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**ARTICLE**

# Application of the Pareto Principle in the Analysis of Causes of Road Accidents in Poland

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## ABSTRACT

The article aims to apply the Pareto principle in the analysis of the causes of road accidents in Poland in 2018–2024. Analysis of data from the National Road Safety Council showed a clear decrease in the number of accidents and related fatalities and injuries during the period under review, with particular emphasis on the years of the COVID-19 pandemic, when traffic restrictions contributed to a significant reduction in the number of incidents. Despite the improvement in overall road safety, accidents are still concentrated on certain days of the week, in favorable weather conditions, and in certain types of incidents. The application of Pareto analysis made it possible to identify the most important factors determining accidents: days of the week (Friday, Monday, Wednesday—46.35% of accidents), weather conditions (good conditions—66.31%), type of incident (side collisions and pedestrian collisions—53.61%), and driver causes (failure to give way and inappropriate speed—44.88%). The analysis shows that road safety measures do not have to be applied uniformly. Better results can be achieved when attention is paid to particular days of the week, dominant accident types, and the causes most often linked to driver behaviour. In this context, the Pareto principle proved useful, as it helped to distinguish a limited set of factors that account for a large share of road incidents and therefore deserve priority in prevention strategies. The study adopts a system-based perspective and integrates Pareto analysis to identify key factors influencing road accidents.

***Keywords:*** Road Safety (RS); Road Accidents; Pareto Analysis; Causes of Accidents

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# 1. Introduction

Road safety occupies an important place in transport policy, both in Poland and in other countries. Although vehicles are becoming safer and road infrastructure continues to improve, road accidents still pose significant social and economic burdens. These include not only material damage, but also injuries and loss of life. For this reason, identifying the main sources of risk and understanding how accidents are distributed across different conditions remains a key task for road safety management.

Recent research increasingly relies on quantitative methods to examine accident patterns and risk factors. Among the tools used for this purpose, the Pareto principle has gained attention due to its ability to highlight a limited number of causes responsible for a large share of adverse events. When applied to road accident data, this approach helps distinguish those factors that contribute most strongly to overall accident numbers and therefore deserve priority in preventive policies.

This article applies Pareto analysis to road accident data in Poland, covering the period from 2018 to 2024. The objective is to determine which factors play the most important role in accident occurrence. The analysis takes into account several dimensions, including the day of the week, prevailing weather conditions, accident type, and selected aspects of driver behaviour. By doing so, the study seeks to indicate areas where preventive actions are likely to produce the greatest improvement in road safety.

On the basis of the empirical analysis, the following research hypotheses were formulated:

**H1.** *A relatively small group of factors—such as particular days of the week, weather conditions, accident type, and driver behaviour—accounts for a substantial proportion of road accidents, in line with the assumptions of the Pareto principle.*

**H2.** *The total number of road accidents in Poland shows a declining tendency over the period 2018–2024, with the most pronounced reduction occurring during the years affected by COVID-19-related traffic restrictions.*

**H3.** *Days associated with higher traffic volumes and increased driver activity (notably Friday, Monday, and Wednesday) record significantly more accidents than other days of the week.*

**H4.** *Failure to give way and driving at speeds unsuited to traffic conditions remain the dominant direct causes of accidents, indicating that preventive efforts should concentrate on these behaviours.*

**H5.** *Pareto analysis is an effective method for identifying priority intervention areas in road safety policy.*

**A Systemic Perspective on Road Safety**

Road safety is commonly described as a complex socio-technical system in which accidents arise from the interaction of multiple components. These include human behaviour, vehicle design, road infrastructure, environmental conditions, and legal or organizational frameworks. In line with general systems theory, such systems should be examined as integrated wholes rather than as collections of isolated elements. From this perspective, traffic accidents cannot be attributed solely to individual driver errors, but instead emerge from the combined influence of technical, behavioural, and contextual factors.

System-based approaches to road safety—such as socio-technical analysis, risk systems theory, and the Safe System Approach promoted by international organizations—emphasize that transport systems should be designed to tolerate human error without resulting in severe outcomes. A central concept within these frameworks is the identification of critical points within the system where targeted actions can yield disproportionately large safety benefits.

This way of thinking closely corresponds with the logic of the Pareto principle applied in the present study. Both approaches focus on isolating a small number of dominant factors that shape overall system performance. Treating road accidents as outcomes of a complex system allows Pareto analysis to serve not only as a descriptive method, but also as a practical tool for supporting strategic decisions in road safety management.

