ANALYSIS OF PEDESTRIAN CROSSING ACCIDENT RATES IN URBAN ENVIRONMENTS

Lucie Kosňovská[*,1]

[*]lucie.kosnovska@vut.cz
[1] Brno University of Technology, Faculty of Civil Engineering, Institute of Road Structures, Veveří 331/95, 602 00 Brno, Czech Republic

Abstract

The purpose of this article is to examine the safety of pedestrian crossings in the urban environment in terms of the accident rate at crossings with one or multiple same-direction lanes without a traffic signal. The study uses accident data such as the number and severity of injuries and the age of participants to identify risk factors and evaluate the impact of crossing design on safety. The findings provide recommendations for improvements and are intended to be used for the revision of the ČSN 73 6110 standard in order to improve the safety of the pedestrians.

Keywords

Pedestrian crossing, pedestrian safety, accident analysis, urban transport, traffic safety

1 INTRODUCTION

The pedestrian is the most vulnerable road user. In a collision with a vehicle, the deformation zones of the vehicle, higher speed, and other passive safety features available to vehicle passengers, such as seat belts, work in the vehicle's favour. The article focuses on pedestrian crossings, which are locations where the path of a vehicle intersects with the path of a pedestrian, and as a result, there are potential collision risks. Safety at pedestrian crossings is an important aspect of urban traffic planning. The current standard ČSN 73 6110 prohibits the design of pedestrian crossings over multiple same-direction lanes without traffic signals, regarding traffic lights as a safety measure [1]. In fact, previous versions of this standard only recommended adding a pedestrian refuge island when crossings included multiple lanes [2].

It is crucial to address traffic safety comprehensively, as highlighted by the Swedish Vision Zero initiative, which aims to eliminate all road traffic fatalities and serious injuries [3]. This approach reduces risks and ensures safety for all road users, including pedestrians. Therefore, this study is necessary to create safer urban environments by studying pedestrian crossing safety.

This article attempts to explore whether the assumption that crossings across multiple lanes are by nature riskier than those across a single lane is valid in its assumption. Through comparing accident rates and severity at crossings of one versus multiple same-direction lanes without signalization, the study attempts to determine whether multi-lane crossings are always more hazardous, or if they only become riskier under certain conditions (such as when a crossing lacks a refuge island or adequate lighting).

Existing literature has focused on various aspects of pedestrian safety. For example, in Slovakia, the use of headphones and mobile phones at unsignalized pedestrian crossings and their impact on safety were investigated [4], and in Los Angeles, the impact of a low-cost sign that warned pedestrians at crosswalks to put down their cell phones was assessed [5]. But fewer studies have directly compared the safety of single-lane and multi-lane crossings without traffic signals.

Further insights into pedestrian safety at unsignalized crossings have been offered by recent European studies. Budzyński et al. analysed over 2,000 unsignalized crossings in Poland, identifying infrastructure-related risk factors such as crossing length, lighting, and lane configuration. Their findings showed that road design significantly influences driver behaviour and may increase risks for pedestrians—especially in countries like Poland, where pedestrians account for more than 30% of all traffic fatalities [6]. Olszewski et al. introduced a new safety assessment tool, the Dangerous Encounter Index (DEI), which uses video analysis to quantify risky interactions between pedestrians and vehicles. Their research demonstrated that crossings with two or more lanes

Received 04/02/2025/Accepted 12/05/2025/Published 30/09/2025 DOI 10.13164/juniorstav.2025.25034

pose greater risks than single-lane crossings, even under similar traffic conditions [7]. In the Czech context, Adámek and Burgr analysed accident data at intersections in Prague and found that signalized intersections are not automatically safer. In fact, they can introduce specific risks such as sudden braking or driver indecision at yellow lights if not implemented where traffic capacity demands it [8].

Using statistical analysis of publicly available accident data, this study tests the hypothesis that the risk associated with multi-lane crossings is justified.

2 METHODOLOGY

This study aims to analyse accident rates at pedestrian crossings over one and multiple same-direction lanes without traffic signals. The methodology includes data collection, statistical analysis, and evaluation of accident rates to determine potential risk factors. The main steps of the research process are as follows.

Data Collection

Selection of Pedestrian Crossings

For the purposes of this study, a comprehensive survey of pedestrian crossings without traffic signals was conducted in various urban areas across the Czech Republic. All identified multi-lane crossings were included in the analysis. For single-lane crossings, a random sample was selected to ensure representativeness. A total of 60 single-lane crossings (30 in Brno and 30 in Prague) and 60 multi-lane crossings (25 in Brno and 35 in Prague) were analysed. The selection of specific crossings is shown in Fig. 1, Fig. 2, Fig. 3, and Fig. 4.

