HELMET USAGE FOR SINGLE-TRACK VEHICLE USERS IN THE POZNAN AGGLOMERATION: A PRELIMINARY STUDY

Maciej Obst, Szymon Rzepczyk, Anna Karwasz, Sebastian Głowiński

Abstract

Accidents are inherent elements of human activity, and engineers have strived to develop safety systems to safeguard people against accidents, which are often random and unpredictable. Helmets have become the most popular means of protection over the years. They have undergone significant modifications, evolving into effective and advanced tools for head protection. Unfortunately, because helmets remain optional for bicycle users, some individuals choose to ignore safety guidelines. Methods: This research employed a survey method conducted among the residents of the Poznan agglomeration to determine the reasons behind the low adoption of helmets. A questionnaire consisting of 15 questions was distributed to 173 users of two-wheeled vehicles, including motorbikes, bicycles, mopeds, and electric scooters. Results: The findings revealed that only 41.4% of men declared using helmets, with 24.4% of women doing so. Additionally, 44.4% of the helmets in use were new, while the remaining 55.6% were purchased second-hand. Conclusion: The research indicates that individuals are more likely to wear protective helmets on older two-wheelers, and helmet usage is higher in larger cities. Therefore, it is essential to focus bicycle helmet educational campaigns on children and teenagers to improve safety awareness and encourage helmet usage.

Keywords:

head protection, helmets, Poznan road safety, agglomeration safety

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1. Introduction

Road accidents remain a persistent and challenging issue with no immediate resolution in sight. Concurrently, traffic accidents continue to stand as a leading cause of injuries in our communities (Prochowski & Pusty, 2015). Despite notable advancements in technology, the development of innovative helmet designs, improved safety gear for motorcyclists, enhanced protective systems, and upgrades in road infrastructure, injuries sustained by motorcyclists persist as a critical concern that demands ongoing scientific investigation. In a study conducted by Sosin et al. (1999), the authors compiled data pertaining to head injuries and fatalities resulting from motorcycle accidents. Their research revealed that motorcyclists in the United States aged 15 to 34 accounted for a staggering 69% of fatalities in accidents occurring between 1979 and 1984, with 53% of the 28,744 deaths being attributed to head injuries. Furthermore, a significant spike in mortality was noted among motorcycle riders who neglected to employ head protection through the use of helmets. Notably, in Great Britain, between 1995 and 2004, the fatality rate among motorcyclists increased from 416 to 585 fatalities per year (Sosin, Sacks, & Holmgreen, 1999). These statistics indicate that a substantial 70% of severe injuries are a consequence of head impact among motorcyclists. Considering the escalating popularity of motorcycles, it is conceivable that head injuries will emerge as the primary cause of disability or death among motorcyclists in the years to come. This notion is substantiated by the study of Mellor et al. (2007), who focused on the analysis of helmet damage in accidents. Their findings disclosed that 23.6% of helmet shell damage occurred at the front, 21% at the rear, and a substantial 53.2% on the sides of the helmet shell.

In general, people are aware of the potential dangers associated with their daily activities. However, many tend to believe that such problems do not directly affect them and are distant concerns. Nevertheless, the reports of traffic accidents unmistakably highlight the presence of a significant problem. Furthermore, professional activities and recreational sports carry inherent risks of accidents and associated injuries. With the growing number of vehicles on the road, including two-wheeled vehicles, safety concerns have escalated. Helmets have emerged as one of the most widely accepted means of protection. Over the years, helmets have undergone significant modifications and now represent an effective and advanced method of safeguarding the head. Ongoing advancements in construction, materials, research, and design techniques have led to significant progress in helmet manufacturing.

Bicycle helmets (and most other types of helmets) aim to reduce the risk of serious injuries due to impact to the head. They reduce the deceleration of the skull and hence the brain by controlling the impact characteristics. This was achieved by deformation of the soft material incorporated into the helmet. Additionally, helmets prevent direct contact between the skull and the impacting object. The helmets spread to the area where the impact forces reached the skull, to prevent them from being concentrated in small areas of the skull. Several studies have described the biomechanics of head injuries subjected to dynamic loads (Shuaeib, et al. 2002; Glowinski, & Krzyzynski, 2013; Tse, et al. 2015; Fernandes, & Alves De Sousa, 2013).

