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Research paper

The impact of the COVID-19 pandemic on pedestrian safety at unsignalized crossings in Poland

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Abstract: In order to assess the impact of COVID-19 on the safety of pedestrians in Poland, a time-series model of the monthly number of killed and seriously injured (*KSI*) pedestrians was formulated. According to the calibrated model, the monthly KSI number was dependent on the average traffic volume index, which was a measure of exposure, presence of COVID-19 restrictions, and seasonality factors. *KSI* was significantly higher during autumn and winter months due mostly to longer periods of darkness during the day. COVID-19 restrictions caused a drop in this number by 22.9%. In addition, during the lockdown periods, there was a 28.6% drop in average reference traffic volumes, which translates into an additional decrease in pedestrian casualties by 41.4%. The overall impact of COVID-19 restrictions could amount to as much as 54.8%. Although during the COVID-19 restriction periods, the overall number of accidents decreased, there was a marked increase in the mortality rate. A new safety indicator, called "Monthly Average Daily Deaths," is proposed at unsignalized pedestrian crossings, which can express the overall safety trend as well as seasonal variations of the safety situation. The overall trend is a decrease in the number of killed pedestrians by around 11% per year on average. The authors anticipate that the conclusions presented in the article will make it possible to distinguish the impact of various factors (such as the pandemic, changes in regulations, etc.) in future analyses related to improving road safety.

Keywords: COVID-19, pedestrian safety, traffic volume, unsignalized crossings, monthly average daily deaths

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1. Introduction

Pedestrian safety level in Poland ranks among the lowest in the European Union. In the year 2022, Poland documented 4762 road accidents that involved pedestrians, representing 22.3% of all reported accidents. They resulted in 460 pedestrian fatalities, accounting for 24.3% of all reported fatalities, and 4367 injuries, which constituted 17.6% of all injuries. In comparison to other European Union countries – Fig. 1, Poland exhibits the fifth-highest rate of pedestrian road fatalities, with approximately 21 deaths per million inhabitants, according to 2019 statistics.

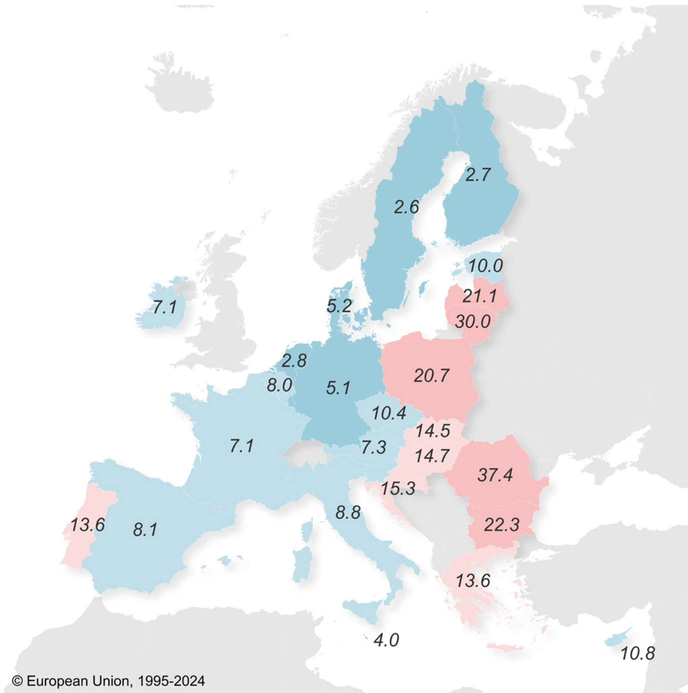

Fig. 1. EU countries with pedestrian road fatality index – number of fatalities in 2019 per million inhabitants – based on [1]

In March 2020, a COVID-19 epidemic state was declared in Poland. Due to the restrictions and social isolation introduced, the number of traffic accidents decisively decreased – by 30% compared to 2019 [2]. Some restrictions remained in place through subsequent Covid waves and until April 2021. In addition, in the middle of 2021, fundamental changes were made to the Traffic Law [3], among other things, in establishing pedestrian priority at unsignalized pedestrian crossings.

According to the work of researchers from the Gdansk University of Technology, in general, road safety in Poland has improved significantly since 1991 [4]. The number of traffic fatalities has fallen from a catastrophic level of almost 8,000 in 1991 to less than 3,000 in 2017. Unfortunately, according to the data analysis presented in the PhD dissertation [5], it is difficult to speak of a downward trend in the number of accidents involving pedestrians at road crossings without traffic lights. Comparing data from 2010 and 2019, one can even speak of a deterioration in pedestrian crossing safety – a very worrying phenomenon (see Fig. 2).