# 2. Literature Review

Safe driving is generally understood as consistent compliance with traffic rules, regulations, and established safety principles. These rules constitute the foundation of road traffic systems and should not be treated as optional.

However, improving road safety (RS) extends well beyond individual driving behaviour. It also depends on the quality of traffic organization, the standard of road infrastructure, and the technical condition of vehicles. Equally important are driver education processes, including initial training, examination systems, and ongoing education, all of which influence driving habits and long-term safety outcomes [1].

Road safety is therefore a distinctly multidisciplinary domain. In addition to behavioural and organizational aspects, it encompasses road traffic enforcement, accident prevention strategies, emergency medical response, and transport psychology. As a result, effective RS management cannot rely on isolated measures, but requires an integrated perspective that simultaneously addresses human, technical, and environmental components of the transport system.

The issue of road safety has been widely examined in the scientific literature. Bibliometric analyses of knowledge indicate that the classic core of BRD research consists of: accident frequency analysis, driver behavior questionnaires, road injury studies, and the relationship between speed and accidents [2]. Within road injuries, five sub-areas have been identified: causes of accidents, methods of analysis, health and injuries, safety management, and general "traffic" [3]. More recent systematic reviews emphasize the growing role of data-driven methods (machine learning, deep learning) in risk prediction, integrating data on infrastructure, user behavior, and traffic conditions [4–6].

At the same time, increasing attention is being paid to human factors—personality, risky behavior, and risk perception—as predictors of accident rates [7]. Observational studies of road behavior (often using video recordings) are an important source of knowledge about real interactions in traffic, although they remain scattered and methodologically diverse [8]. The literature also features the "Safety-II" paradigm, which calls for the analysis not only of dangerous events, but also of "successful" interactions as an expression of system resilience [9].

In addition to empirical studies, comprehensive discussions of road safety can be found in textbooks and monographs. These works present conceptual foundations, methodological tools, and practical recommendations aimed at improving safety in road transport systems. Further empirical evidence is provided by statistical analyses of accident data [10]. In addition, statistics on the number of road accidents are also available from the Ministry of Road Transport and Highways report [11], and official national and international reports [12,13], which document accident trends, dominant risk factors, and the outcomes of preventive policies. Research devoted to the operational safety of vehicles and transport systems [14–17] also offers important insights into infrastructure design, vehicle engineering, and regulatory frameworks that support accident reduction.

The Pareto principle, also known as the 80/20 rule, indicates that a small number of causes account for most of the effects. Mathematical and statistical analyses show that this rule has a solid theoretical basis, including random distribution models, random variable products, and links to the Gaussian distribution and the Lorenz/Gini curve. In the context of occupational safety and accidents, the Pareto principle allows us to identify the "few key" factors that generate the greatest risks [18–20].

The literature is dominated by applications of Pareto analysis in the occupational safety sector, although this methodology is easily transferable to other types of accidents, including road accidents. For example, Górny uses it as a quality engineering tool to identify the main causes of accidents at work in Poland, based on data from the Central Statistical Office (GUS) for 2010–2013. This analysis allows preventive measures to be concentrated on a small group of key factors with limited resources [21].

Other studies combine Pareto analysis with the Ishikawa diagram to identify causes requiring immediate intervention, e.g., in the case of a forklift overturning [22]. The TOH (Technical-Organizational-Human) methodology, combined with Pareto-Lorenz analysis and ABC classification, makes it possible to identify the most significant causes of accidents involving construction scaffolding in Poland [23].

The Pareto principle is also used in the analysis of accidents involving cranes, allowing the identification of countries and groups of causes responsible for approximately 80% of injuries and fatalities, with Poland being one of the countries with a high proportion of fatal accidents. Similarly, in Vietnam, Pareto analysis showed that a small number of categories—traffic accidents, falls from height, and electric shocks—account for approximately 80% of fatal accidents at work, which is an important basis

for prioritizing safety policies [24].

In other industries, such as the cement industry, Pareto analysis also makes it possible to identify approximately 20% of the causes responsible for the majority of accidents and supports the design of corrective and preventive measures [25,26].

Taken together, the reviewed literature clearly indicates that road safety is a complex and multidimensional challenge. Effective improvement requires coordinated action across education, infrastructure development, vehicle technology, traffic management, and regulatory enforcement. A thorough understanding of these interdependencies is essential for designing targeted and efficient interventions. This perspective provides a strong justification for the application of analytical approaches, such as the Pareto principle, which can support the identification of dominant risk factors and the prioritization of actions within road traffic management in Poland.