Many statistical studies have focused on analysing traffic accidents in relation to specific countries and agglomerations. Grimm et al. (2016), analysed data on accidents involving motorbike drivers in Delhi, India. Unfortunately, not all drivers protect their heads using helmets. As a problem solution, the implementation of training, increasing awareness of the danger among motorcycle users and development of road infrastructure was proposed. This study focused on Hyderabard, India, where the relationship between the number of fatalities among motorcyclists and popularity of protective helmets was investigated (Wadhwaniya, et al. 2017). It was pointed out that youth drivers are more prone to not using a protective helmets and risky behaviour. Research has shown that better-educated people more often use helmet head protection. Another study was conducted in Vietnam (Olson, et al. 2016). Authors showed an increase in the popularity of protective helmets among motorcycle users from 30% to 93% and the effectiveness of head protection with helmets both in terms of the extent of injuries as well as paying attention to the social costs. The increased popularity of helmet head protection is because of legal regulations. The diverse views of researchers on motorcyclists' accident rates allow for the assessment of this problem using various criteria. The authors presented the influence of weight and cutting of helmets and clothing on injuries of motorcycle passengers (people sitting back on the driver were the subjects of research) (Ahmed, at al., 2016). This research was conducted in Lahore, Pakistan. The authors drew attention to the need to introduce structural changes in both protective clothing and protective helmets, and to raise awareness of safety among motorcycle users. Many researchers have emphasized the need for training and campaigns to ensure road safety. The authors used questionnaire data from Taiwan to assess the extent of injuries sustained by motorcyclists depending on the type of protective helmet (Lam, et al., 2020). The authors concluded that the severity of the injuries was influenced by the type of protective helmet. The full-face helmets showed the lowest degree of injury. The results of a survey conducted in Malaysia by Ramli et al. (2016), formed the basis for identifying a link between head injuries, protective helmets and fastening systems. The popularity of repaired helmets has also been reported. It was found that the effectiveness of the fastening system of the protective helmet played a more important role in accidents than the helmet type.

Jones et al. (2017) pointed out that not all states in the United States have mandatory regulations for wearing protective helmets. Despite 30 years

of pressure from the federal government, a unified set of regulations is yet to be established. Jung et al. (2013) presented relevant statistical data on the accident rates among motorcyclists aged up to 24 and between 45 and 54 in California State, USA. They identified the lack of or improper use of protective helmets as a leading cause of head injuries. Proposed solutions to enhance the safety of motorcycle users include training programs, promoting safe driving practices, and enforcing applicable laws. Legal regulations and increased awareness of road safety are pivotal factors in improving accident statistics. Ouellet J.V. (2011) conducted an assessment of various factors influencing motorcycle accidents by examining reconstructions of accidents in Los Angeles from 1976–1977 and in Thailand from 1999 to 2000. The assessment included the role of head protection provided by helmets. His findings suggested that there is no evidence to support the claim that the use of protective helmets leads to riskier behaviour among motorcyclists. However, an opposing viewpoint exists among those sceptical of legal regulations mandating helmet use. Boone et al. (2018) presented statistical data from the states of South Carolina, Indiana, Florida, and Hawaii to illustrate the effectiveness of helmet head protection among moped users. Legal regulations in this context are also subject to scientific evaluation. Peng et al. (2017) conducted an assessment of the applicable legal regulations concerning helmet use among motorcyclists in the United States. They noted a decrease in the number of motorcycle users wearing protective helmets in 2013. Importantly, the study highlighted the direct impact of existing legal regulations on the head protection of motorcyclists. Eltorai et al. (2016) described instances of non-compliance with protective helmet usage regulations among motorcyclists in the United States. Proposals for changes in federal regulations have been made, which could contribute to the increased adoption of helmet head protection among motorcycle users.

A questionnaire survey was undertaken to assess the perceptions of safety systems among two-wheeler users in the Poznan agglomeration, Poland. The primary objective of this study was to determine the proportion of two-wheeler users who employ protective helmets and those who do not, and to understand their perceptions regarding helmet usage. The survey questions also inquired about the risks associated with the use of these vehicles and the number of accidents in which respondents had been involved.