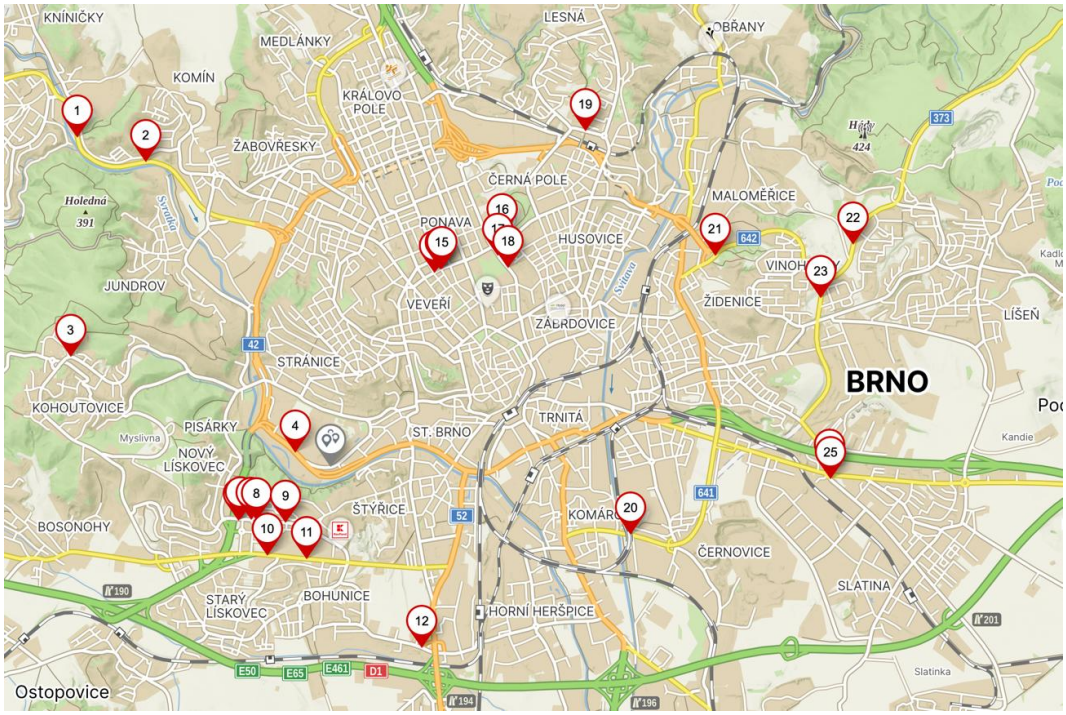

Fig. 1 Single-lane crossings in Brno [9].

