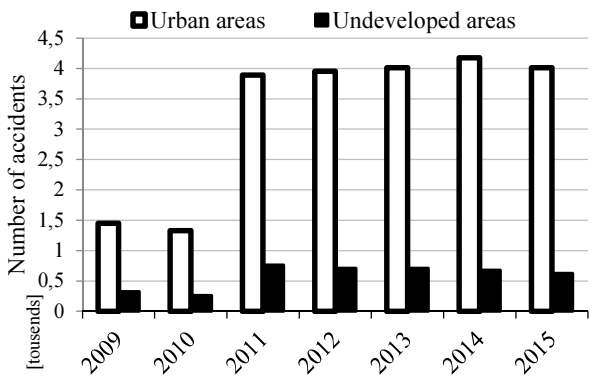

Fig. 2. The number of accidents involving cyclists in urban and undeveloped areas in Poland
Source: SEWiK 2016

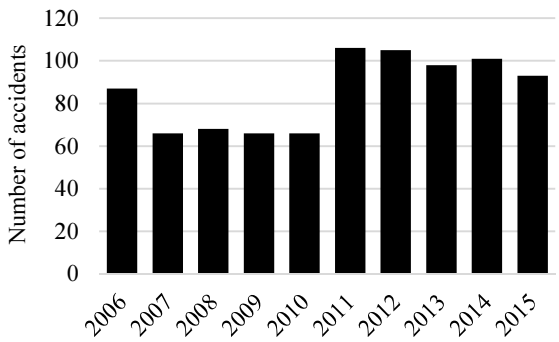

Fig. 3. The number of accidents involving cyclists in Gdansk
Source: own study based on SEWiK 2016

Intensity of bicycle traffic

To determine the relationship between the number of accidents involving cyclists and the intensity of bicycle traffic, data on the number of accidents should be referred to the data on the intensity of bicycle traffic. Traffic Research in Gdansk (performed in 1998, 2009, 2016) conducted by Gdansk Development Office allows to specify the share of bicycles in the modal split (Fig. 4). While thanks for automatic measuring system operating for 4 years, it is possible to measure the intensity of bicycle traffic in selected sections (currently 26 positions). Additionally, manual measurements of biking intensity are carried out regularly in selected locations between May and June by the staff of Gdansk Development Office. The results of the automatic and manual measurements are consistent; demonstrate the general increasing trend in the number of cyclists (Fig. 5). The change in the number of bicycle trips is influenced by the cycling policy in the city (Okraszewska *et al.* 2016: 87–99), changes in the ecological awareness of the residents and fashion for a healthy lifestyle.

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Decrease in the number of cyclists reported in 2015 in the sections analysed with simultaneous increase in the proportion of cycling in the modal split, may be a consequence of new investments in the cycling infrastructure and dispersion of traffic on the spreading network of cycling routes.

Fig. 4. Changes in Modal Split in Gdansk in years 2009–2016
Source: own study based on VIA VISTULA 2016; Gdansk Development Office 2009