2. Materials and Methods

The study was conducted from September 2021 to January 2022. Respondents completed an online questionnaire via Google Drive Forms. Potential participants were informed about the survey through social media and direct contact, particularly during academic lectures. This data collection method primarily reached individuals in the Poznan agglomeration and neighbouring towns, estimated to have a population of approximately one million people in 2022 (as per ESPON and Eurostat data). The questionnaire included inquiries about the types of vehicles respondents used, such as bicycles, mopeds, electric scooters, and motorcycles. If someone utilized multiple types of vehicles, they had the option to select multiple choices. Questions covered topics like head protection, helmet condition, the advantages and disadvantages of helmet use, and respondents' accident history. The survey also included questions about elements of the road environment and safety-related factors. To be included in the study, individuals had to meet specific criteria, which were the use of a two-wheeled vehicle and an age range between 15 and 90 years. Exclusion criteria included not using a single-track vehicle. Statistical calculations were carried out using the STATISTICA software package version 13.0 from StatSoft Inc., along with the Python open-source programming language. Qualitative variables were presented using cardinality statistics and percentage values. A significance level of p=0.05 was used for all calculations.

3. Results

3.1. Study Group Characteristics

The questionnaire was completed by 173 participants, consisting of 87 men (50.3%) and 86 women (49.7%). Among the respondents, 26% resided in rural areas, 8.1% in small cities with up to 10,000 inhabitants, 15.6% in cities with populations of up to 50,000, 6.4% in cities with populations between 50,000 and 100,000, and 43.4% in provincial cities. Notably, 56.5% of the respondents living in rural areas were women, while in small cities, the corresponding percentage was 57.1%. In cities with populations up to 50,000, 51.9% of respondents were women, and in cities with populations between 50,000 and 100,000, 63.6% of respondents were women. In provincial cities, women constituted 41.3% of all residents. The respondents' ages were categorized into the following groups:

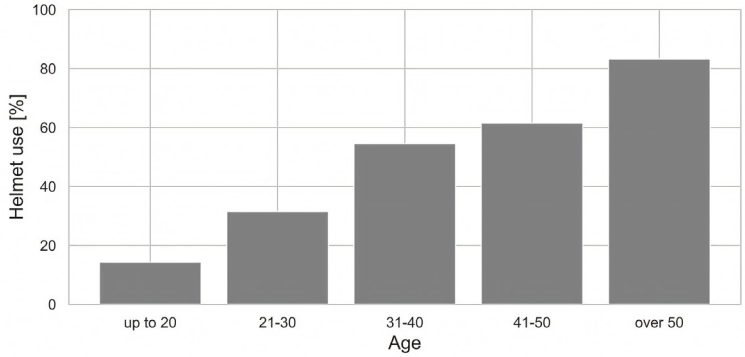
- up to 20 years,
- 21÷30 years,
- 31÷40 years,
- 41÷50 years,
- over 50 years.

3.2. Qualitative variables

The use of bicycles declared 91.9%, motorcycles 11.0%, electric scooters 9.7% and moped 4,5%. The research shows that in the group of people up to 20 years old, only 14.3% of teenagers use a helmet, whereas in group 21÷30 the value is 31.5%. In the range of 31÷40 it was 54.5%. It can be concluded that the older the two-wheeler, the more often he/she wears protective helmets (Fig. 1). Among the bicycle users only 31.3% declared the use of a protective helmet. The drivers of electric scooters and motorcycles have been reported to use helmets in 65.0%. Only 41.4% of the men and 24.4% of the women reported using helmets.

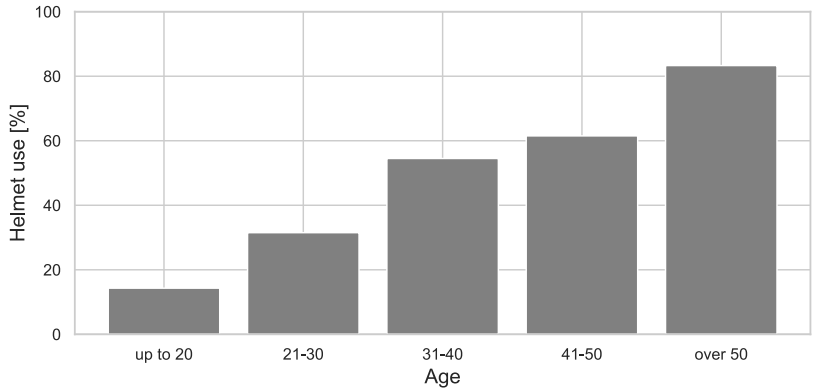
Statistical analysis was conducted using the Chi-2 Pearson test (p=0.0006) and the Chi-2 Maximum Likelihood test (p=0.0006). The test results revealed a significant difference between two age groups: those up to 20 years old and those between 21 and 30 years old, in comparison to other age groups. These findings suggest that older individuals are more conscious of and tend to use safety helmets more frequently than those under 30 years of age.