# 3. Research Methodology

## 3.1. Data Sources

The analysis was based on official data on road safety in Poland in 2018–2024, provided by SEWIK [19]. The data included the total number of road incidents, including accidents, the number of people slightly and seriously injured, and fatalities. In addition, information was taken into account on:

- the day of the week on which the accident occurred,
- weather conditions,
- lighting conditions,
- type of incident,
- characteristics of the location of the incident (roadway, pedestrian crossing),
- road geometry (straight section, bend),
- presence of traffic lights,
- speed limit,
- area (built-up/unbuilt),
- causes attributable to drivers.

In total, data on 172,049 road accidents were collected during the analyzed period.

## 3.2. Analysis Methods

The data analysis was carried out in several stages:

- Analysis of time trends—changes in the number of accidents, injuries, and fatalities between 2018 and 2024 were determined, as well as percentage indicators such as the percentage of accidents among all road incidents and accident fatality rates.
- Analysis of accident causes—based on the collected data, the most common factors determining road accidents were identified, including the distribution of accidents by day of the week, weather conditions, type of incident, and driver behavior.
- Pareto analysis—the Pareto principle (80/20) was applied to identify the most important categories responsible for the highest number of accidents. For this purpose, the percentage share of individual categories and cumulative values was calculated, which allowed for the identification of priority areas requiring preventive measures.
- Presentation of results—the data was presented in tabular and descriptive form. Percentage indicators and cumulative values allowed for the unambiguous identification of the factors with the greatest impact on road safety.

## 3.3. Limitations of the Study

The analysis was based solely on official data, which may involve the risk of incomplete recording of all traffic incidents, especially those with less serious consequences. In addition, the Pareto analysis only took into account the main categories of accident causes, which may have limited the ability to identify less frequent but potentially significant factors.

## 3.4. System Methods Applied in the Study

Beyond statistical and Pareto-based analyses, the study incorporates a system-oriented perspective. Road safety was conceptualized as a socio-technical system, composed of interacting subsystems such as drivers, vehicles, road infrastructure, traffic organization, and environ-

mental conditions. The study examined both the structure of these subsystems and their interrelations using system analysis methods commonly applied in transport research. This included identifying key variables, dominant feedback loops, and critical components that shape overall system performance.

Within this systemic framework, Pareto analysis functioned as a tool to pinpoint the most influential subsystems—those whose improvement could yield the largest positive effect on overall road safety. Framing the analysis in this way strengthens the interpretative value of the results and situates the empirical findings within established system theories.

# 4. Results

## 4.1. RS Analysis for 2018–2024

Analysis of road safety data from 2018 to 2024 (**Table 1**) reveals a clear overall improvement. The total number of road incidents rose slightly from 468,063 in 2018 to 485,741 in 2019, before dropping sharply to 405,583 in 2020, likely due to traffic restrictions during the COVID-19 pandemic. In the years that followed, incidents increased gradually, reaching 411,167 in 2024, but still remained below pre-pandemic levels.

The number of accidents decreased from 31,674 in 2018 to 21,473 in 2024, representing an approximate 32% reduction. Minor injuries fell from 26,418 to 16,952, while serious injuries dropped from 10,941 to 7782. Fatalities also declined significantly, from 2862 to 1891, which corresponds to roughly a 34% decrease.

Percentage indicators further confirm this improvement. The share of accidents among all road incidents declined from 6.77% in 2018 to 5.22% in 2024. Meanwhile, the fatality rate per accident decreased slightly from 9.03% to 8.81%, suggesting modest gains in rescue efficiency and overall road safety. On average, each accident involved 0.80 minor injuries and 0.36 serious injuries, meaning that roughly 1.16 people were injured per incident.

Overall, these data point to a noticeable improvement in road safety in Poland over the analyzed period. The largest reductions in accidents, injuries, and fatalities occurred between 2020 and 2022, coinciding with the pandemic-related traffic restrictions. From 2023 to 2024, accident numbers and victim counts stabilized, possibly indicating that a minimum baseline level has been reached under the current infrastructure and road safety policies.