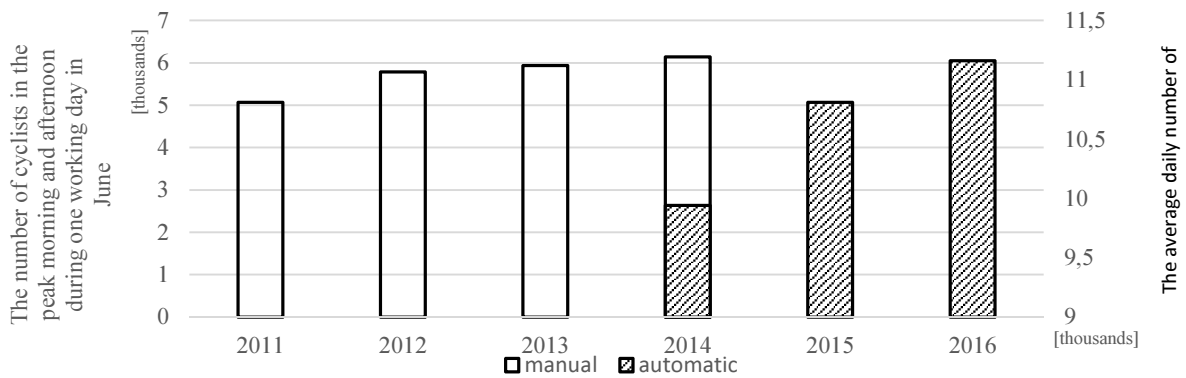

Fig. 5. Comparison of the trend change in the size of traffic volumes of cyclists – the results from automatic and manual measurements
Source: own study based on City Hall in Gdansk 2016; Gdansk Development Office 2014

Analyzing the impact of factors associated with the road accident on its occurrence

In police statistics on the accidents involving cyclists, the following data can be obtained:

- location of the accident (geographical coordinates, street name, type of infrastructure),
- conditions (state of the road surface, weather conditions, speed limit (on the road), time of day in which the accident occurred),
- participants of the accident (age, gender, perpetrator),
- causes, type and consequences of accidents.

The objective of this study was to classify the factors that affect the accidents reported according to the degree of significance. Analysis of relationship between the occurrence of an accident and independent variables identified in the police database SEWIK from 2006–2015 allowed for grouping factors associated with the accident into three groups in terms of their impact on the occurrence of an accident:

- factors having no significant effect on the occurrence of an accident,
- factors potentially affecting the occurrence of an accident,
- factors having a significant effect on the occurrence of an accident.

Among factors with no significant effect on the occurrence of an accident, the following ones can be mentioned:

- weather conditions, as 76% of the accidents occurred under good weather conditions (Fig. 6),
- state of the road surface, as in 88% of cases, the road surface was dry (Fig. 6),
- time of day, as 88% of accidents occurred in daylight (Fig. 6),
- consumption of alcohol, as only 2.33% of accidents reported were caused by drivers under the influence of alcohol,
- age of cyclists, as only 4% of accidents with children were reported (Fig. 7).

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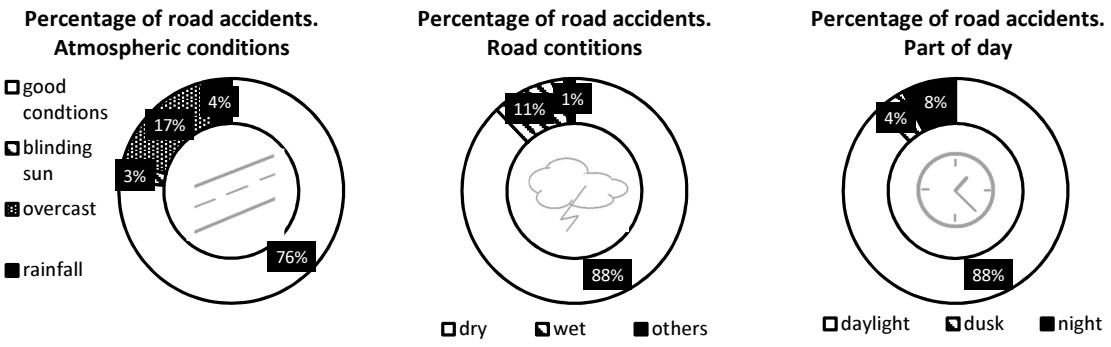

Fig. 6. The share of accidents according to weather conditions, time of day and the state of the road surface in 2006–2015 in Gdansk
Source: Own study based on SEWiK 2016

Theoretically, bad state of the road surface affects the deterioration of road safety. However, these conditions induce increasing caution and speed reduction by drivers. Moreover, good weather conditions affect the increased proportion of cyclists on the roads.