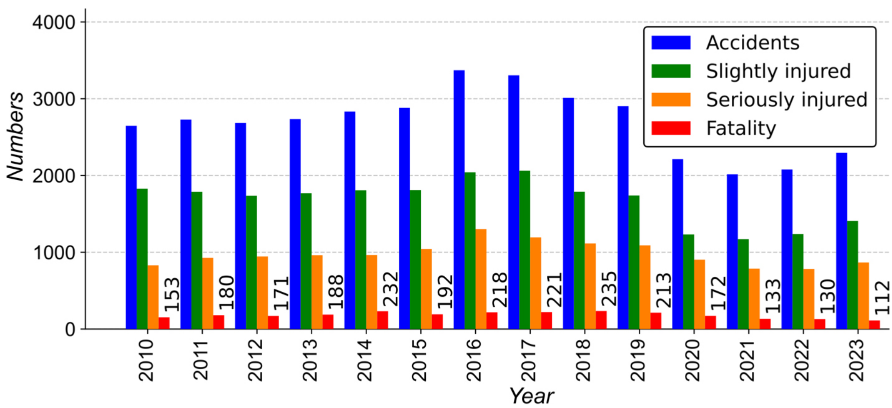

Fig. 2. Trends in the numbers of accidents and pedestrian victims at zebra crossings in Poland

In the current study, the authors aim to assess the impact of COVID-19 on safety of pedestrians in Poland, creating a time-series model of a monthly number of killed and seriously injured (*KSI*) pedestrians. The objective is to investigate how various variables influence the number of *KSI* at unsignalized pedestrian crossings in Poland, which the authors consider to be an area currently lacking sufficient research.

2. Literature review

2.1. The COVID pandemic

The COVID-19 pandemic has led to social restrictions, profoundly affecting mobility patterns, public life, and individual well-being. In Poland, as in many other countries, lockdowns, travel limitations, and physical distancing policies were introduced to minimise viral transmission [6]. These measures rapidly changed behaviour and conditions across multiple domains: transport, shopping, energy use, and environmental conditions. Several studies have investigated mobility-related changes under lockdown. For example, public transport usage declined significantly following strict government regulations on limits of vehicle occupancy [7]. In Kraków, analyses of road traffic revealed that initial restrictions reduced vehicle flow, yet volumes rebounded once people adapted to the pandemic, often disregarding subsequent waves of infection [8]. At the same time, certain environmental benefits – such as improvements in air quality – were inconsistent: particulate matter levels did not uniformly decrease, indicating that residential heating combustion remained a predominant source of emissions [9, 10].

Broader economic impacts were also evident. Reduced commuting and constrained economic activities led to quantifiable shifts in electricity consumption, particularly among commercial clients [11]. Meanwhile, restricted access to public spaces highlighted the role of urban green areas in supporting local well-being [12]. Notably, attitudes towards restrictions varied: although most Poles initially complied, fatigue and scepticism grew over time, leading some to relax adherence [6].

2.2. Effect of mobility changes on pedestrian safety

Over the past several years, numerous studies have investigated how changes in traffic volume, infrastructure, and user behaviour affect road safety, particularly in the context of the COVID-19 pandemic. Much of this research emphasises that mobility patterns shifted dramatically during lockdowns and other restrictions, influencing the frequency and severity of crashes, as well as perceptions of safety among pedestrians, drivers, and public transport users [13, 14]. Although reductions in traffic volume frequently coincided with lower absolute numbers of collisions, several studies also reveal an increase in crash severity and risk-taking behaviour such as speeding [15]. In Italy, for example, monthly road traffic accidents declined by 70–80% in March–April 2020 compared to the same period in 2019, yet fatalities decreased by a comparatively smaller percentage of 62–74% [16]. When lockdown measures eased, traffic volumes rebounded, though not always to pre-pandemic levels, and crash severity patterns often shifted [13, 16].

Recent Polish research examined urban road safety in Szczecin across three time periods: 2017–2018, 2019–2020, and 2021 – focusing on how network saturation and traffic intensity influence accident numbers and severity [13]. Findings showed that pandemic mobility restrictions helped to reduce traffic volume and moderated accident severity, but accidents rose again post-pandemic, though with fewer serious outcomes. Despite these changes, local surveys suggested that overall safety perceptions did not improve, underscoring persistent risks for vulnerable road users. In response, the authors advocated targeted infrastructure enhancements, such as more thorough auditing of pedestrian crossings and modernising high-risk sites.

Pedestrian safety, more broadly, remains a focal point of pandemic-related research. Although the number of pedestrian accidents diminished in several urban centres alongside reduced traffic, some studies reported an uptick in more serious injuries or fatalities. Driver willingness to yield also appeared to decline, possibly because less dense traffic emboldened riskier driving [17]. In line with the Szczecin findings, Polish data further confirmed that, despite fewer vehicles on the road, potentially dangerous VRU–driver interactions persisted at a relatively high frequency [13].

Public transport systems likewise encountered substantial challenges. Researchers observed a steep ridership decline in cities where travellers avoided buses and trains for fear of infection despite measures imposing strict health protocols [14, 18]. Although the severity of public transport reductions varied by region, many operators experienced significant revenue shortfalls requiring government assistance [18, 19]. Even as infection rates declined in some areas, many passengers remained wary of close physical proximity [14].