**Table 1.** RS analysis in Poland in 2018–2024.

| Years | Number of Incidents | Number of Accidents | Number of Accidents in Which People Were Slightly Injured | Number of Accidents in Which People Were Seriously Injured | Number of Accidents with Fatalities |
|---|---|---|---|---|---|
| 2018 | 468,063 | 31,674 | 26,418 | 10,941 | 2862 |
| 2019 | 485,741 | 30,288 | 24,844 | 10,633 | 2909 |
| 2020 | 405,583 | 23,540 | 17,658 | 8805 | 2491 |
| 2021 | 445,435 | 22,816 | 18,139 | 8276 | 2245 |
| 2022 | 383,588 | 21,322 | 17,202 | 7541 | 1896 |
| 2023 | 386,913 | 20,936 | 16,530 | 7594 | 1893 |
| 2024 | 411,167 | 21,473 | 16,952 | 7782 | 1891 |
| Total: | 2,986,490 | 172,049 | 137,743 | 61,572 | 16,187 |
| Mean | 426,641.4 | 24,578.43 | 19,677.57 | 8796 | 2312.429 |

## 4.2. Causes of Road Accidents

Between 2018 and 2024, Poland recorded a total of 172,049 road accidents. Analyzing this dataset allows the identification of key factors influencing accident occurrence. Looking at the distribution across days of the week, Fridays accounted for the highest share of accidents (16.57%), whereas Sundays had the lowest (11.06%). Other days showed a relatively uniform pattern, with accident shares fluctuating around 14–15% per day (**Table 2**). The analysis focused on categories exceeding 20,000 accidents over the period.

**Table 2.** Number of accidents by cause (2018–2024).

| Category | Number of Road Accidents | Share (%) |
|---|---|---|
| Total | 172,049 | 100.00% |
| Events by day of the week | | |
| Monday | 26,201 | 15.23% |
| Tuesday | 24,606 | 14.30% |
| Wednesday | 25,037 | 14.55% |
| Thursday | 25,038 | 14.55% |
| Friday | 28,501 | 16.57% |
| Saturday | 23,634 | 13.74% |
| Sunday | 19,032 | 11.06% |
| Events by weather conditions | | |
| Good weather conditions | 114,084 | 66.31% |
| Cloudy | 33,773 | 19.63% |
| Rainfall | 21,494 | 12.49% |
| Lighting conditions | | |
| Daylight | 122,608 | 71.26% |
| Night—a lit road | 24,393 | 14.18% |
| Events by province | | |
| Mazowieckie Province | 22,439 | 13.04% |
| Events by type | | |
| Side collision between vehicles | 54,735 | 31.81% |
| Rear-end collision between vehicles | 20,802 | 12.09% |
| Hitting a pedestrian | 37,504 | 21.80% |
| Characteristics of the scene | | |
| Roadway | 122,939 | 71.46% |
| Pedestrian crossing | 21,480 | 12.48% |
| Road geometry | | |
| Straight section | 92,393 | 53.70% |
| Traffic lights | | |
| None | 154,154 | 89.60% |
| Permissible speed | | |
| 50 | 106,947 | 62.16% |
| 90 | 31,178 | 18.12% |
| Built-up area | | |
| Built-up area | 120,930 | 70.29% |
| Unbuilt area | 51,119 | 29.71% |
| Reasons for drivers | | |
| Failure to yield the right of way | 40,664 | 23.64% |
| Failure to adjust speed to traffic conditions | 36,537 | 21.24% |

Weather conditions also played a notable role. Good weather conditions were defined as days without precipitation and with clear or partly cloudy skies. The majority of accidents (66.31%) occurred during good weather, 19.63% took place in cloudy conditions, and 12.49% happened during rain. This suggests that favorable weather does not eliminate the risk of accidents, which remain a significant safety concern.

Lighting conditions further revealed that most accidents (71.26%) occurred in daylight, while 14.18% happened at night on illuminated roads. These findings point to the importance of improving street lighting, particularly

in areas with heavy pedestrian activity.

Geographically, the Mazowieckie Province recorded the highest number of accidents, accounting for 13.04% of all incidents.

Regarding the type of incident, side collisions between vehicles were most frequent (31.81%), followed by collisions with pedestrians (21.80%) and rear-end collisions (12.09%). Most accidents occurred on the roadway itself (71.46%), while 12.48% were registered near pedestrian crossings.

Road geometry also influenced accident occurrence. Over half of all accidents (53.70%) happened on straight sections, and in most cases (89.60%), there were no traffic lights, indicating a potential impact of insufficient traffic control infrastructure on safety.

Speed limits were another contributing factor: 62.16% of accidents occurred on roads with a 50 km/h limit, and 18.12% on roads with a 90 km/h limit. Similarly, 70.29% of accidents took place in built-up areas, while 29.71% occurred outside urban zones.

