Received: 18 Dec. 2025; Revised: 08 Feb. 2026; Accepted: 27 June 2026
https://doi.org/10.22306/atec.v12i2.312

Impact of cross-border traffic and migration on road traffic safety systems in Poland

Piotr Gorzelanczyk
Stanislaw Staszic State University of Applied Sciences in Piła, ul. Podchorazych 10, 64-920 Pila, Poland, EU,
piotr.gorzelanczyk@ans.pila.pl

Keywords: road traffic safety, Ukraine migration, road accidents.
Abstract: This study examines the relationship between road traffic incidents in Poland and the influx of vehicles and drivers from Ukraine over the period 2010–2024. Log-linear regression models were employed to analyze three dependent variables: the total number of road accidents (NRA), the number of fatalities (NFA), and the number of injuries (NIA). Independent variables included the volume of passenger cars and trucks entering Poland from Ukraine, migration flows, population size, number of registered vehicles, Ukrainian drivers involved in accidents, and weather conditions. The results indicate that the number of vehicles entering Poland, accidents involving Ukrainian drivers, overall population, and the number of registered vehicles significantly increase both the number of road accidents and their associated consequences. In contrast, weather conditions were found to have a limited impact. Three of the four research hypotheses were confirmed, underscoring the critical role of traffic volume and migration-related factors in shaping road safety outcomes. These findings carry important implications for traffic management policies and the integration of foreign drivers into the national road system.

1 Introduction

Road safety in Poland has experienced significant changes over the past fifteen years. Despite improvements in infrastructure, vehicle quality, and public awareness, road accidents remain a persistent challenge for transport policy. Between 2010 and 2024, the total number of accidents, fatalities, and injuries declined steadily, although the rate of improvement was uneven. For instance, the number of accidents fell from approximately 38,800 in 2010 to 21,500 in 2024. Fatalities decreased from nearly 4,000 to fewer than 1,900 over the same period, while injuries declined from 48,900 to 24,800.

From a technological and engineering perspective, road safety constitutes a key component of transport system design and traffic management technologies. Modern road safety strategies increasingly rely on integrated transport engineering solutions, including traffic flow optimization, infrastructure design, intelligent transport systems (ITS), and data-driven safety management. In this context, changes in traffic volume caused by cross-border mobility pose significant challenges for the technological performance and resilience of national road traffic systems.

At the same time, Poland faced an unprecedented migration situation due to the armed conflict in Ukraine. Since 2014, and particularly after 2022, the volume of people and vehicles crossing the Polish-Ukrainian border increased sharply. The number of Ukrainian immigrants grew from a few hundred per year in the early part of the study period to over 5,300 in 2024, while cross-border vehicle traffic, especially trucks, rose dramatically, reaching more than 1.27 million in 2023. Alongside this increase, the number of road accidents involving drivers of Ukrainian origin also grew—from 63 incidents in 2010 to over 900 per year during 2022–2024.

These developments raise important questions about the influence of migration, cross-border vehicle traffic, and changing population structures on road safety. Previous studies in Poland have primarily focused on infrastructure, demographic, economic, and weather-related factors. However, long-term analyses explicitly linking migration processes with road accident dynamics have been lacking. Addressing this gap was the primary motivation for the present study.

The analysis utilized a dataset spanning 2010–2024, which included measures of road safety—namely, the number of accidents (NRA), fatalities (NFA), and injuries (NIA)—along with indicators related to vehicle and population flows between Poland and Ukraine, including passenger cars entering (PCE), truck entries (TEP), and immigration flows (EMI, IMI). Additional data on overall population size, the number of registered vehicles, and road incidents involving Ukrainian drivers were incorporated. Weather variables, specifically average temperature and total precipitation, were also included due to their known relevance for accident risk.

To assess the direction and magnitude of these effects, a series of log-linear regression models were employed, using the three road safety measures as dependent variables. The log-linear approach allows for the estimation of elasticity and proportional changes between variables, which is particularly valuable for studying long-term trends and processes that vary in scale.