Researchers have turned to various statistical and modelling approaches to analyse these pandemic-induced changes in greater depth. Several studies used K-means clustering, renewal process methods, and Gaussian process-modulated models to capture highly dynamic crash patterns and to factor in different socio-economic contexts [20, 21]. In China, traffic volume declines were more pronounced in areas with higher Gross domestic product (GDP) per capita, suggesting a link between income levels and the ability to adopt remote work or avoid travel [20]. Negative binomial and Generalised Method of Moments (GMM) models further revealed that policy interventions like speed limit changes or installing safety cameras had distinct impacts on crash frequency, depending on local conditions [22]. These findings align with broader evidence that sustained infrastructure investments and tailored policy measures can significantly mitigate pandemic-related disruptions [23].Several authors stress that the positive safety outcomes linked to reduced traffic must be preserved, while also counteracting undesirable side effects such as speeding and driver inattention [13, 17]. Consequently, tighter regulations against dangerous driving and more rigorous road design improvements have been advocated [15]. Furthermore, ensuring the resilience of public transport systems in the face of future health crises is another priority, necessitating robust safety protocols, reliable financial support, and transparent communication to reassure passengers [18, 19]. Lastly, many experts call for enhanced data collection – particularly real-time traffic and user-behaviour information – to refine predictive models and better target intervention measures [21]. Overall, the COVID-19 crisis has highlighted both the fragility and adaptability of road transport systems, reinforcing the need for multi-faceted approaches to road safety that include VRUs (Vulnerable Road Users), motorised vehicles, and public transport alike.

3. Methodology

In line with the stated objectives, the authors analysed publicly available data on pedestrian accidents at unsignalized crossings (see Section 3.1 for more details). Additionally, information on vehicle traffic volumes was utilized (see Section 3.2). All the collected data were imported into a PostgreSQL database and organized by year and month. This enabled further analyses related to the development of models to be conducted using custom Python scripts (see Section 5 for more details).

3.1. SEWIK accident database description

An analysis of accident statistics can be conducted on the basis of the Polish nationwide SEWiK database maintained by the National Police Headquarters [24]. SEWiK is an acronym for Road Accident and Collision Recording System. It constitutes a central data repository gathering information on road accidents and collisions. The SEWiK database contains records of all road accidents registered by the police that occurred in Polish territory. These data include, for instance, the date and time of the accident, the location, the type of event, and the number of injured or killed individuals, along with details on the participants involved and information concerning vehicle drivers. The information is generated on the basis of a Road Incident Report compiled by the police officers during on-site procedures.

These data are employed, among other purposes, to analyse road safety and to plan measures aimed at improving safety in traffic. Part of the database is available online, and its most widely accessed resource is the accident map, provided by the Polish Road Safety Observatory website [25]. On that webpage, one can examine accident statistics displayed on a map and view the locations where they occurred. In the present study, attention is directed towards accidents involving a vehicle striking a pedestrian at crossings without traffic lights. Given the COVID-19 pandemic period and the related amendments to road traffic regulations (discussed in detail in Chapter 5), the years 2018–2023 were selected for analysis. The severity of injuries reported in official statistics is defined as follows:

- Fatality – a person who died at the scene or within 30 days of the accident as a result of sustained injuries;
- Seriously injured – a person who has suffered loss of sight, hearing, speech, or other serious disability; other injuries leading to impairment of an organ's function or ill health lasting more than 7 days;
- Slightly injured – a person who, according to a physician or paramedic, suffered health impairments or injuries other than those classified as serious.

A data analysis was carried out on records obtained directly from the Road Traffic Bureau of the National Police Headquarters. XML files containing information on traffic incidents from 2018 to 2023 were processed and imported into a PostgreSQL database. This relational database comprises a table detailing the incidents (2,575,329 records), another table describing the vehicles involved (3,979,491 records), and a further one for participants (4,569,778 records). Altogether, more than 10 million records were assembled. On this basis, the statistics on pedestrian-involved accidents at unsignalized crossings were investigated.

According to the Supreme Audit Office [26] report, the SEWiK system faces several significant challenges, including erroneous data entry, the absence of automated data verification, inaccuracies in event geolocation (primarily due to incorrect input of GPS coordinates), and an insufficient number of GPS measurement devices in some Police units. These shortcomings result in unreliable datasets, particularly regarding the precise location of incidents – some of which could even be shown as situated in the Baltic Sea. Such anomalies necessitate further cleaning of2 accident data. For example, the Warsaw Municipal Road Authority verifies data on accidents in the Warsaw region by comparing database entries with accident sketches [27].

3.2. Traffic volume data

Accident frequency is obviously dependent on traffic volumes, as motorised traffic exposes crossing pedestrians to accident risk. During the six-year analysis period, a total of 63 Continuous Traffic Measurement Stations (SCPRs) [28] were active across the Polish road network. For the purposes of this study, selection criteria were applied to identify which SCPRs would be included in the analysis. These criteria included, among others, the following two main requirements:

- the SCPR should be located on a road with pedestrian crossings – which implies trunk roads, not expressways;
- traffic data should not contain gaps exceeding 20 consecutive days in a given year.

After applying these criteria, a final set of 8 SCPRs was selected for further analysis (Fig. 3). It should be noted that even the SCPRs selected for the analysis contained data gaps of varying lengths (up to a maximum of 20 consecutive days per year). To address these gaps, a modelling approach2 was applied. This involved imputing hourly traffic volumes based on traffic counts recorded at the same hour 7 and 14 days before and 7 and 14 days after the missing data.