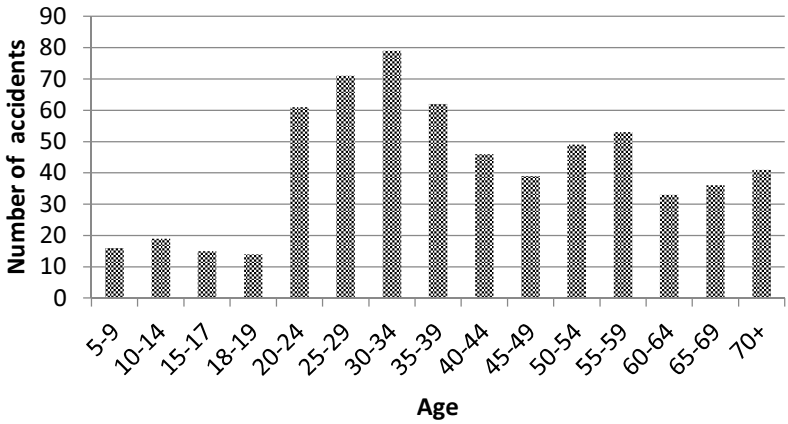

Fig. 7. Number of road accidents by age. Gdansk 2006–2015
Source: Own study based on SEWiK 2016

Among factors having a potential impact on the occurrence of the accidents were:

- Speed limit, as 83% of the accidents occurred at a speed limit of 50 km/h. However, considering that the accidents occurred in the urban areas, where in the majority, speed limit of 50 km/h is reported and the relation observed does not have to be cause and effect.
- Lack of traffic lights, as under such conditions, 70% of accidents occurred. Moreover, these accidents were serious – 78% of all fatalities occurred in locations where there no traffic lights or traffic lights damage were observed.
- Season, as during the winter, conditions in terms of visibility and surface conditions affecting braking distance can be much worse than in summer. Small proportion of bicycles in the winter in Gdansk does not allow to make inference based on such a small sample.
- Gender, in 80% of cases, men were perpetrators, however not knowing the gender of drivers and cyclists, one cannot identify the cause and effect. From other studies on the structure type of cyclists it can be concluded that men ride bikes more frequently than women.

On the other hand, among factors which have a significant effect on the occurrence of the accident we can include:

- Traffic volume of cyclists.
- Users' behavior – among the causes of the accident, we can primarily distinguish a failure to yield the right of way – 52% of accidents.
- Limited visibility – it may be confirmed by the number of accidents with failure to yield the right of way and a big proportion of the side impact accidents (66%).
- Conflict relationship between a driver and cyclist or intersecting the cyclist's road with a car.

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Analysis of the relationship between the number of cyclists reported by automatic measurements and the number of accidents involving cyclists can relate to a time period of year, week or day. The use of bikes in bicycles trips is strongly correlated to the season (Fig. 8). The greatest cycling intensity occurs from April to October and in the remaining months it is much lower. The plot of annual distribution of the number of accidents involving cyclists is also variable during the year. Figure 8 summarizes a trend in the change of the magnitude of traffic intensity with the number of accidents. Moreover, analyzing the relationship between the intensity of bicycle traffic and the number of accidents per week, mutual correlation can be observed. Along the main transport axis of Gdansk, the intensity of cycling is higher on weekdays in comparison to weekend.

In Gdansk area, a number of accidents involving cyclists is also higher on weekdays, less intense on Saturday with the least intensity on Sunday. Lack of data from speed meters when dividing into hours does not allow to compare the intensity of cycling in daily distribution with the number of accidents. Statistics data show that only between 2006 and 2014, 63% of the accidents occurred in the afternoon. From the above-mentioned comparisons it can be concluded that the larger the number of accidents the greater the intensity of cycling.