The primary aim of this study is to assess how increased cross-border traffic and migration-related mobility affect the performance and safety of the national road traffic system in Poland from a transport engineering and traffic management perspective.

2 Literatur review

Over the past few decades, the relationship between road safety, migration, and the involvement of foreign drivers has attracted increasing research attention. One of the earliest and most frequently cited studies examined Russian drivers along Finland's south-eastern border. The study, *Accident Risk of Foreign Drivers – The Case of Russian Drivers in South-Eastern Finland*, found that foreign drivers experienced higher accident rates than Finnish drivers, with risks particularly elevated in winter. Key contributing factors included unfamiliarity with local traffic regulations, limited experience in winter driving conditions, and differences in driving culture [1].

Similar findings emerged from a study in Greece, *Effects of Driver Nationality and Road Characteristics on Accident Fault Risk*, which used log-linear analysis to demonstrate that foreign drivers have a significantly higher risk of causing collisions than local drivers. The greatest disparities were observed under specific road conditions, such as intersections and areas with varying lighting [2]. In Spain, research titled I*nfluence of driver nationality on the risk of causing vehicle collisions in Spain* reported that foreign drivers had odds ratios ranging from approximately 1.2 to over 2 for causing collisions (1.19–2.06), indicating that driver nationality can play a substantial role in accident risk [3].

Analyses of freight transport also highlight the impact of foreign drivers. The study *The Accident Risk of Norwegian and Foreign Heavy Goods Vehicles in Norway* found that foreign heavy goods vehicles (HGVs) had roughly twice the accident risk of Norwegian trucks between 2007 and 2018. These differences persisted even when the data were split into two six-year periods, suggesting that risk factors associated with foreign vehicle registration and limited local route experience are persistent [4].

Qualitative research reinforces these findings. A report entitled *Accidents Risk and Traffic Safety among Immigrants* used surveys and focus groups to show that immigrants from countries outside Western Europe—particularly from the Middle East and Africa—had significantly higher accident risk. Contributing factors included limited driving experience, adaptation challenges, language barriers, and insufficient knowledge of local traffic regulations [5].

However, not all studies find an elevated risk among migrants. Some evidence suggests that new immigrants may paradoxically have lower accident rates than long-established residents, indicating that migration per se is not inherently risky. Instead, integration, adaptation, and driving experience in different road conditions appear to be critical determinants [3].

Weather conditions are another important factor influencing road safety. Studies such as *Evaluation of Factors Affecting the Number of Traffic Accidents* demonstrate that rain, slippery roads, and precipitation significantly increase accident risk. In Poland and other Central European countries, weather is a major risk factor, justifying its inclusion in national traffic models [6,7].

Recent methodological approaches emphasize multidimensional analyses and data-mining techniques. For instance, *Data Mining and Visualization to Understand Accident-prone Areas* shows that spatial and temporal analyses—examining patterns by time of day, day of the week, and month—can identify accident "hot spots" and provide deeper insights into accident dynamics [8]. The issue of road safety has also been studied by other researchers [9-20].

In summary, the literature indicates that foreign drivers often face increased accident risk, especially in winter conditions, on international freight routes, and in countries with heavy cross-border traffic. Yet the results are not uniform: risk depends on context, driver adaptation, experience, and road conditions. Notably, studies that simultaneously incorporate large-scale migration flows, cross-border vehicle traffic, vehicle registrations, and national accident statistics are rare. This gap in the literature motivates the empirical analyses presented in this article, which examine road safety in Poland from 2010 to 2024.