Driver behavior remained a crucial determinant. The most frequent causes of accidents were failure to yield the right of way (23.64%) and speeding (21.24%). These results underscore the importance of compliance with traffic regulations and adjusting speed to road conditions in efforts to reduce accident numbers.

## 4.3. Pareto Analysis

To identify the key factors influencing the number of road accidents, a Pareto analysis was performed using data on days of the week, weather conditions, incident types, and driver-related causes.

The results confirm that a small number of categories account for a disproportionately large share of road incidents, in line with the Pareto principle (80/20). Specifically:

1. **Days of the week** (**Table 3**)**:** Fridays, Mondays, and Wednesdays together account for 46.35% of all accidents, highlighting a notably higher risk on these days.
2. **Weather conditions** (**Table 4**)**:** Most accidents (66.31%) occur during good weather, with 19.63% happening under cloudy conditions. This suggests that favorable weather does not eliminate risk and may be associated with overconfidence or lapses in driver attention.
3. **Type of incident** (**Table 5**)**:** Side collisions involving vehicles and collisions with pedestrians make up 53.61% of incidents, emphasizing the need for targeted traffic management and public education on pedestrian safety, especially at intersections.
4. **Driver-related causes** (**Table 6**)**:** Failure to yield the right of way (23.64%) and speeding (21.24%) together account for nearly half of all accidents, underlining the critical importance of adherence to traffic rules and speed management.

Concentrating preventive measures on the most critical days, the most common types of accidents, and the dominant driver-related causes can substantially reduce the number of road incidents. The analysis demonstrates that the Pareto principle is a practical and effective tool for identifying priority areas for intervention in road safety management.

**Table 3.** Events by day of the week.

| Day of the Week | Number of Accidents | % | Cumulative % |
|---|---|---|---|
| Friday | 28,501 | 16.57% | 16.57% |
| Monday | 26,201 | 15.23% | 31.80% |
| Wednesday | 25,037 | 14.55% | 46.35% |
| Thursday | 25,038 | 14.55% | 60.90% |
| Tuesday | 24,606 | 14.30% | 75.20% |
| Saturday | 23,634 | 13.74% | 88.94% |
| Sunday | 19,032 | 11.06% | 100% |

**Table 4.** Events by weather conditions.

| Conditions | Number of Accidents | % | Cumulative % |
|---|---|---|---|
| Good conditions | 114,084 | 66.31% | 66.31% |
| Cloudy | 33,773 | 19.63% | 85.94% |
| Rainfall | 21,494 | 12.49% | 98.43% |

**Table 5.** Events by type of accident.

| Type of Incident | Number of Accidents | % | Cumulative % |
|---|---|---|---|
| Side collision between vehicles | 54,735 | 31.81% | 31.81% |
| Hitting a pedestrian | 37,504 | 21.80% | 53.61% |
| Rear-end collision between vehicles | 20,802 | 12.09% | 65.70% |

**Table 6.** Reasons for drivers.

| Cause | Number of Accidents | % | Cumulative % |
|---|---|---|---|
| Failure to yield the right of way | 40,664 | 23.64% | 23.64% |
| Inappropriate speed | 36,537 | 21.24% | 44.88% |

Between 2018 and 2024, road safety in Poland showed a noticeable improvement. The total number of accidents decreased by roughly 32%, while fatalities fell by approximately 34%. The sharpest decline occurred during 2020–2022, coinciding with lower traffic volumes due to COVID-19 restrictions. After 2022, the numbers stabilized, suggesting that the current level of infrastructure and safety measures supports a baseline level of risk. The share of accidents among all traffic incidents dropped from 6.77% to 5.22%, and the fatality rate per accident decreased slightly from 9.03% to 8.81%, reflecting modest gains in both emergency response efficiency and overall road safety.

Analysis of the dataset revealed that most accidents occurred on Fridays, Mondays, and Wednesdays, which together accounted for 46.35% of all incidents. Interestingly, two-thirds of accidents happened during good weather, indicating that favorable conditions do not eliminate risk and may sometimes contribute to overconfidence or lapses in attention. Side collisions between vehicles and pedestrian accidents represented over half of all incidents, highlighting specific areas where preventive interventions could be most effective. Driver-related factors, particularly failure to yield and inappropriate speed, were responsible for nearly half of the total accidents, underscoring the continuing importance of adherence to traffic regulations.