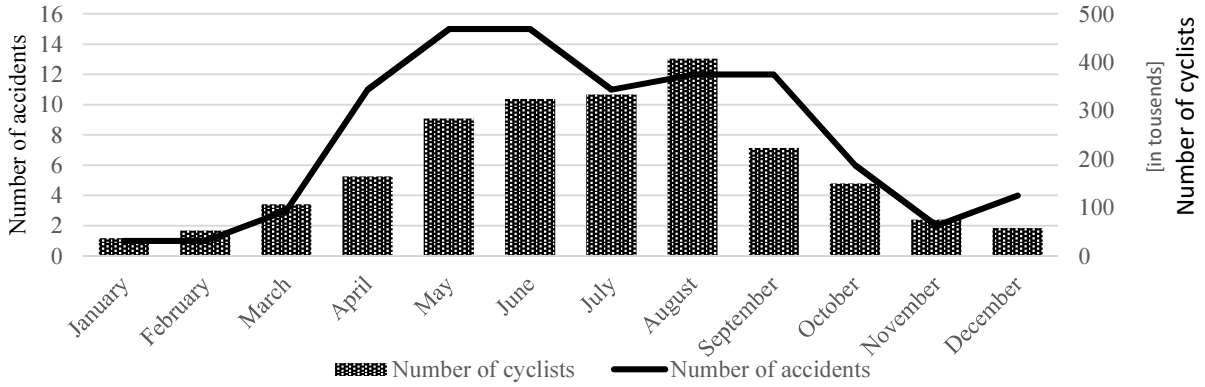

Fig. 8. Comparison between the trend of changes in individual months of 2015 in terms of the number of cyclists on three most important road sections (Zwycięstwa Avenue, Coastal belt and Grunwaldzka Avenue) and the number accidents involving a cyclist
Source: own study based on City Hall in Gdansk 2016; SEWiK 2016

While a correlation between the magnitude of traffic intensity and a number of accidents in a given road section was observed, the intensity of cycling is not a criterion determining the level of safety. It can be confirmed by the analysis of the spatial concentration of accidents involving cyclists. One of the path with the lowest number of accidents was the Pas Nadmorski, which is characterized by the highest intensity of cycling. Streets in Gdansk where the largest numbers of accidents are reported include: Grunwaldzka Avenue, where 14% events occur, Hallera Avenue (above 5%), Kartuska Street (above 3%), Słowackiego Street (above 3%), Zwycięstwa Avenue (above 2%). Within all of these streets, cycle tracks can be found which are located at the side-walks and intertwined with them, with an average distance from the road edge of about 2 meters. This situation allows to raise a conclusion that formation of bicycle infrastructure is not sufficient to ensure safety for cyclists. Moreover, it should be emphasized that in Gdansk, the total length of separated tracks for bicycles is 118 km (Table 1), which represents 15% of the public roads (788 km).

Table 1. Linear cycling infrastructure in Gdansk

The cycling routes include e.g.:	
- separated cycling routes	– 117.9 km
- foot and cycle tracks with pedestrian priority	– 17.2 km
- sidewalks with cycle tracks available *(in contrast to footpath and cycle tracks, the cycler is not obligated to use it)*	– 29 km
- cycle lanes on the road	– 7.3 km
- bus and bicycle lanes	– 0.7 km

Source: City Hall in Gdansk 2016.

Analyzing statistics of events involving cyclists, it can be observed that 67% of the accidents occur on tracks with a separate path for bicycles, 30% in the streets without a separate track for bicycles (also without bicycle lanes), 2% on pedestrian crossings and 1% in other locations such as pavement, pedestrian paths, bicycle lanes. However, the above-mentioned data should not be misin-terpreted and one should be aware that, e.g. the total length of bicycle lanes in Gdansk is rela-tively small, equal to 7.3 km long and can be found in “tempo 30” area.

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The most common types of accidents are side running accidents which were observed in 66% of all the accidents (Fig. 9). This kind of accident is observed in both, bicycle lanes (64% of events) and on the road (65% of events). The second most frequent type of accident is a head-on collision, which was reported in 15% of accidents. Almost 69% of head-on collisions occur on the bicycle tracks between cyclists. Regarding collisions with a pedestrian, these accidents occur both on lanes with a separated path for bicycles (57% of events), for which the most common cause is the invasion of pedestrians on the road resulting in being knocked over by a car (39%) and failure to yield the right of way to pedestrians (28%).