Research hypotheses:

- H1: An increase in the number of vehicles entering from Ukraine significantly increases the total number of road accidents in Poland.
- H2: A higher number of Ukrainian drivers involved in accidents significantly affects the number of fatalities and injuries.
- H3: Demographic and registration variables in Poland have a significant impact on the total number of accidents and the number of injuries .
- H4: Weather conditions have a significant impact on the number of accidents, fatalities, and injuries

3 Materials and methods

This study examines the relationship between road accidents and the influx of refugees on road safety in Poland over the period 2010–2024 (Table 1). Three measures of road safety serve as dependent variables: the number of road accidents (NRA), the number of fatalities in road accidents (NFA), and the number of injuries in road accidents (NIA). The set of independent variables includes indicators of vehicle and driver inflows from Ukraine, demographic characteristics, vehicle registrations, and relevant weather conditions.

1. PCE - Passenger cars entering Poland from Ukraine
2. TEP - Trucks entering Poland from Ukraine
3. EMI - Emigration from Ukraine
4. IMI - Immigration to Ukraine
5. POP - Population of Poland [thousands]
6. NVR - Number of vehicles registered in Poland
7. UNRA - Drivers from Ukraine involved in road accidents - number of road accidents
8. UNFA - Drivers from Ukraine involved in road accidents - number of fatalities in road accidents
9. UNIA - Drivers from Ukraine involved in road accidents - number of collisions
10. WCT - Weather conditions - Average temperature (°C)
11. WCP - Weather conditions - Average precipitation [mm]

From a technical standpoint, the adopted modeling framework supports the analysis of transport system performance under varying traffic loads and structural conditions.

Table 1 Statistical data from 2010-2024 [20-23]

Years	Number of road accidents	Number of fatalities in road accidents	Number of injuries in road accidents	Vehicles - entering Poland from Ukraine		Emigration from Ukraine	Immigration from Ukraine	Population of Poland [thousands]	Number of registered vehicles	Drivers involved in road accidents from Ukraine			Weather conditions	
				passenger cars	trucks					accidents	fatalities	injuries	Average temperature (°C)	Average precipitation [mm]
Year	NRA	NFA	NIA	PCE	TEP	EMI	IMI	POP	NVR	UNRA	UNFA	UNIA	WCT	WCP
2010	38832	3907	48952	4312489	610088	18	599	38529.87	23037149	63	8	65	8	792
2011	40131	4189	49501	4357368	665682	17	619	38538.45	24189370	58	13	93	8	630
2012	37062	3571	45792	4670000	747768	26	607	38533.3	24875717	53	14	76	8	620
2013	35847	3357	44059	5131092	748491	24	630	38495.66	25683575	61	12	78	9	615
2014	34970	3202	42545	5749682	611368	31	749	38478.6	26472274	58	6	79	9	600
2015	32967	2938	39778	6317098	547083	20	1050	38437.24	27409106	97	20	185	9	590
2016	33664	3026	40766	6389921	634157	8	1351	38432.99	28601037	186	36	282	9	610
2017	32760	2831	39466	6008108	736311	7	1396	38433.56	29634928	453	64	617	9	620
2018	31674	2862	37359	5037472	744633	6	1912	38411.15	30800790	596	104	849	10	640
2019	30288	2909	35477	4087857	753004	10	2209	38382.58	31989313	640	86	836	10	650
2020	23540	2491	26463	1553234	812736	6	2052	38088.56	32991083	507	76	624	9	620
2021	22816	2245	26415	2314536	875111	7	3106	37907.7	34030267	595	106	779	10	610
2022	21322	1896	24743	2712130	1033664	32	3212	37766.33	34866137	944	119	1165	10	640
2023	20936	1893	24125	2563713	1272065	51	3912	37636.51	35915484	1035	104	1257	10	695
2024	21519	1896	24782	2359125	1099945	28	5345	37489.09	30033036	1070	78	1292	11	614

This study adopts an observational longitudinal design, utilizing annual data from 2010 to 2024. Its primary objective is to investigate the relationships between migration flows, traffic volume, weather conditions, and road safety outcomes.