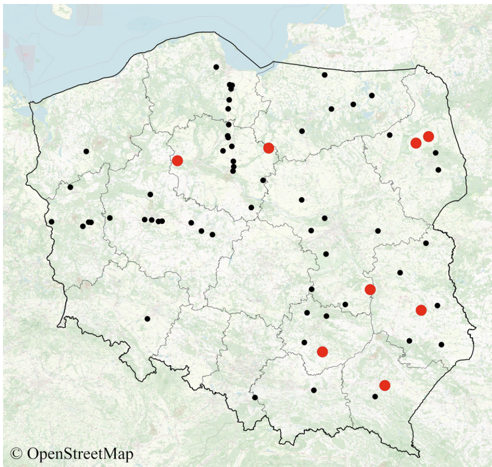

Fig. 3. Locations of SCPRs active in the period 2018–2023 (in red: stations selected for analysis)

The complete dataset from the selected SCPRs consisted of 786,843 records for total vehicle volumes and an equal number of records for heavy vehicle volumes. These data were imported into a PostgreSQL database.

4. Traffic volume analysis

Based on the data from the selected SCPRs, the Annual Average Daily Traffic (AADT) and the Monthly Average Daily Traffic (MADT) were calculated for each year and each month, respectively. By dividing MADT for each month by AADT for the corresponding year, seasonal variation indices were obtained for each count station.

The resulting indices reflect a typical traffic pattern for interurban roads, with higher traffic volumes observed during the summer months and lower volumes during the winter. Traffic levels in April/May and October/November tend to approximate the annual average. To visualize the presence of seasonal variations phenomena, data for the year 2021 were presented in Fig. 4.

An aggregated time series of MADT values averaged across all selected SCPRs for the full analysis period (January 2018 to December 2023) is presented in Fig. 5. It shows a marked decline in traffic volume during the COVID-19 lockdown period – falling significantly below the seasonal variation corridor – and an increase in traffic volume above the seasonal corridor after the lockdown ended (it is marked with blue circles in Fig. 5).

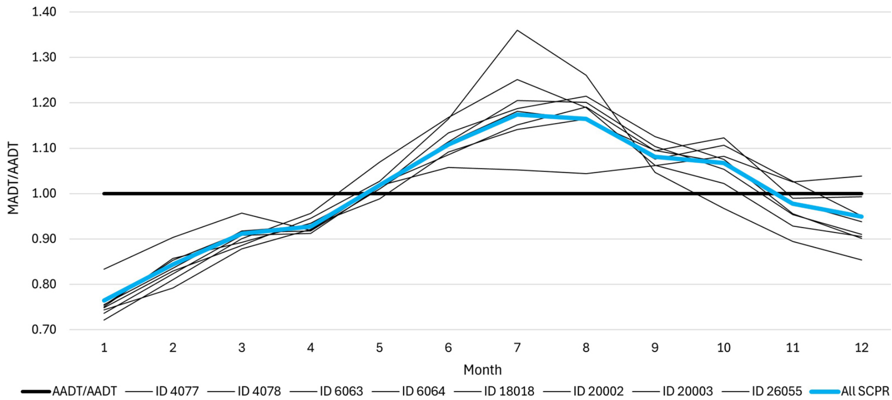

Fig. 4. Seasonal variation in traffic volumes at SCPRs selected for analysis in 2021

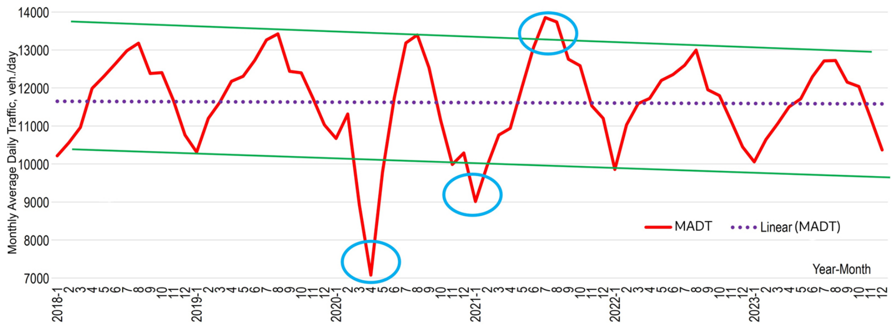

Fig. 5. Monthly Average Daily Traffic volume trend and seasonal variation corridor

Furthermore, the extended observation period enabled the identification of a long-term trend in MADT traffic volumes. A consistent decrease in traffic levels was observed on roads where the selected SCPRs were located – Fig. 5. One possible explanation is the ongoing development of motorway and expressway networks, which is likely diverting long-distance traffic away from lower-class roads.

5. Analysis of accidents at pedestrian crossings

5.1. Modeling the number of pedestrians killed or severely injured in a month

The primary objective of the current study is to investigate how various variables influence the number of fatalities and serious injuries at unsignalized pedestrian crossings in Poland. During the study period, 6600 fatalities and seriously injured pedestrians were recorded. The average *KSI* (Killed or Seriously Injured) value for all months was approximately 92, ranging from 20 (May 2020) to 254 (December 2018). Particular focus is placed on the impact of mobility restrictions during the three waves of Covid and the periods in between when some mobility restrictions were in place. To this end, a time series model has been formulated expressing the number of pedestrians killed and seriously injured (*KSI*) at all crossings in month j (where j is the running number of the month, starting from January 2018). Thus, the analysis is conducted on a monthly basis. The fundamental variables under consideration are presented in Table 1.