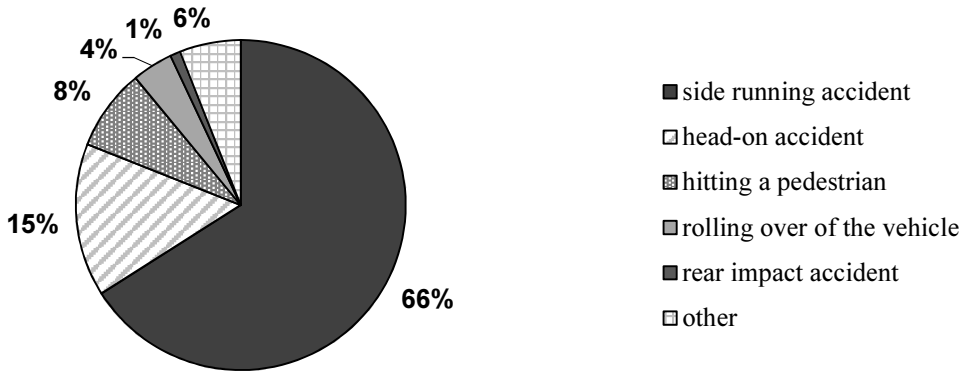

Fig. 9. Type of event in accidents involving cyclists in Gdansk between 2006 and 2015
Source: own study based on SEWiK 2016

Undoubtedly, safety level is affected by the intensity of traffic on adjacent streets and adjusting the cycling track. The above-mentioned path through the Pas Nadmorski is characterized by a low rate of accidents, because it is a completely separated track, isolated from the traffic, where the cyclist track does not cross the road. Meanwhile, the most common and most serious consequences are collisions with a car. The track developed for bicycles located along the road becomes dangerous in areas where the roads cross, so in the area of crossings, pedestrian crossings, bicycle tracks and when driving out of homes. When the track of cyclists and drivers crosses, mutual visibility of road users is especially important.

In previously-mentioned Kartuska Street, where a lot of road accidents involving cyclists are observed, a separated bicycle track can be found between residential commercial buildings and a road (including the parallel parking spaces). The approximate distance of the edge of the road from the buildings is only equal to 5 meters where a bicycle track, sidewalk and often a lawn can be found. This situation affects the frequent invasion of pedestrians on the bicycle track. In addition, numerous locations where driving out of home, buildings and access roads without right of way can be found in this area on which reduced visibility is reported due to the occurrence of multiple buildings. This example shows that the solution in the form of a separated bicycle path is not always an effective way to ensure safety for cyclists.

Conclusions from analyzes

Considering relatively low proportion of traveling by bike in the modal split in the city, based on data from the Registration System of Accidents and Collisions on the number of accidents involving cyclists, the safety of cyclists in Gdansk should be regarded as low, however systematically improving:

- the number of accidents involving cyclists in Gdańsk is decreasing since 2011,
- the number of cyclists and the proportion of bicycles in the modal split is growing, in 2009–2016 it increased by 4 percentage points.

Based on the analysis of police data conducted from the locations of accidents and based on the knowledge of cycling infrastructure of the city, two factors which have a significant correlation with the occurrence of the accident, were observed:

- traffic volume of cyclists,
- users' behavior,
- infrastructure solutions.

A safe infrastructure solution of a bicycle track must consider local conditions related to the intensity of traffic on the adjacent route, current speed, nature of the adjacent buildings, availability of space for bicycle infrastructure. Analysis of the accidents helped to identify locations with the highest frequency of accidents. However, the assessment

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of the level of safety of a given infrastructure should be based on calculation of the number of accidents per users' number. In Gdansk, a growing intensity of cycling from year to year may result in an increase in the number of accidents.

Recommendations

Based on the conclusions from the analyzes conducted it should be stated that cycling will likely grow further and therefore, the number of accidents involving cyclists can also grow. To increase the safety of cycling routes in Gdansk:

- it is necessary to continue the development of a cycling infrastructure with an emphasis on technical standards for which the elements of infrastructure should be subjected along with the use of best practices,
- it would be advisable to develop guidelines for the design of safe infrastructure for cyclists at the country scale,
- we should undertake promotional and educational activities which raise the awareness of road users in terms of existing legislation and the needs and expectations of particular groups of traffic users.

Disclosure statement

Authors are required to include a statement at the end of their article to declare whether or not they have any competing financial, professional, or personal interests from other parties.

We, the authors, declare we don't have any competing financial, professional, or personal interests from other parties.

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