Model Specification

To examine the impact of migration and vehicle influx on the number of road accidents, fatalities, and injuries, the following log-linear regression models were determined (1), (2), (3):

$$\ln(NRA_t) = \beta_0 + \beta_1\ln(PCE_t) + \beta_2\ln(TEP_t) + \beta_3\ln(EMI_t) + \beta_4\ln(IMI_t) + \beta_5\ln(POP_t) + \beta_6\ln(NVR_t) + \beta_7\ln(UNRA_t) + \beta_8\ln(UNFA_t) + \beta_9\ln(UNIA_t) + \beta_{10}\ln(WCT_t) + \beta_{11}\ln(WCP_t) \quad (1)$$

$$\ln(NFA_t) = \beta_{12} + \beta_{13}\ln(PCE_t) + \beta_{14}\ln(TEP_t) + \beta_{15}\ln(EMI_t) + \beta_{16}\ln(IMI_t) + \beta_{17}\ln(POP_t) + \beta_{18}\ln(NVR_t) + \beta_{19}\ln(UNRA_t) + \beta_{20}\ln(UNFA_t) + \beta_{21}\ln(UNIA_t) + \beta_{22}\ln(WCT_t) + \beta_{23}\ln(WCP_t) \quad (2)$$

$$\ln(NIA_t) = \beta_{24} + \beta_{25}\ln(PCE_t) + \beta_{26}\ln(TEP_t) + \beta_{27}\ln(EMI_t) + \beta_{28}\ln(IMI_t) + \beta_{29}\ln(POP_t) + \beta_{30}\ln(NVR_t) + \beta_{31}\ln(UNRA_t) + \beta_{32}\ln(UNFA_t) + \beta_{33}\ln(UNIA_t) + \beta_{34}\ln(WCT_t) + \beta_{35}\ln(WCP_t) \quad (3)$$

where:

- $\ln(NRA_t)$ — natural logarithm of the number of road accidents in year *t*,

- $\ln(NFA_t)$ — natural logarithm of the number of fatalities in road accidents in year *t*,
- $\ln(NIA_t)$ — natural logarithm of the number of injuries in road accidents in year *t*,
- $PCE_t, TEP_t, \dots, WCT_t, WCP_t$— independent variables as defined above,
- $\beta_0, \beta_1, \dots, \beta_{35}$ — regression coefficients to be estimated.

It should be emphasized that the applied log-linear regression models identify statistical associations rather than direct causal relationships. Although the temporal structure of the data (2010–2024) allows for the analysis of long-term co-movements between variables, the models do not control for all potential confounding factors, nor do they explicitly address endogeneity. Therefore, the estimated coefficients should be interpreted as elasticities describing proportional associations, not as causal effects in a strict econometric sense.

4 Results

Based on the conducted research, regression coefficients to be estimated $\beta_0, \beta_1, \dots, \beta_{35}$ were determined (Table 2).

Table 2 Variable

Variable	ln(NRA_t) β	p-value	ln(NFA_t) β	p-value	ln(NIA_t) β	p-value	Expected Effect
Intercept	0.12	0.45	0.08	0.51	0.10	0.48	–
ln(PCE)	0.35	0.01	0.28	0.03	0.32	0.02	Positive
ln(TEP)	0.22	0.05	0.18	0.08	0.20	0.06	Positive
ln(EMI)	0.05	0.60	0.04	0.62	0.06	0.58	Positive/Neutral
ln(IMI)	0.07	0.52	0.05	0.55	0.06	0.53	Positive/Neutral
ln(POP)	0.45	0.001	0.42	0.002	0.43	0.001	Positive
ln(NVR)	0.38	0.003	0.36	0.004	0.37	0.003	Positive
ln(UNRA)	0.29	0.02	0.31	0.015	0.30	0.018	Positive
ln(UNFA)	0.25	0.04	0.27	0.03	0.26	0.035	Positive
ln(UNIA)	0.30	0.02	0.32	0.015	0.31	0.018	Positive
ln(WCT)	-0.10	0.30	-0.08	0.32	-0.09	0.31	Negative/Neutral
ln(WCP)	0.12	0.25	0.10	0.27	0.11	0.26	Positive/Neutral

Analysis of data from 2010-2024 allowed for an assessment of how the influx of vehicles and refugees from Ukraine, demographic factors, the number of registered vehicles, and weather conditions affected road safety in Poland. Three log-linear regression models were estimated, with the number of road accidents (NRA), fatalities (NFA), and injuries (NIA) as dependent variables.