Fig. 1. Percentage of helmet users by age group



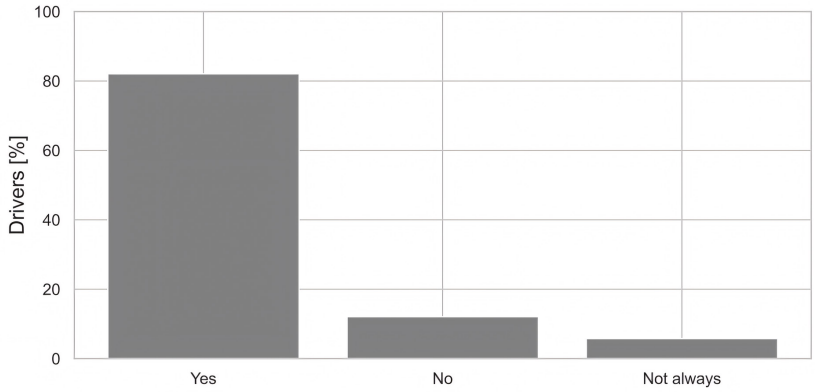
Helmet users reported that only 44.4% of the helmets were purchased as new, while in the remaining cases (55.6%), the helmets were acquired second-hand. Fig. 2 illustrates the distribution of helmet types across different age groups. Among those aged up to 20, 66.6% of men stated that they purchased new helmets, and for women in this age group, the percentage was 100%. In the 21–30 age group, 70.8% of men and 91.7% of women used new helmets. In the 31–40 age group, 75.0% of men opted for new helmets, whereas 50.0% of women did the same. Moving to the 41–50 age group, 80.0% of men and 100.0% of women selected new helmets. For individuals over the age of 50, there were no reports of using second-hand equipment. Approximately 67.7% of users prioritize the price when purchasing a helmet. Aesthetics and color are important to 51% of respondents. Helmet type (full or open) is a crucial factor for 43.8% of respondents, while the presence of a safety certificate ranks fourth at 40.6%. 34.4% of people take into account the opinions of other users, and 29.2% consider the brand when choosing a helmet. Survey respondents highlighted several concerns with using helmets. The most significant issues include a reduction in travel comfort (66.5%) and limited visibility while wearing a helmet (26.6%). Additional disadvantages of helmet use include difficulties in storage (46.0%) and concerns about high prices (41.0% of respondents). There was no statistically significant difference between individual age groups. Chi-2 Pearson test (p=0.9367) and the Chi-2 Maximum Likelihood test (p=0.8485).

Fig. 2. Percentage of new helmet users by age group



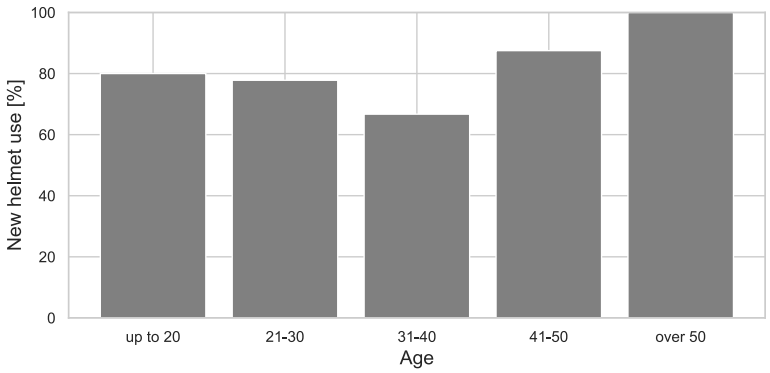
The most significant variation in helmet usage was observed among rural residents, where only 23.9% reported using a protective helmet. In small cities, the percentage was 21.4%, while in cities with populations up to 50,000, it was 22.2%. In cities with populations between 50,000 and 100,000, 45.5% of respondents used helmets, and in provincial cities, the percentage was 44.0%. This suggests a trend where larger cities tend to have a higher percentage of helmet users.

Fig. 3. Percentage of drivers who felt safe while driving.