Table 1. List of variables used in modelling

Variables (x_i)	**Values**	**Description**
Qv_j	thousand vehicles/day	The measure of exposure – an average of MADT$_j$ (monthly average daily traffic) volumes in month j – at selected count stations
rc_j	0, 1	Dummy variable indicating periods of restrictions (lockdowns) related to COVID-19, the following periods were adopted: 3-5.2020, 10-12.2020, 3-5.2021
rci_j	0, 1	Dummy variable indicating intervals between the above restrictions
zp_j	0, 1	Dummy variable indicating intervention – legislation changes in the Road Traffic Act since June 2021
zt_j	0, 1	Dummy variable indicating intervention – modifications to the fines for traffic offences
tr_j	month running number 1–72	General time-trend towards improving pedestrian safety (education, road safety elements, etc.)
from $m1_j$ to $m12_j$	0, 1	Dummy variable indicating months – reflecting seasonal variations in accident numbers due to changing daylight duration and traffic characteristics during the months under examination

In accordance with the [29], a non-linear general time series model was adopted:

$$KSI_j = \beta_0 Qv_j^{\beta_1} e^{\beta_2 x_{ij} + \ldots} \tag{5.1}$$

Eq. (5.1) can be transformed into a linear form [30]:

$$\ln KSI_j = \ln \beta_0 + \beta_1 \ln Qv_j + \beta_2 x_{ij} + \ldots \tag{5.2}$$

where: KSI_j – number of killed or severely injured pedestrians in month j – the dependent variable; Qv_j – average daily volume of vehicular traffic ($MADT_j$ – based on selected count stations) in month j, which is a proxy measure of pedestrian exposure to traffic; x_{ij} – explanatory variable i in month j; β_0, β_1, β_2, β_3 – regression model parameters to be calibrated.

Relevant explanatory variable values were assigned for each month from January 2018 to December 2023. In the first step, the Pearson correlation coefficients among the variables considered were examined. As shown in the Fig. 6, there is a significant correlation between *zp* and *tr* variables, as well as between *zt* and *tr*. Consequently, these variables were not used simultaneously in the models examined.

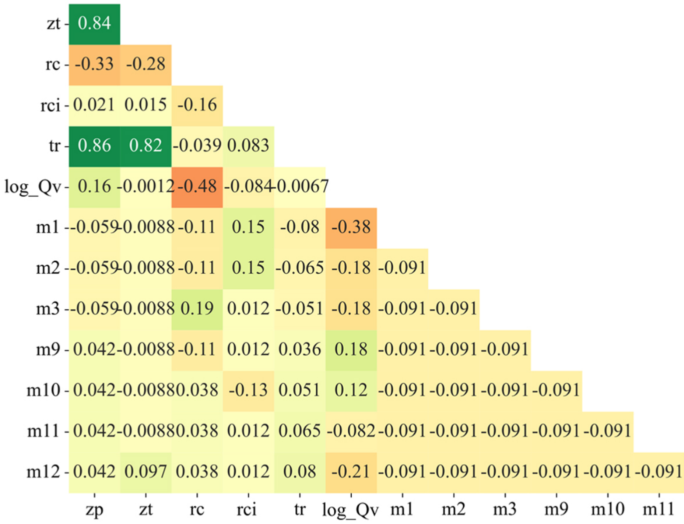

Fig. 6. Pearson correlation matrix for explanatory variables

Several models were analysed, each incorporating a different combination of variables. In particular, the models that included both *rc* and *zp* proved to be of special interest. The linear regression a2nalysis indicated that the models labelled R1 and R2 contain statistically significant regression coefficients (at the significance level of 0.05). The results of this analysis for the selected models studied are presented in Table 2. Additionally, models R3 and R4 demonstrate that the inclusion of the time trend variable (*tr*) renders the effect of the COVID variable (*rc*) statistically insignificant. This finding supports the decision to exclude the time trend variable from the finally selected model.

According to the regression results presented in Table 2, model R2 provides the best fit for describing the number of fatalities and serious injuries. Although adding the trend variable *tr* improves model R2 slightly (see model R4), it makes the COVID indicator variables (*rc*, *rci*) not significant, which defeats the analysis objective.