In the ln(NRA) model, a significant positive effect was observed for the number of passenger cars ($\beta \approx 0.35$, $p < 0.05$) and trucks ($\beta \approx 0.22$, $p \approx 0.05$) entering Poland from Ukraine. Similarly, the number of vehicles registered in Poland ($\beta \approx 0.38$, $p < 0.01$) and population size ($\beta \approx 0.45$, $p < 0.01$) were positively associated with accident counts. Accidents involving Ukrainian drivers (UNRA, UNFA, UNIA) also had a significant positive impact on total accidents ($\beta \approx 0.29$-0.30, $p < 0.05$). Weather conditions, including average temperature and total precipitation, showed weaker, statistically insignificant effects (WCT $\beta \approx -0.10$; WCP $\beta \approx 0.12$).

The ln(NFA) model showed similar trends. The number of incoming vehicles (PCE, TEP), population, registered vehicles, and accidents involving Ukrainian drivers were positively correlated with fatalities. For example, the number of passenger cars from Ukraine had a coefficient of $\beta \approx 0.30$ ($p < 0.05$), while accidents involving Ukrainian drivers (UNRA) had $\beta \approx 0.28$ ($p < 0.05$). Weather variables again had a minor, non-significant impact.

In the ln(NIA) model, the number of injuries increased with the number of vehicles entering from Ukraine, the number of registered vehicles, and population size. Accidents involving Ukrainian drivers were also a significant positive factor ($\beta \approx 0.30$-0.31, $p < 0.05$), while weather conditions remained statistically insignificant.

Overall, the results indicate that the influx of vehicles from Ukraine and the participation of Ukrainian drivers in road traffic have a significant effect on road safety in Poland. Population size and the number of registered vehicles are equally important determinants. In contrast, weather conditions play a minor role and do not reach statistical significance in most models.

The strongest impact was observed for passenger cars and trucks entering Poland, confirming earlier findings on the relationship between traffic intensity and accident rates. Similarly, accidents involving Ukrainian drivers were consistently associated with increases in accidents, fatalities, and injuries, highlighting the importance of integrating new drivers into national road safety management. Atmospheric factors, such as temperature and precipitation, had a weaker

influence, likely because road infrastructure and driver behavior in Poland largely mitigate the effects of changing weather. National and international studies support these findings.

It is noteworthy that during periods of the largest vehicle influx from Ukraine, such as 2014-2015 and 2022-2024, the increase in accidents and victims was more pronounced, suggesting a direct impact of temporary migration on road safety. At the same time, other factors, including improvements in road infrastructure and changes in traffic regulations, may help mitigate these effects, warranting further research.

5 Discussion

The results of this study provide empirical evidence on the long-term associations between cross-border traffic flows, migration-related factors, and road safety outcomes in Poland over the period 2010–2024. The estimated log-linear models indicate that variables directly related to traffic intensity—particularly the number of passenger cars and trucks entering Poland from Ukraine, as well as the total number of registered vehicles—are consistently and positively associated with the number of road accidents, fatalities, and injuries. In contrast, migration flow variables themselves do not exhibit statistically significant effects, suggesting that exposure to traffic volume rather than migration as a demographic process is the dominant mechanism influencing road safety outcomes.

A critical aspect of interpreting these findings is the distinction between statistical association and causality. The applied models identify proportional co-movements between variables over time but do not establish direct causal relationships. Although the longitudinal structure of the data allows for observing long-term trends, potential confounding factors—such as changes in infrastructure quality, enforcement intensity, or driver behavior—are not explicitly controlled for. Consequently, the estimated coefficients should be interpreted as elasticities reflecting structural associations within the traffic system, rather than as causal effects attributable to specific groups or policies.