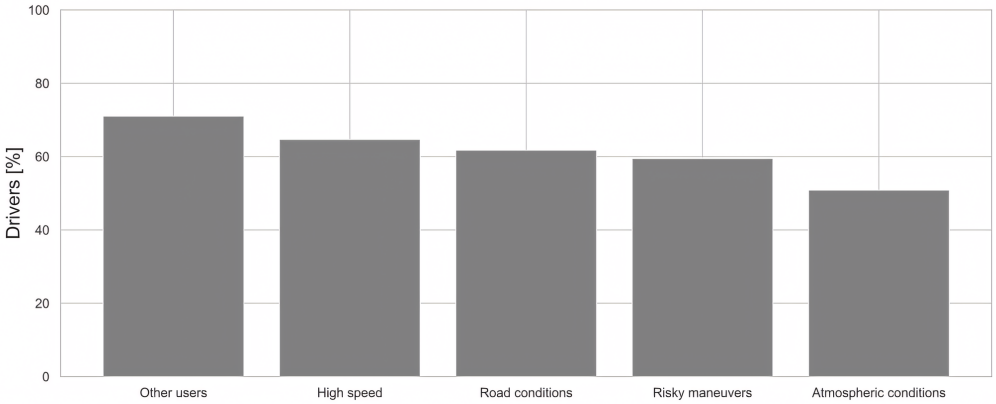
An interesting indicator is the respondents' self-reported involvement in a road accident. Surprisingly, as much as 17.9% of survey participants declared that they had been in an accident. This statistic highlights that road accidents are not uncommon and can affect a significant portion of the population. Specifically, in the age group up to 20 years, 11.4% of individuals reported involvement in a road accident, while for those aged 21 to 30, the percentage was 17.6%. The highest incidence, at 36.4%, occurred in the age group between 31 and 40 years. For those aged 41 to 50, it was 23.1%, and for individuals over 50, it was 16.7%. The majority of accidents occurred while riding a bicycle (83.3%), followed by motorcycle accidents at 27.8%. Electric scooter and moped accidents accounted for 8.3% of all reported accidents, respectively. It's worth noting that some respondents reported accidents involving both bikes and motorcycles. Regarding their perception of safety, a significant portion of drivers, approximately 82.1%, declared that they feel safe when using their vehicles. Only 12.1% did not feel safe, while 5.8% indicated that their sense of safety depended on the specific situation (as shown in Fig. 3).

Fig. 4. Parts of the body most exposed to injuries, according to respondents



The respondents demonstrated a high level of awareness regarding accidental injuries, as shown in Fig. 4. A significant majority of drivers (85.5%) identified the head as the body part most vulnerable to serious injury during an accident. This perception was consistent across all age groups of respondents, with the head consistently being recognized as the body part most susceptible to injury. Hand injuries were reported by 55.5% of the respondents, while 38.7% mentioned leg injuries.

Fig. 5. Factors affecting accident risk according to respondents



Among the causes of threats, other road users were identified as the primary factor, cited by 71.1% of respondents. High travel speed was mentioned by 64.7% of the participants. A portion of the respondents, 18.8%, attributed threats to poor road infrastructure. Furthermore, only 61.8% of respondents identified high travel speed as a cause of threats. Risky manoeuvres were recognized by 59.5% of users, while atmospheric conditions were noted by 50.9%, as depicted in Fig. 5.

The impact of environmental factors on the safety of two-wheeler users was also considered. A majority, 69.9% of users, identified curbs, topography (including ditches and slopes), and advertising banners as potential hazards while using their vehicles. Railings were indicated as such by 32.9% of participants, and trees by 20.8% of respondents.

4. Discussion

The popularity of two-wheeled vehicles has witnessed a significant surge in recent times. This surge extends to electric bikes, electric scooters, and other modern modes of transport. People are increasingly using two-wheeled vehicles both for daily transportation and recreational purposes. While there is a high level of awareness regarding the associated dangers and the risk of injuries, the adoption of safety measures like wearing helmets, especially among younger bike and electric scooter users, remains relatively low. Given the heightened awareness of these risks, it's essential to address why the problem of accidents persists and new, previously undiscovered aspects continue to emerge. Implementing systematic training, engaging in social initiatives, and developing road infrastructure are potential avenues to enhance safety and contribute to the improvement of accident statistics. This study, based on a well-prepared survey, identifies areas where safety for unprotected riders and other road users can be enhanced. Efforts related to training and systematic social initiatives should be directed toward individuals of all age groups, with a particular focus on young people and children. The modernization and introduction of new solutions in road infrastructure elements can significantly enhance the safety of all drivers.