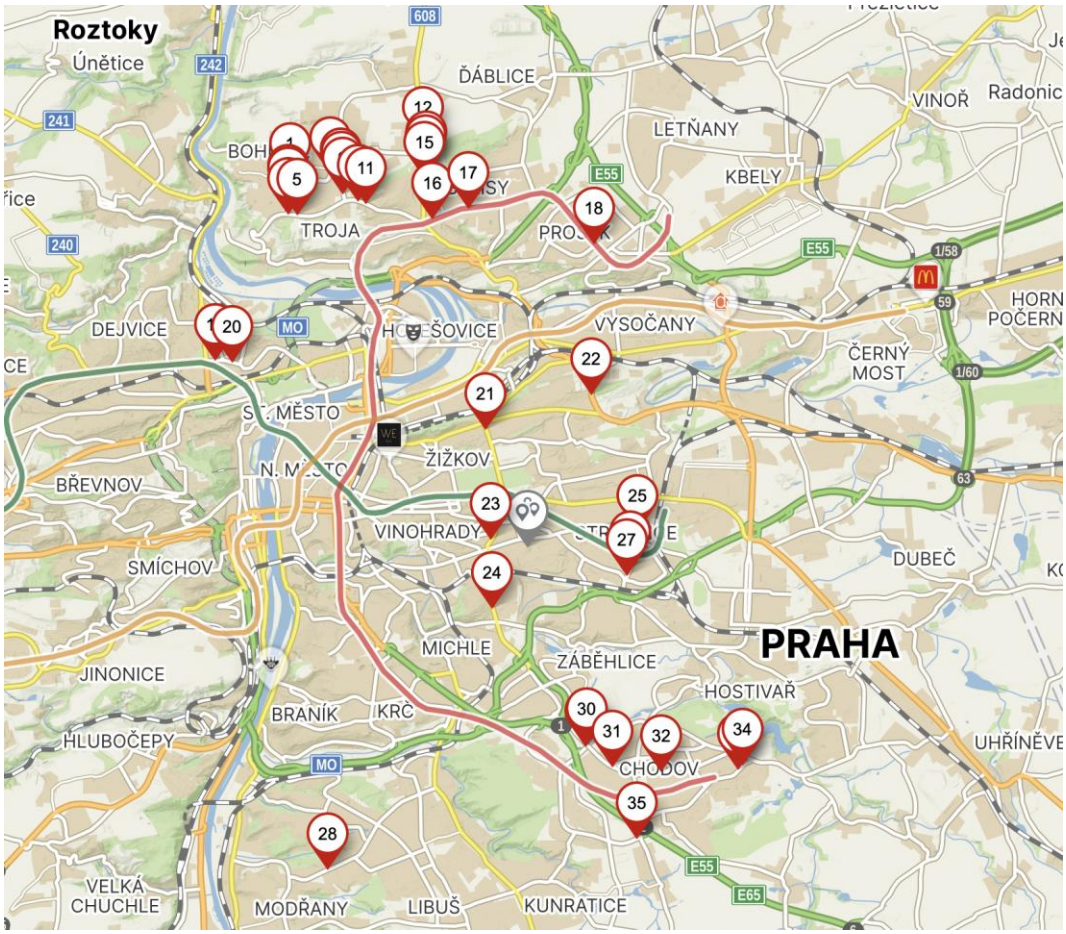

Fig. 2 Single-lane crossings in Prague [9].

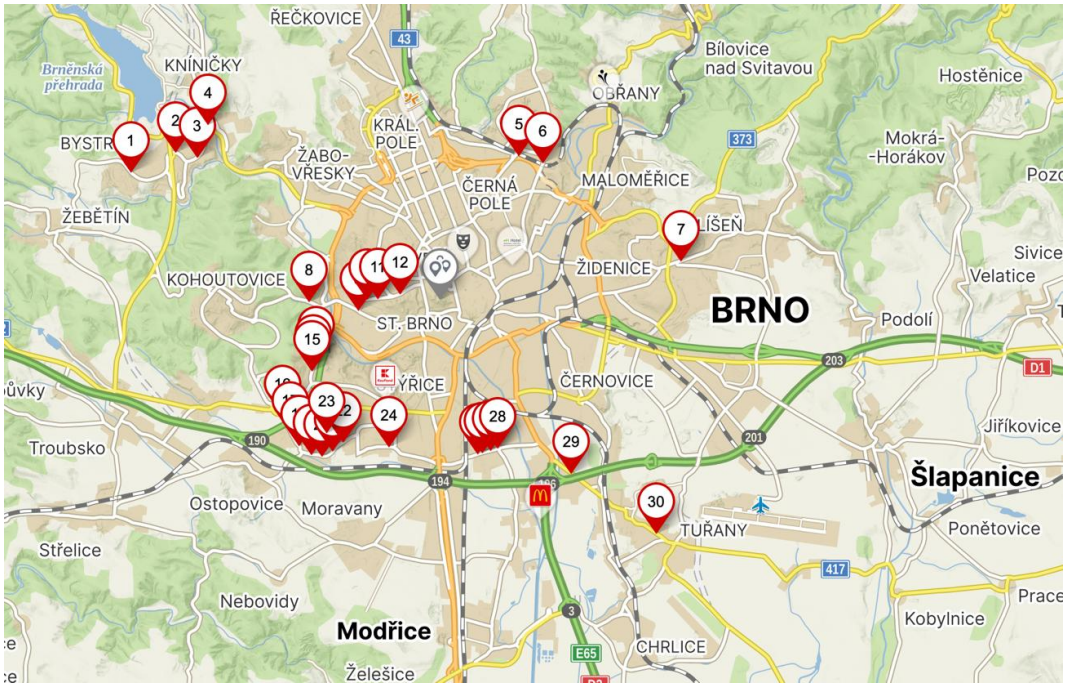

Fig. 3 Multi-lane crossings in Brno [9].