Applying the Pareto principle to these results made it clear that a small number of factors dominate accident occurrence. This approach allows for the identification of priority areas where interventions can be most effective. By focusing preventive efforts on the critical days, high-risk incident types, and the main driver behaviors, road safety authorities could potentially achieve the greatest reductions in accidents with relatively limited resources.

# 5. Discussion

The observed decline in accidents and fatalities during the pandemic period highlights the strong influence of traffic intensity on road safety. The concentration of incidents on particular weekdays and in good weather conditions suggests that preventive measures should be strategically targeted rather than applied uniformly. From a system-level perspective, infrastructure, traffic organization, and driver behavior interact in complex ways, meaning that improvements in one component can produce significant benefits throughout the entire traffic system.

These findings also carry clear practical implications. Traffic enforcement and speed monitoring could be prioritized on Fridays, Mondays, and Wednesdays, especially on roads with the highest accident rates. Enhancing lighting and signage at pedestrian-heavy intersections may reduce collisions, while educational campaigns can emphasize the importance of yielding and adjusting speed to road conditions. Targeted interventions in these areas are likely to yield disproportionate improvements in overall road safety.

Combining the Pareto approach with a system-oriented perspective helps to identify leverage points where relatively small changes can produce substantial benefits. This dual approach highlights the most critical factors contributing to accidents and points to specific subsystems—such as driver behavior and traffic control measures—where policy adjustments or infrastructure improvements can have the greatest impact.

The results are consistent with previous studies conducted in Poland and across Europe, confirming that accidents tend to occur more frequently on specific weekdays and during favorable weather conditions. It is worth noting that minor incidents, which may not be fully captured in official databases, still represent important safety risks and should be considered when designing prevention strategies.

Finally, the study has certain limitations. Data from SEWIK may not include all minor accidents, which could slightly underestimate the total number of incidents. Future research could incorporate real-time traffic data, monitor driver behavior more closely, and explore the impact of emerging technologies, such as intelligent transport systems, to further enhance accident prevention strategies and support evidence-based road safety management. Future studies could explore the use of real-time traffic data and monitor driver behavior more closely, which would provide deeper insights into accident dynamics and support more timely and effective road safety interventions. These results provide a basis for targeted interventions, guiding authorities to focus on the most critical days, accident types, and driver behaviors. These findings can directly support strategic decision-making by Polish transport authorities and road safety agencies, allowing for evidence-based prioritization of preventive measures.

# 6. Conclusions

Analysis of road accident data in Poland from 2018 to 2024, combined with Pareto analysis, reveals several important insights. Overall, road safety has improved considerably during this period. The number of accidents, injuries, and fatalities decreased notably, particularly between 2020 and 2022, largely as a result of COVID-19-related traffic restrictions. In 2023 and 2024, the figures stabilized, suggesting that a baseline level of risk has been reached under the current infrastructure and safety measures.

The data show that a relatively small number of factors account for the majority of accidents. Key contributors include specific weekdays—Friday, Monday, and Wednesday—which together represent 46.35% of all incidents, good weather conditions (66.31% of accidents), side and pedestrian collisions (53.61%), and driver-related causes, such as failure to yield and inappropriate speed (44.88%). These findings highlight the persistent importance of driver behavior, even under favorable weather and with improved infrastructure, and underscore the need for targeted education, enforcement, and public awareness campaigns.

The application of the Pareto principle proved particularly useful in identifying the most influential factors. By concentrating interventions on these dominant causes, authorities can more effectively prioritize resources and reduce accidents. Practical measures should focus on high-risk days, areas with dense traffic, speed management, adequate intersection lighting, and continuous driver education, with special attention to behaviors that most frequently lead to accidents.

Finally, these results suggest several directions for future research. Incorporating real-time traffic data and monitoring driver behavior in greater detail could provide deeper insights into accident dynamics and allow for more timely and precise safety interventions. Such studies would not only improve predictive models but also support the development of targeted strategies aimed at preventing accidents before they occur. The integration of Pareto analysis with a systemic perspective offers a novel framework for prioritizing road safety interventions and optimizing resource allocation in Poland.

All research hypotheses were confirmed. The study demonstrated that few factors dominate accident occurrence (H1), that there has been a downward trend in accidents from 2018 to 2024 (H2), that high-risk days can be clearly identified (H3), that driver-related causes remain critical (H4), and that Pareto analysis is an effective tool for prioritizing interventions (H5).

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## Informed Consent Statement

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## Data Availability Statement

The research data is included in the article.

## Conflicts of Interest

The author declares no conflict of interest.

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