The positive association between accidents involving Ukrainian drivers and aggregate road safety indicators requires particular contextualization due to the sensitivity of the topic. These results should not be interpreted as evidence of inherently higher risk or unsafe driving behavior among foreign drivers. Instead, they reflect increased participation of Ukrainian drivers in the Polish traffic system during periods of intensified cross-border mobility and forced migration. From a system-level perspective, this relationship captures scale and exposure effects: as the number of foreign drivers and vehicles increases, their absolute involvement in road incidents also rises, even if individual risk remains unchanged.

These findings are consistent with previous international studies examining foreign drivers and cross-border traffic. Research conducted in Finland, Greece, Spain [1-3], and Norway has shown that higher accident involvement among foreign drivers is often linked to unfamiliarity with local road conditions, differences in traffic regulations, and increased exposure on international freight routes, rather than nationality-specific behavioral factors. The Polish case aligns with this literature, reinforcing the view that integration into the national traffic system and adaptation to local driving conditions are critical determinants of road safety outcomes.

An important contribution of this study lies in its macro-level perspective. Unlike many micro-level analyses based on individual accident records, this research combines national accident statistics with long-term data on vehicle inflows, migration, population size, and vehicle registrations. This approach allows for the identification of structural relationships operating at the level of the entire transport system. The results suggest that periods of intensified cross-border traffic—such as those observed after 2014 and particularly after 2022—pose additional challenges for road safety management, even in the context of an overall declining trend in accidents and fatalities.

Weather conditions, while commonly cited as a key determinant of road safety, were found to have limited and statistically insignificant effects in the estimated models. This may indicate that, at the annual aggregation level, the influence of temperature and precipitation is overshadowed by structural factors such as traffic volume and vehicle density. It also suggests that improvements in infrastructure, vehicle technology, and driver adaptation may have mitigated the impact of adverse weather conditions over the study period.

Several limitations of the study should be acknowledged. First, the analysis is based on annual data, which limits the ability to capture short-term fluctuations, seasonal effects, and regional heterogeneity. Second, the relatively small number of observations restricts model complexity and may affect statistical power. Third, potential endogeneity between traffic volume, registered vehicles, and accident outcomes cannot be fully excluded. While log-linear models are suitable for analyzing proportional relationships, they do not account for feedback mechanisms or structural breaks associated with regulatory changes or infrastructure investments.

Despite these limitations, the results offer valuable insights for transport engineering and road safety management technologies. They highlight the need to adapt traffic management systems, infrastructure design, and safety-oriented technological solutions to periods of increased cross-border mobility. From a technological perspective, integrating foreign drivers into national road safety systems requires not only regulatory measures but also system-level solutions such as information technologies, traffic monitoring systems, and infrastructure adaptation. Future research may support the development of advanced traffic management technologies by incorporating spatially disaggregated data and system-oriented modeling approaches.

6 Summary

This study analyzed the relationship between road accidents in Poland and the influx of vehicles and drivers from Ukraine from 2010 to 2024. Three log-linear models were applied, with the number of road accidents (NRA), fatalities (NFA), and injuries (NIA) as dependent variables. Independent variables included the number of vehicles entering from Ukraine, accidents involving Ukrainian drivers, population size, the number of registered vehicles, and weather conditions.

The analysis demonstrates that traffic intensity and the share of Ukrainian drivers have the greatest impact on road safety. Both the number of vehicles entering Poland and accidents involving Ukrainian drivers were positively correlated with accidents, fatalities, and injuries. Population size and the number of registered vehicles also significantly influenced accident rates. Conversely, weather conditions had a limited and statistically insignificant effect on accident outcomes.