DOI 10.13164/juniorstav.2025.25034

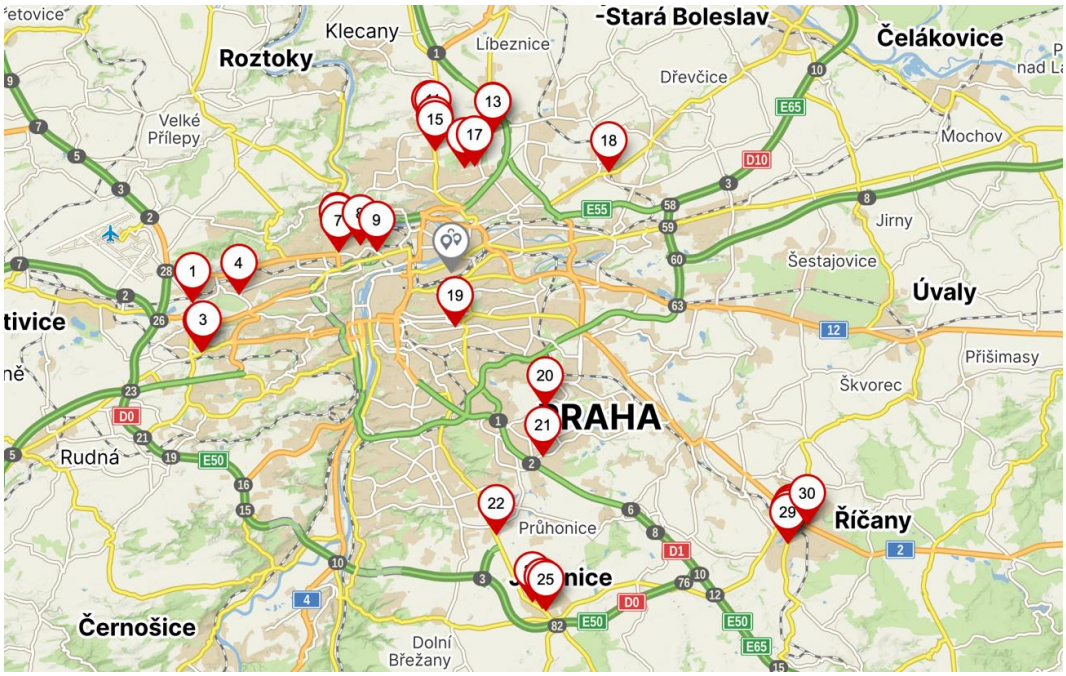

Fig. 4 Multi-lane crossings in Prague [9].

Accident Data Collection

Accident data, such as the severity of injuries, number of participants, gender of those involved, property damage, and time of day, were obtained from publicly available records provided by the Czech Police to the Transport Research Centre (Centrum dopravního výzkumu) [10]. These comprehensive datasets formed the basis for the statistical analysis and evaluation of accident risk factors.

To ensure relevant data for the analysis, accidents were filtered over a five-year period, from 30/06/2019 to 30/06/2024. This five-year time frame is commonly used in road safety audits to ensure there are enough accidents to analyse while minimizing the effect of potential changes in the road infrastructure. The primary filtering condition was accidents caused by "pedestrians on marked crossings", which includes all accidents involving pedestrian crossings reported to the Czech Police. This filter, in addition to the most common accidents, such as collisions between vehicles and pedestrians, also includes collisions between two vehicles in which one vehicle stops to let a pedestrian pass at a crosswalk and the other crashes into it from behind. It also includes accidents where cyclists are riding across the crossing (who, under the law, are not considered pedestrians) and collide with a vehicle. The process of filtration is shown in Fig. 5.

Each accident displayed on the interactive map has been manually checked for research purposes using detailed information about the incident to verify whether it really belongs to the crossing or if it is misplaced. GPS coordinates are provided by police officers and put into the system retrospectively, so they are not always accurate, and simply looking at the map without further verification could distort the results.