When using regression models (such as Eq. 5.1) with time-series data, there is a potential problem of violating the assumption of residuals being independent (not correlated) and normally distributed [30]. Residual diagnostics for the selected R2 model indicate that the Omnibus test (2.518, $p = 0.284$) and the Jarque–Bera test (1.969, $p = 0.374$) show no evidence of non-normality (Skew = −0.399, Kurtosis = 3.144). Although the Durbin–Watson statistic (1.724) hints at slight positive autocorrelation, the Breusch–Godfrey test ($p > 0.05$) confirms no statistically significant autocorrelation. The model's KSI is influenced by the average monthly traffic volume, as well as by whether a given month was under COVID-related restrictions or represented a transitional period between lockdowns. Regulatory changes also

Table 2. Regression Analysis Results for Selected Models

Model variable	**R1**	**R2**	**R3**	**R4**
Model regression coefficients				
const	–11.075	–10.761	–10.594	–10.428
zp	–0.242	–0.242	–	–
rc	–0.233	–0.260	–0.131*	–0.149*
rci	–	–0.140	–	–0.105*
tr	–	–	–0.006	–0.006
log_*Qv*	1.614	1.583	1.573	1.556
*m*1	1.189	1.212	1.190	1.209
*m*2	0.757	0.783	0.767	0.788
*m*3	0.490	0.501	0.472	0.481
*m*9	0.388	0.395	0.404	0.408
*m*10	0.823	0.80	0.826	0.815
*m*11	1.093	1.101	1.099	1.104
*m*12	1.278	1.284	1.288	1.292
Model performance indicators				
R-squared	0.846	0.856	0.853	0.858
Adj. R-squared	0.821	0.30	0.828	0.832
AIC	–10.17	–12.84	–13.09	–13.74
Durbin–Watson Statistic	1.623	1.724	1.67	1.749
Breusch–Godfrey Test F stat p-value	2.227 0.137	1.1841 0.2809	1.721 0.1945	0.977 0.327
Omnibus Test – p-value	0.062	0.284	0.167	0.249
Jarque–Bera Test – p-value	0.094	0.374	0.242	0.316

* not significant at $p = 0.05$

exert a significant effect. Furthermore, seasonality plays a notable role, particularly from September through March. When month indicator variables for months from April to August were used, their coefficients were not significant in all models. Therefore, these spring and summer months can be regarded as a reference period, with the number of *KSI* pedestrians increasing significantly during the September–April period.

5.2. Mortality rates

While the presented results indicate a decrease in the number of pedestrians killed and severely injured during the COVID-19 pandemic and after the regulatory changes, an opposite trend can be observed regarding the mortality rate. This indicator represents the number of fatal victims per 100 accidents involving pedestrians at unsignalized crossings. As we can see in Fig. 7, during the lockdown periods, this indicator increases significantly (approximately twofold compared to analogous periods). This observation is in line with experience from other countries [15]. One may infer that the situation was influenced by higher vehicle speeds resulting from lower traffic volumes. However, this hypothesis should be confirmed by further research.

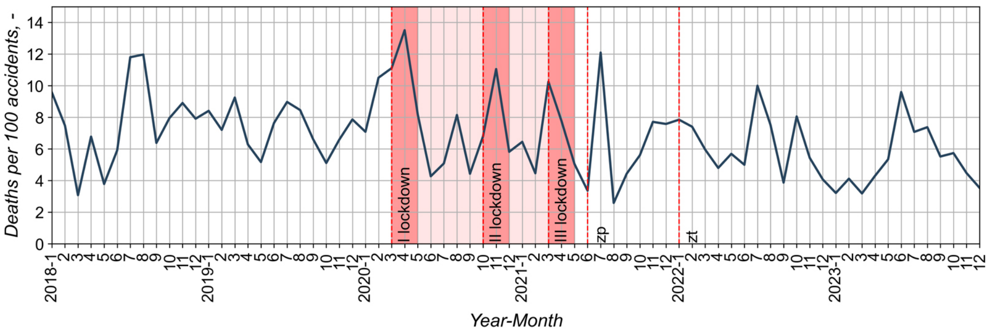

Fig. 7. Mortality rate for pedestrians at unsignalized crossings

6. Discussion of results

Results of the present study indicate that the introduction of COVID restrictions produces a decrease of around 22.9% in the number of *KSI* pedestrians. The impact of transitional periods between lockdowns amounts to about 13.1% reduction. Similarly, the amendment of regulations, represented by the parameter $\beta_{zp} = -0.2428$, leads to a reduction in the *KSI* variable by approximately 21.5%. Conversely, an increase in Qv from 7000 to 12000 vehicles per day is associated with roughly a 2.3-fold rise in the predicted number of casualties, while every 10% increase in Qv triggers a 14% rise in the incidence of fatalities and severe injuries. The months $m1$, $m2$, $m3$, $m9$, $m10$, $m11$, and $m12$ significantly elevate the value of the *KSI* variable, with January ($\beta_{m1} = 1.21$) indicating an approximately 236% increase relative to the baseline summer months.

In summary, vehicular traffic (log_Qv) exerts the strongest positive (i.e. increasing) impact on the number of *KSI* victims which is expected as the traffic volume is a measure of exposure to risk for pedestrians crossing roads. On the other hand, COVID restrictions, regulatory changes, and transitional periods between lockdowns significantly reduce the *KSI* number. Moreover, marked seasonality is observed, with certain months exhibiting a multiple-fold increase in *KSI* pedestrians compared to the baseline.

Long term observations indicate the presence of a decreasing trend in the number of pedestrians killed at unsignalized crossings. It is especially visible when a new proposed indicator is used, namely: Monthly Average Daily Deaths (MADD). This indicator represents the observed daily number of pedestrians killed at unsignalized zebra crossings averaged over each calendar month (Fig. 8).