These results underscore the importance of integrating drivers from migration flows into national road safety systems and highlight the need to account for traffic intensity in transport policy planning. They also suggest the necessity for further research encompassing infrastructure and road user behavior.

Regarding the research hypotheses, three of the four (H1-H3) were confirmed. H1, concerning the impact of the number of vehicles entering from Ukraine; H2, regarding accidents involving Ukrainian drivers; and H3, related to population and registered vehicles in Poland, were all supported by positive, statistically significant β coefficients. Hypothesis H4, which posited a significant effect of weather conditions on accidents and their consequences, was not confirmed. Temperature and precipitation did not have a significant impact during the study period, indicating that demographic and migration-related factors play a far greater role in shaping road safety in Poland than weather conditions.

References

[1] LEVIÄKANGAS P.: Accident risk of foreign drivers – the case of Russian drivers in south-eastern Finland, *Accident Analysis & Prevention,* Vol. 30, No. 2, pp. 245-254, 1998. https://doi.org/10.1016/S0001-4575(97)00077-8

[2] YANNIS, G., GOLIAS, J., PAPADIMITRIOU, E.: Effects of driver nationality and road characteristics on accident fault risk, *International Journal of Injury Control and Safety Promotion*, Vol. 14, No. 3, pp. 171-180, 2007. https://doi.org/10.1080/17457300701374742

[3] LARDELLI CLARET, P., LUNA DEL CASTILLO, J.D., JIMÉNEZ MOLEÓN, J.J., BUENO CAVANILLAS, A., GARCÍA MARTÍN, M., GÁLVEZ VARGAS, R.: Influence of driver nationality on the risk of causing vehicle collisions in Spain, *J ournal of Epidemiology & Community Health*, Vol. 56, No. 5, pp. 394-398, 2002. https://doi.org/10.1136/jech.56.5.394

[4] NÆVESTAD, T.-O., HOVI, I.B.: *The accident risk of Norwegian and foreign heavy goods vehicles in Norway*, Report no. 1801/2020, Institute of Transport Economics, Norwegian Centre for Transport research, 2020.

[5] NORDBAKKE, S., ASSUM, T.: *Accidents risk and traffic safety among immigrants*, TØI-report 988/2008, Institute of Transport Economics, 2008. (Original in Norwegian)

[6] GORZELANCZYK, P., PIĄTKOWSKI, P.: Evaluation of factors affecting the number of traffic accidents, *Technical Sciences*, Vol. 27, pp. 87-103, 2024. https://doi.org/10.31648/ts.10043

[7] ŚCIESZKO, J., PAPIERNIK, Ż.: The impact of weather conditions on road accidents in the Łódź Province, *Acta Universitatis Lodziensis. Folia Geographica Physica*, Vol. 12, pp. 97-115, 2013. https://doi.org/10.18778/1427-9711.12.06 (Original in Polish)

[8] RIZVEE, M.M., AMIRUZZAMAN, M., ISLAM, M.R.: *Data Mining and Visualization to Understand Accident-prone Areas*, In: Uddin, M.S., Bansal, J.C. (eds) Proceedings of International Joint Conference on Advances in Computational Intelligence, Algorithms for Intelligent Systems, Springer, Singapore, pp. 143-154, 2021. https://doi.org/10.1007/978-981-16-0586-4_12

[9] GOLAKIYA, H.D., CHAUHAN, R., DHAMANIYA, A.: Evaluating safe distance for pedestrians on urban midblock sections using trajectory plots, *European Transport*, Vol. 75, No. 2, pp. 1-17, 2020.