DOI 10.13164/juniorstav.2025.25034

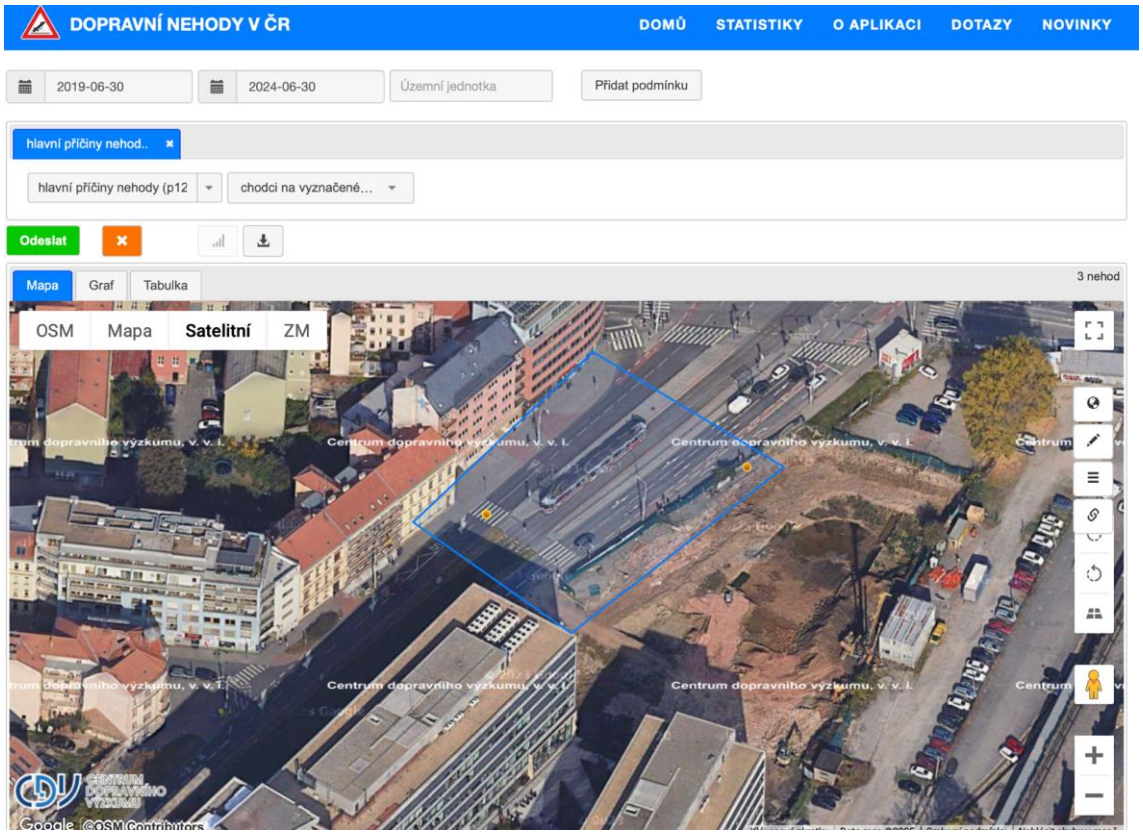

Fig. 5 Accident Data Filtering [10].

Average Daily Traffic Intensity

Traffic intensity data is significant in evaluating the risk of accidents at pedestrian crossings. For each crossing selected, the average daily traffic intensity (vehicles per 24 hours) was recorded [11], [12]. High traffic volumes are often linked to increased accident rates, and these statistics help in identifying which crossings are most dangerous to pedestrians.

Calculation of Relative Accident Rate Indicator

To compare the accident rates between different types of crossings, the relative accident rate indicator (R) was calculated [13]. This indicator is commonly used to evaluate road safety based on the number of accidents per unit of traffic exposure. The formula (1) is as follows:

$$R = \frac{N_0}{365 \times I \times t} \times 10^6 \,, \tag{1}$$

where R is the relative accident rate, measured in accidents per million vehicles per year; N_0 is the number of accidents; I is the average daily traffic intensity, in vehicles per 24 hours; and t is the time period, in years.

This indicator is typically used to assess the safety of a road section, with values above 1.6 indicating significant safety concerns [13].

Data Analysis

Comparison of Accident Rates

Accident data were compared for pedestrian crossings over one and multiple same-direction lanes without traffic signals. The goal was to find out if crossings over multiple lanes naturally have a higher accident rate, or if the risk is conditional upon factors such as the presence of pedestrian refuge islands, lighting, or traffic intensity.

DOI 10.13164/juniorstav.2025.25034

Statistical Methods

Simple statistical methods were used for initial data analysis. Future research that will follow up on this article will use more sophisticated statistical methods, such as regression analysis (to quantify the impact of various factors on accident rates), correlation analysis (to identify factors with the strongest influence on pedestrian safety), and cluster analysis (to group crossings based on their accident rates and identify common characteristics of high-risk crossings).

Optimization and Revision of ČSN 73 6110

Based on the analysis, recommendations will be developed to improve pedestrian crossing safety. The findings from this study will be useful in the revision of the ČSN 73 6110 standard, which defines the requirements for the design of pedestrian crossings in urban areas. The research will provide important evidence that can help in the development of future modifications to the standard and enhance pedestrian safety across the Czech Republic.

3 RESULTS

Sample Selection and Accident Data

For the comparison, 60 crossings over single-lane same-direction roads (30 in Brno and 30 in Prague) and 60 crossings over multi-lane same-direction roads (25 in Brno and 35 in Prague) were selected. Crossings were chosen via random sampling. All identified multi-lane crossings were included in the analysis. For single-lane crossings, a truly random selection was ensured to avoid distortion considering the abundance of such crossings. Accident data were calculated only after the selection to maintain objectivity.

Summary of Accidents

The overview of the number of accidents, their severity, and the median annual accident rates is presented in Tab. 1.

- Single-lane crossings: 88 accidents, median accident rate: 0.030.
- Multi-lane crossings: 77 accidents, median accident rate: 0.056.

Tab. 1 Overview of Accident Data by Single-Lane and Multi-Lane Pedestrian Crossings.

	Number of Accidents	Relative Accident Rate	Minor Injuries	Serious Injuries	Fatalities	Accidents per Year
Multi-Lane	77	0.030	66	10	0	0.200
Single-Lane	88	0.056	76	16	1	0.200

Statistical Distribution of Relative Accident Rates

As shown in Fig. 6 and Fig. 7, both single-lane and multi-lane crossings have skewed distributions with outliers that affect the mean. This indicates that medians are reported, as they better represent the typical values.