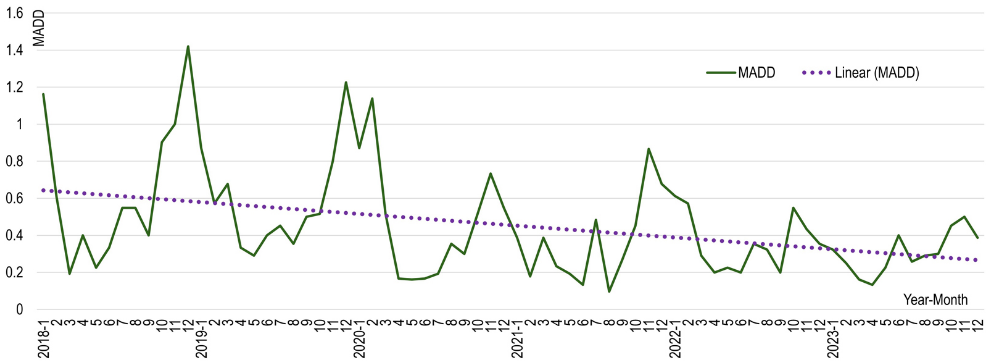

Fig. 8. Monthly Average Daily Deaths at unsignalized pedestrian crossings

It should be noted that the dependent variable is pedestrian *KSI* in all aeras, both rural and urban, while the exposure variable comprises vehicle counts on rural roads. Another problem is the general lack of pedestrian volume data for pedestrian crossings. These two issues could be potential sources of error. However, in all models tested, the exposure variable (log_Qv) was highly significant which means that it was a good predictor of the pedestrian KSI.

7. Conclusions and direction for further work

Time-series modelling of the monthly number of pedestrians killed and seriously injured at unsignalized crossings in Poland indicates that Covid restrictions caused a drop of this number by 22.9%. In addition, during the first lockdown period, there was a 28.6% drop in average reference traffic volumes, which translates into an additional decrease in pedestrian casualties by 41.4%. Thus, the overall impact of Covid restrictions could amount to as much as 54.8%. It should be noted that our analysis is based on monthly periods which do not exactly coincide with lockdowns – for example, the first lockdown in Poland was from 12 March to 30 May 2020, which covers only two-thirds of the month of March. The time series model shows the long-term impact of the amendment of traffic law which gives priority to pedestrians intending to enter a zebra crossing. The change resulted in a reduction in the number of killed and seriously injured pedestrians by approximately 21.5% which is highly significant.

An important finding is that during Covid restriction periods involving lockdowns, when the overall number of accidents decreased, there was a marked increase in the mortality rate. The likely cause of this phenomenon is perhaps an increase in traffic speeds under conditions of generally smaller traffic flows and no congestion.

The authors anticipate that the conclusions presented here will make it possible to distinguish the impact of various factors (such as the pandemic, changes in regulations, etc.) in future analyses related to improving road safety.

A new safety indicator, called "Monthly Average Daily Deaths", is proposed for unsignalized pedestrian crossings, which can express the overall safety trend as well as seasonal variations of the safety situation. We can see that the overall trend is decreasing by around 11% per year on average. At the same time, the seasonal variations are getting smaller.

In future research studies, we plan to verify the hypothesis that the rise of pedestrian mortality during COVID-19 restriction periods was caused by increased traffic speeds on roads in the vicinity of pedestrian crossings. Big Data sources will be utilized, including probe vehicle data from navigation system providers and GSM (Global System for Mobile Communications) mobile telephony data. Probe Vehicle Data (PVD) on traffic speeds will be available for all days and hours covered by the study. PVD data will also be used to study the impact of legal changes on vehicle speeds in urban areas, both close to and far from unsignalized pedestrian crossings.

Another problem that needs to be addressed in future studies is the lack of exposure data related to the intensity of pedestrian flows at the zebra crossings. This could be achieved using GSM mobile telephony operator data, which will be available from 2020 for all days and hours. For designated areas within 100–300 meters of the studied pedestrian crossing, data will be obtained on the number of people who travelled to/from this area at various hours of the day. Data will also be obtained on the number of people remaining in these areas at various hours without traveling. Utilizing this data will enable matching accident hours at pedestrian crossings with inbound/outbound traffic flow and the number of people staying in areas near the crossings.

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Wpływ pandemii COVID-19 na bezpieczeństwo pieszych na przejściach bez sygnalizacji świetlnej w Polsce

Słowa kluczowe: COVID-19, Bezpieczeństwo pieszych, Natężenie ruchu, Przejścia bez sygnalizacji, Średnia dobowa liczba zabitych w miesiącu

Streszczenie:

Pandemia COVID-19 znacząco wpłynęła na wiele obszarów życia społecznego, w tym na bezpieczeństwo ruchu drogowego. W niniejszym artykule przeanalizowano, w jakim stopniu restrykcje epidemiologiczne oraz zmiany prawne wpłynęły na liczbę wypadków z udziałem pieszych na przejściach bez sygnalizacji świetlnej w Polsce. W tym celu wykorzystano dane z lat 2018–2023, pochodzące z bazy SEWiK (System Ewidencji Wypadków i Kolizji) oraz z wybranych stacji ciągłego pomiaru ruchu (SCPR). Aby zbadać możliwe zależności między natężeniem ruchu a liczbą ofiar wśród pieszych, uwzględniono zarówno informacje o wypadkach (liczbie lekko rannych, ofiar śmiertelnych i ciężko rannych), jak i dane dotyczące sezonowych wahań ruchu pojazdów – wykorzystano w tym celu średnie dobowe natężenie ruchu pojazdów w miesiącu. Szczególną uwagę skupiono na okresie wprowadzenia stanu epidemii w Polsce (marzec 2020), kiedy nałożono liczne ograniczenia w przemieszczaniu się. Doprowadziło to do około 30-procentowego spadku liczby wypadków w porównaniu z rokiem 2019. Jednocześnie w okresach pomiędzy kolejnymi falami zachorowań utrzymywano część obostrzeń, co wpływało na ograniczenie mobilności oraz zachowania kierowców i pieszych. W ramach badań porównano liczbę i charakter wypadków przed pandemią oraz w trakcie różnych jej faz. Zestawiono również sytuację sprzed nowelizacji ustawy Prawo o ruchu drogowym (w połowie 2021 roku piesi otrzymali większe przywileje przy wkraczaniu na przejście) z okresem po jej wprowadzeniu. Dodatkowo w analizach uwzględniono wielkość ruchu drogowego. Takie podejście pozwoliło określić wpływ poszczególnych czynników (m.in. restrykcji pandemicznych, zmian legislacyjnych czy wahań sezonowych natężeń ruchu) na miesięczną liczbę pieszych zabitych oraz ciężko rannych (*KSI*). Opracowany model liczby ciężko rannych i zabitych pieszych w miesiącu potwierdził, że najważniejszym czynnikiem zwiększającym ryzyko wypadków o poważnych konsekwencjach pozostaje wysokie natężenie ruchu. Ograniczenia w przemieszczaniu się, wprowadzone w ramach walki z pandemią, przyczyniły się jednak do spadku liczby najtragiczniejszych zdarzeń: w okresach restrykcji liczba pieszych zabitych lub ciężko rannych (*KSI*) zmniejszyła się około 22.9%, a w okresach przejściowych – około 13.1%. Z kolei nowe przepisy dotyczące pierwszeństwa pieszych na przejściach bez sygnalizacji świetlnej spowodowały około 21.5 procentowy spadek liczby najpoważniejszych ofiar. Jednocześnie zaobserwowano wzrost śmiertelności (tj. liczby zabitych na 100 wypadków) w trakcie lockdown’ów. Zgromadzone dane sugerują, że przy mniejszym natężeniu ruchu kierowcy rozwijali większe prędkości, co przekładało się na poważniejsze obrażenia pieszych. Podobne zjawisko odnotowano w innych krajach, co potwierdza hipotezę, iż spadek ogólnej liczby

wypadków przy niższym natężeniu ruchu nie musi oznaczać poprawy bezpieczeństwa, jeśli jednocześnie wzrasta prędkość pojazdów. W artykule zwrócono także uwagę na konieczność dalszego udoskonalania metod pozyskiwania i weryfikacji danych o wypadkach. Podkreślono również potrzebę gromadzenia dokładnych danych o liczbie pieszych przekraczających jezdnię i rzeczywistych prędkościach pojazdów w pobliżu przejść. W tym kontekście planowane jest wykorzystanie narzędzi Big Data, w tym danych z systemów nawigacyjnych od operatorów telefonii komórkowej, co może pozwolić na precyzyjniejsze odwzorowanie rzeczywistych prędkości pojazdów i wielkości ruchu pieszych. W końcowej części pracy zaproponowano nowy wskaźnik, MADD (Monthly Average Daily Deaths), opisujący miesięczną średnią dobowej liczby ofiar śmiertelnych wśród pieszych na przejściach bez sygnalizacji. Umożliwia on uchwycenie długoterminowych trendów wypadkowości oraz uwzględnia wpływ czynników sezonowych, które – jak zaobserwowano – mogą oddziaływać na poziom bezpieczeństwa (zwłaszcza w miesiącach jesiennych i zimowych). Podsumowując, wyniki badań potwierdziły istotny wpływ zarówno restrykcji związanych z pandemią COVID-19, jak i nowelizacji przepisów ruchu drogowego na bezpieczeństwo pieszych. Okresy największych ograniczeń mobilności skutkowały co prawda spadkiem ogólnej liczby wypadków z udziałem pieszych, lecz w tym samym czasie wzrastał wskaźnik śmiertelności. Natomiast nowelizacja ustawy (nadająca pieszym priorytet przy wchodzeniu na przejście) realnie zmniejszyła liczbę ofiar najpoważniejszych wypadków. W kolejnych badaniach warto zweryfikować hipotezę, iż to prędkość stała się głównym czynnikiem ryzyka w okresach lockdown'ów, a także uzupełnić analizy o dane dotyczące rzeczywistej liczby pieszych i intensywności ich ruchu. Zastosowanie metod analizy Big Data może w przyszłości umożliwić jeszcze pełniejsze odtworzenie dynamiki wypadków oraz wyciągnięcie wniosków sprzyjających poprawie bezpieczeństwa pieszych w ruchu drogowym.

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