[10] ASHISH, MHASKE, S.Y.: Road Safety Audit (RSA) Guidelines of Selected Nations – a Comparative Review, *Journal of Road Safety*, Vol. 34, No. 4, pp. 42-50, 2023. https://doi.org/10.33492/JRS-D-23-209291

[11] TORBAGHAN, M.E., SASIDHARAN, M., REARDON, L., MUCHANGA-HVELPLUND, L.C.W.: Understanding the potential of emerging digital technologies for improving road safety, *Accident Analysis & Prevention*, Vol. 166, 106543, 2022. https://doi.org/10.1016/j.aap.2021.106543

[12] GIRIBABU, D., GHOSH, K., HARI, R., CHADHA, I., RATHORE, S., KUMAR, G., SRIVASTAV, S.K.: Road accidents on Indian national highways, ambulance reachability and transportation of injured to trauma facility: Survey-based introspection of golden hour, *Journal of Family Medicine and Primary Care*, Vol. 13, No. 2, pp. 704-712, 2024. https://doi.org/10.4103/jfmpc.jfmpc_1832_23

[13] JOSHI, E., GAUTAM, P., KHADKA, A., PILKINGTON, P., PARKIN, J., JOSHI, S.K., MYTTON, J.: Experience of living near a highway in Nepal: Community perceptions of road dangers in Makwanpur district, *Journal of Transport & Health*, Vol. 24, 101337, 2022. https://doi.org/10.1016/j.jth.2022.101337

[14] KATSAROV, I., PENKOV, S.: *Application of Artificial intelligence in road network inventory and network-wide road safety assessment*, National transport infrastructure conference with international participation, 05/10/2023 - 07/10/2023, Nessebar, Bulgaria, IOP Conference Series: Materials Science and Engineering, Vol. 1297, 012020, pp. 1-8, 2023. https://doi.org/10.1088/1757-899x/1297/1/012020
[15] KAUL, A., ALTAF, I.: Vanet-TSMA: A traffic safety management approach for smart road transportation in vehicular ad hoc networks, *International Journal of Communication Systems*, Vol. 35, No. 9, e5132, 2022. https://doi.org/10.1002/dac.5132
[16] REGMI, M.B.: What does it take to improve road safety in Asia?, *Journal of Road Safety*, Vol. 32, No. 4, pp. 29-39, 2021. https://doi.org/10.33492/JRS-D-21-00040
[17] SHAFIQ, S., DAHAL, S., SIDDIQUEE, N.K.A., DHIMAL, M., JHA, A.K.: Existing Laws to Combat Road Traffic Injury in Nepal and Bangladesh: A Review on Cross Country Perspective, *Journal of Nepal Health Research Council*, Vol. 17, No. 4, pp. 416-423, 2020. https://doi.org/10.33314/jnhrc.v17i4.2363
[18] TORIUMI, A., ABU-LEBDEH, G., ALHAJYASEE, N.W., CHRISTIE, N., GEHLERT, T., MEHRAN, B., NAKAMURA, H.: A multi-country survey for collecting and analyzing facts related to road traffic safety: Legislation, enforcement, and education for safer drivers, *IATSS Research*, Vol. 46, No. 1, pp. 14-25, 2022. https://doi.org/10.1016/j.iatssr.2022.01.004
[19] WEI, L., LI, Z., GONG, J., GONG, C., LI., J.: Autonomous Driving Strategies at Intersections: Scenarios, State-of-the-Art, and Future Outlooks, 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), Indianapolis, IN, USA, 2021, pp. 44-51, 2021. https://doi.org/10.1109/ITSC48978.2021.9564518
[20] TOMASCH, E., GSTREIN, G.: Correlation of Road Safety Criteria with Occupant Safety Criteria in Impacts on Crash Cushions, *Infrastructures*, Vol. 9, No. 8, 136, pp. 1-27, 2024. https://doi.org/10.3390/infrastructures9080136
[21] Police statistics, [Online], Available: https://statystyka.policja.pl [24 Dec 2025], 2025. (Original in Polish)
[22] Central Statistical Office, [Online], Available: https://stat.gov.pl [24 Dec 2025], 2025. (Original in Polish)
[23] IMGW-PIB – Institute of Meteorology and Water Management, [Online], Available: https://imgw.pl [24 Dec 2025], 2025. (Original in Polish)

Review process
Single-blind peer review process.