DOI 10.13164/juniorstav.2025.25034

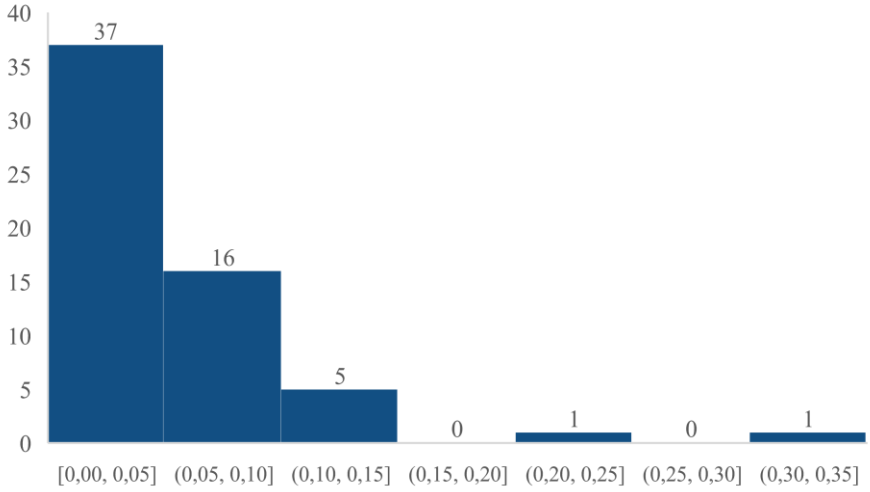

Fig. 6 Histogram of Accident Frequency for Multi-Lane Pedestrian Crossings.

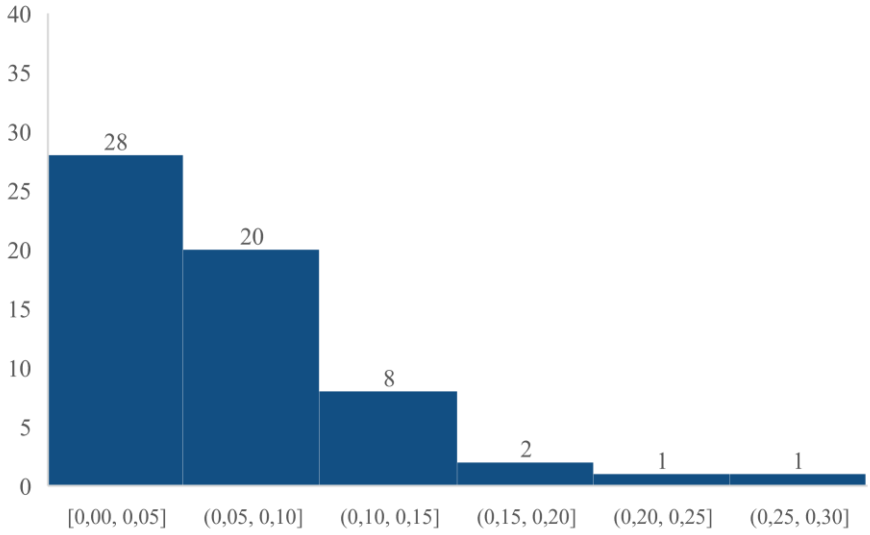

Fig. 7 Histogram of Accident Frequency for Single-Lane Pedestrian Crossings.

Driver and Pedestrian Demographics

The median age of the driver involved in the accident is 50 years, which implies that older drivers are more likely to be involved in accidents. The median age of the pedestrians involved in accidents is 28 years. The age distribution of drivers and pedestrians is shown in Fig. 8 and Fig. 9.

DOI 10.13164/juniorstav.2025.25034

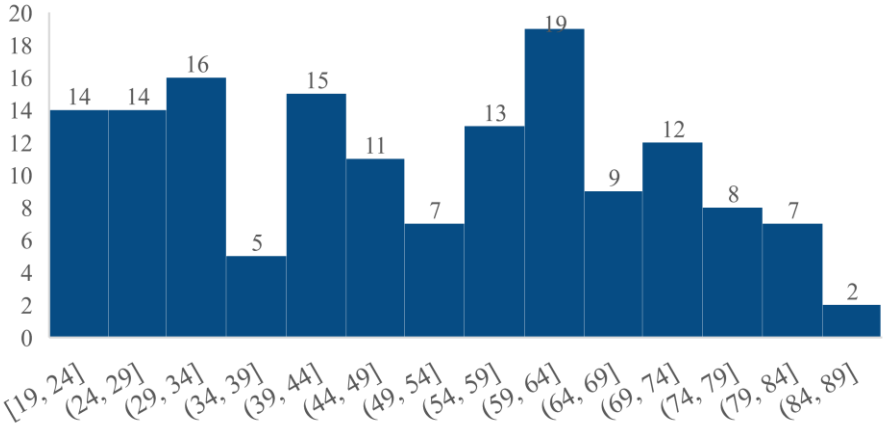

Fig. 8 Histogram of Driver Age Frequency.