A prepared survey was conducted in the Poznan agglomeration, serving as an initial assessment of the issue. These findings offer valuable insights for future research and more specific investigations. It is crucial to highlight the ongoing and prevalent risk of injuries among riders concerning traffic organization. The safety of agglomeration residents is a multifaceted problem that requires thorough examination through a systematic approach.

Fig. 6. The common brain injuries as a consequence of traffic accidents: epidural hematoma (red), subdural hematoma (blue), intracerebral haematoma (green) and cerebral contusion (orange)

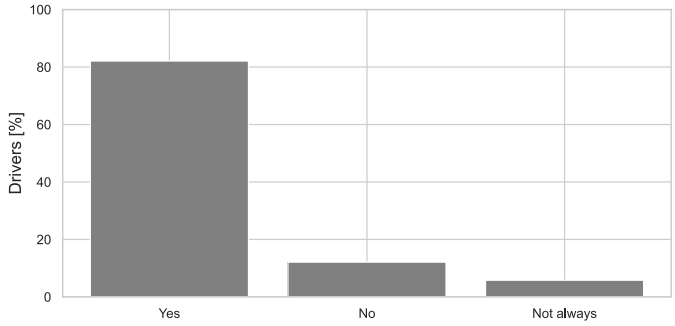


Fig. 6 illustrates common head injuries. Head injuries typically result in wounds and abrasions to the scalp, damage to the bones of the skull, as well as hematomas and contusions of the nerve tissue (Teresiński, 2019; Kowalczewska et al., 2022). Lenticular-shaped epidural hematomas are the consequence of damage to the meningeal arteries, while subdural hematomas take on a crescent shape due to damage to bridging veins (Teresiński, 2019; Khairat & Waseem, 2022; Shabani et al., 2016). It's important to note that neither type penetrates the brain tissue; they instead exert pressure on it, forming between the layers of the meninges. Intracerebral hematomas, found within the cerebrum, exhibit various shapes and can be situated within different layers of the brain's subcortex and deep structures (Teresiński, 2019). Contusions, which most frequently occur in the cerebral cortex, result from the contact and compression of nerve tissue against the hard structures of the skull bones following an impact (Kołpa et al., 2016). They may also form on the opposite side from where the force is applied, a mechanism known as contrecoup (Teresiński, 2019; Payne et al., 2022).

Road infrastructure elements like poles, energy-intensive barriers, sharp-edged objects, and protruding bolts can pose significant injury risks to individuals using bicycles, bikes, electric scooters, skateboards, and similar devices without protective measures. This issue should be addressed on a global scale. Initiatives to address this problem should encompass modifications to infrastructure design, awareness campaigns, educational programs, and personal protective measures, all working in concert.

5. Conclusion

Most bicycle helmet education campaigns are primarily aimed at children and teenagers, as this age group frequently uses two-wheeled and other "rides on" vehicles but often neglects to protect themselves from the potential consequences of accidents. High speeds are a significant contributing factor to the risk of accidents, and potential riders are generally aware of this fact. This raises the question: Why do so many riders disregard their own safety and continue to operate their vehicles at excessive speeds?

The factors that drive speeding behaviour are well-documented and impact users of all types of vehicles. Therefore, there is a pressing need to develop effective measures for disciplining bicycle and electric scooter riders. Modern high-performance bikes, electric scooters, and electric bikes can attain significant speeds, and when combined with a lack of common sense, they become more susceptible to accidents and an increased risk of serious injuries.

Education campaigns are poised to undertake relatively straightforward safety improvement efforts. However, it's crucial to acknowledge that two-wheeled and other "rides on" vehicles leave users exposed as unprotected road users. Therefore, it's imperative to focus on the factors that can lead to severe injuries for cyclists, electric scooter riders, and others. This includes addressing potential threats posed by infrastructure elements such as barriers, posts, protruding bolts, and sharp edges. Enhancing security for all users should be a priority in this context.

Surveys conducted in the Poznan agglomeration led to the following conclusions:

- popularity of two-wheeled vehicles has been high,
- awareness of risks among riders while driving is high, and drivers are aware of factors that influence safe driving,
- a significant number of riders were involved in the accidents. Among bike riders, 83.3% were involved in an accident,
- head protection by helmets is the most popular among medium and older-aged people. This means that raising awareness is required in all younger age groups.
- attention should be paid to infrastructure elements that represent a potential risk for all people and not just riders.

Ethical Statement/Conflict of Interests

The authors declare that there is no conflict of interest

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