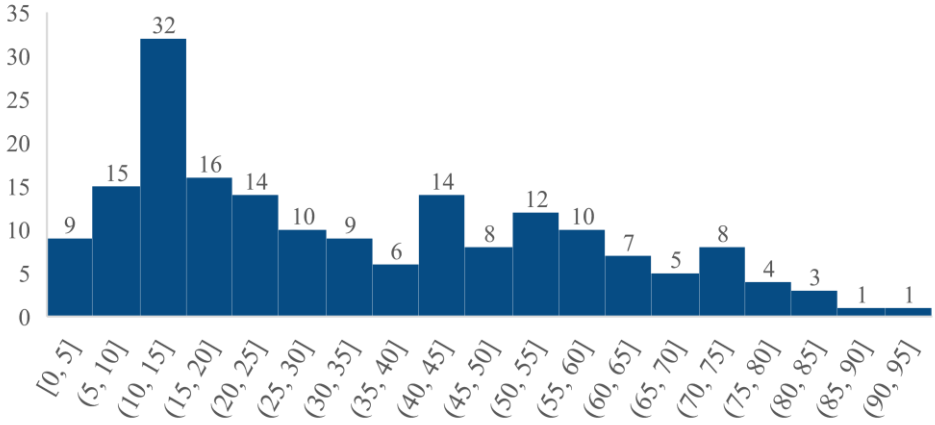

Fig. 9 Histogram of Pedestrian Age Frequency.

Gender of Drivers

As displayed in Fig. 10, 64% of the accidents were caused by male drivers, 29% by female drivers, and in 7% of cases, the driver's gender was unknown because the driver left the accident scene.

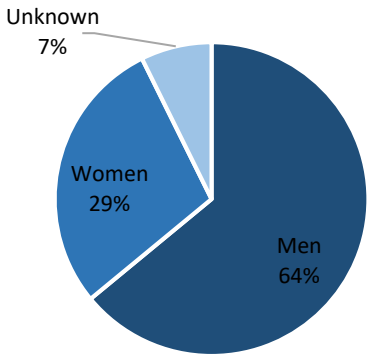

Fig. 10 Gender Distribution of Drivers Involved in Accidents.

DOI 10.13164/juniorstav.2025.25034

4 DISCUSSION

Interpretation of Accident Rates

The analysis found that the annual accident rates at single-lane and multi-lane crossings are comparable, which contradicts the expectation that multi-lane crossings are more dangerous. This challenges the assumption that the number of lanes is the primary factor determining the safety of crossings. Instead, it suggests that other factors, such as the presence of a refuge island or adequate lighting, may play a more significant role.

Children Aged 10–15 Years

The data shown in Fig. 9 indicate that children in the 10–15 age group are most frequently involved in pedestrian accidents. This may be because children who have reached adolescence are usually no longer accompanied by an adult. However, this age group still has an immature brain that cannot fully assess all the risks associated with crossing the road, so they may be negatively affected by, for example, mobile phones, peer pressure, or simply misjudge the speed and distance of a vehicle.

This finding suggests that educational campaigns targeting this age group could significantly reduce the number of accidents at pedestrian crossings. Construction modifications may not play such an important role in this regard.

Older Drivers (50+ Years)

The median age of drivers involved in accidents is 50 years, which suggests that older drivers are more likely to be involved in accidents. This may be due to a generational factor related to the level of adaptation to traffic rules, especially the change in the pedestrian priority rule introduced in 2006 [14], [15]. Drivers who were licensed before this change may have difficulty adhering to the new rules, increasing the accident rate.

Gender of Drivers and Public Misconceptions

The study finds that male drivers were involved in 64% of accidents, a figure close to national statistics, which state that 63% of active drivers are men [16]. Female drivers were involved in 29% of accidents, and in 7% of cases, the driver's gender was unknown because the driver left the accident scene. These findings challenge the common stereotype that women are riskier drivers and instead show that accident rates correspond closely to driving activity levels across genders.

Limitations and Future Directions

This study focused on crossings without traffic signals; therefore, the findings cannot be generalized to other types of crossings.

More attention should be given to the behavioural aspects of driver–pedestrian interactions in future research.

Further studies could help to establish how the change in the rule concerning pedestrian priority in 2006 has influenced the safety features of traffic flows over time.

5 CONCLUSION

This study analysed the accident rate at pedestrian crossings without traffic signals, comparing single-lane and multi-lane crossings. The findings from this research will support the revision of the ČSN 73 6110 standard.

The findings show that the mean annual accident rate for both types of crossings is similar, suggesting that the number of lanes alone does not have a direct impact on safety. No crossing type exceeds the critical threshold of 1.6 accidents per year, suggesting that pedestrian crossings, in general, are not inherently dangerous. Instead, attention should shift to specific factors that could increase the risk at certain crossings, such as the presence of pedestrian refuge islands and adequate lighting.

DOI 10.13164/juniorstav.2025.25034

The study found that children aged 10–15 are involved in the highest number of pedestrian accidents, highlighting the need for targeted educational initiatives for this group.

In addition, older drivers and younger pedestrians were identified as the most frequent accident participants, suggesting a generational gap in risk awareness. Contrary to common stereotypes, the study found no evidence that female drivers are more prone to accidents than male drivers.

Future research should expand the sample size to confirm the findings. Further analysis could compare accident rates at crosswalks only during the day, as poor lighting can adversely affect all types of crosswalks, regardless of the number of lanes.

References

[1] ČSN 73 6110 Z1 Design of urban roads. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví. Amendment 1. Praha, 2010.
[2] ČSN 73 6110, Projektování místních komunikací. Vydavatelství úřadu pro normalizaci a měření. Praha, 1986.
[3] Zero vision. [Online]. In: Centrum služeb pro silniční dopravu. 2018. [Accessed 17/06/2024]. Available at: https://www.cspsd.cz/742-zero-vision
[4] MIKUSOVA, Miroslava; WACHNICKA, Joanna a ZUKOWSKA, Joanna. Research on the Use of Mobile Devices and Headphones on Pedestrian Crossings—Pilot Case Study from Slovakia. Safety. 2021, vol. 7, no. 1. ISSN 2313-576X. Available at: https://doi.org/10.3390/safety7010017
[5] BARIN, Erica N.; MCLAUGHLIN, Cory M.; FARAG, Mina W.; JENSEN, Aaron R.; UPPERMAN, Jeffrey S. et al. Heads Up, Phones Down: A Pedestrian Safety Intervention on Distracted Crosswalk Behavior. Journal of Community Health. 2018, vol. 43, no. 4, pp. 810-815. ISSN 0094-5145. Available at: https://doi.org/10.1007/s10900-018-0488-y
[6] BUDZYNSKI, Marcin; GUMINSKA, Lucyna; JAMROZ, Kazimierz; MACKUN, Tomasz a TOMCZUK, Piotr. Effects of Road Infrastructure on Pedestrian Safety. IOP Conference Series: Materials Science and Engineering. 2019, vol. 603, no. 4. ISSN 1757-8981. Available at: https://doi.org/10.1088/1757-899X/603/4/042052
[7] OLSZEWSKI, Piotr; DĄBKOWSKI, Paweł; SZAGAŁA, Piotr; CZAJEWSKI, Witold a BUTTLER, Ilona. Surrogate safety indicator for unsignalised pedestrian crossings. Transportation Research Part F: Traffic Psychology and Behaviour. 2020, vol. 70, pp. 25–36. ISSN 13698478. Available at: https://doi.org/10.1016/j.trf.2020.02.011
[8] ADÁMEK, J. a BURGR, R. Intenzita, nehodovost a kapacita neřízených a řízených křižovatek v Praze 2009–2010. Silniční obzor. 2011, vol. 72, no. 12, pp. 346–350. ISSN 0322-7154 47 320.
[9] Mapy.cz. [Online]. Seznam.cz. [Accessed 08/11/2019]. Available at: www.mapy.cz
[10] Dopravní nehody v ČR. [Online]. Centrum dopravního výzkumu. 2024. [Accessed 21/06/2024]. Available at: https://nehody.cdv.cz
[11] Ročenka dopravy 2022. [Online]. In: Technická správa komunikací hl. m. Praha. 2022. [Accessed 21/06/2024]. Available at: http://www.tsk-praha.cz/static/udi-rocenka-2022-cz.pdf
[12] Intenzita dopravy – Intenzita vozidel. [Online]. In: Datový portál Brno. C2024. [Accessed 21/06/2024]. Available at: https://data.brno.cz/datasets/mestobrno::intenzita-dopravy-intenzita-vozidel-vehicle-traffic-intensity/explore
[13] ANDRES, Josef a MIKULÍK, Josef. Metodika identifikace a řešení míst častých dopravních nehod. Brno: Centrum dopravního výzkumu, 2001. ISBN 80-902-1419-3.
[14] CZECH REPUBLIC. Zákon č. 361/2000 Sb., o provozu na pozemních komunikacích a o změnách některých zákonů (zákon o silničním provozu) [Act No. 361/2000 Coll., on road traffic and on amendments to certain laws (Road Traffic Act)]. Úplné znění č. 465/2006 Sb. [Consolidated version No. 465/2006 Coll.]. Sbírka zákonů České republiky [Collection of Laws of the Czech Republic]. 2006.
[15] CZECH REPUBLIC. Zákon o provozu na pozemních komunikacích a o změnách některých zákonů (zákon o silničním provozu): Zákon č. 361/2000 Sb. [Act on road traffic and on amendments to certain laws (Road Traffic Act): Act No. 361/2000 Coll.]. Sbírka zákonů České republiky [Collection of Laws of the Czech Republic]. 2000. [Accessed 22/08/2025]. Available from: https://www.zakonyprolidi.cz/cs/2000-361/zneni-20241101
[16] Průzkum ukázal rozdíly v dopravním chování mužů a žen. [Online]. In: Ministerstvo dopravy ČR. 2021. [Accessed 02/12/2024]. Available at: https://md.gov.cz/Media/Media-a-tiskove-zpravy/Pruzkum-ukazal-rozdily-v-dopravnim-chovani-muzu-a