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Safety of Cyclists in Poland in the Context of European Road Traffic

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Abstract: The growing interest in cycling as a means of urban transport has led to an increased focus on cyclist safety as a key aspect of urban planning and transport policy. Simulation studies conducted by the International Transport Forum have demonstrated that reductions in CO_2 and other pollutants can be achieved in the context of urban transport, thus realising the goals of decarbonising road transport. The spread of modal transport in cities is a potential reality within the next decade. Bicycles play a significant role in this context. This article presents an analysis of data on accidents involving cyclists. National and international data were analysed to identify the main risk factors. The aim of the paper is to analyse the risk to cyclists with an attempt to identify and map the five biggest risks to cyclists in urban traffic. The aim of the research is to raise awareness of cyclist safety issues and to identify directions for further action to reduce accidents and improve overall road safety. The results of the conducted analyses indicate that the risk for cyclists in road traffic (including urban traffic) has been on a noticeable downward trend over the past five to ten years. This trend allows for the mapping of the most significant types/risks in cycling in urban environments, thereby enabling the implementation of risk management strategies based on the method of risk mapping.

Keywords: bicycle transport; risk; accident; road traffic

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1. Introduction

The development of urban mobility and the growing popularity of the bicycle as a means of transport emphasise the need to focus on the safety of cyclists. In the context of global changes such as the COVID-19 pandemic [1–3], which has significantly affected mobility patterns, cyclist safety is becoming a priority in urban planning and transport policy [4].

The problem of road traffic safety also concerns cyclists, who are fully fledged participants in this traffic [5]. Consequently, all types of road incidents involving cyclists are included in official statistics. However, not all incidents are recorded, as official data only cover incidents reported to law enforcement services (e.g., the police). Therefore, the statistics mainly cover road incidents of a serious or fatal nature. Cyclists are particularly vulnerable road users to the severe consequences of all traffic incidents involving them [6,7].

A number of studies have been conducted in this area, which address the issue of cyclists' safety [8–11]. Some are concerned about the behaviour of Polish children on their way to school and suggest that the present cycling education in schools, including Polish ones, is not sufficiently effective [12,13]. Other studies analyse the signposting of pedestrians and cyclists in terms of their safety in road traffic [14] and assess the implementation of cycling policy in Polish cities and the development of cycling infrastructure [15–17].

A noteworthy contribution to this field is a research study that examines procedures and measures designed to enhance the safety of cyclists in road traffic. The analyses conducted and the results presented demonstrate that the construction of infrastructure for cyclists is not the sole means of improving the safety of this group of road users. The study presents an analysis of measures and solutions aimed at improving cyclists' road safety. The research findings indicate that infrastructure development is not the sole factor enhancing safety. Rather, it encompasses the selection and assessment of safety devices, risk evaluation, and the choice of infrastructural investments. Additionally, the methods for implementing and monitoring safety initiatives are detailed, emphasising a multifaceted approach to managing the risks encountered by cyclists in urban areas [18,19].

This study examines the critical issue of cyclist safety within urban environments, in response to the increased reliance on bicycles as a primary mode of transportation. The primary aim of the paper is to analyse both national and international data on cycling accidents, identifying key risk factors that contribute to cyclist vulnerability. The objective of this study is to identify the top five risks that cyclists face in urban traffic and to develop a systematic approach to risk mapping that can be used to mitigate these dangers. Through this research, it is hoped that a significant contribution will be made to the ongoing conversation on cyclist safety and that practical, data-driven recommendations will be provided for reducing accident rates and enhancing overall road safety.

The importance of this study lies in its contribution to the growing body of knowledge on the safety of urban cyclists. As cities around the world seek to promote cycling as an environmentally friendly, efficient, and healthy mode of transport, it is of paramount importance to understand the factors that influence cyclist safety. This study provides empirical evidence that can influence policy decisions and urban planning strategies to create safer cycling environments. Consequently, this work not only advances academic understanding of cyclist safety, but also has practical implications for urban development and public health, and by extension, sustainable urban mobility.

2. Materials and Methods

This article presents an analysis of data on the safety of cyclists in Poland. It employs statistical summaries derived from various sources, including the ITF (International Transport Forum) and national statistical surveys. These include data from the Polish Road Safety Observatory, the police, and the ITS. The analysis is based on the determination of the level of risk for cyclists. This is achieved through the examination of statistics on road accidents involving cyclists, at both the national and European/world levels. A risk mapping of cycling in the city was also carried out, identifying the top five types/risks.

Statistical software and in-house scripts in Python were used to process and analyse the data, allowing detailed analysis of trends and comparisons between years and between Poland and other countries. The survey methodology was designed to allow other researchers to repeat the analysis and compare the results over other time periods.

This study employed the Statistical Package for the Social Sciences (SPSS) version 26.0, a software package renowned for its comprehensive array of statistical analysis tools. The decision to utilise SPSS was based on its user-friendly interface and extensive functionality.

To enhance the data analysis conducted in SPSS, bespoke Python scripts were developed utilising Python version 3.8. These scripts leveraged the robust Pandas libraries to manipulate the data.

The primary methodological approach of this study involved comparative analysis, chosen for its effectiveness in identifying and highlighting differences and trends across various datasets related to cyclist safety. This approach allowed for a direct comparison of accident rates, safety measures' impacts, and risk factors within and across different regions, thereby providing valuable insights into effective strategies for enhancing cyclist safety.

However, it is acknowledged that relying predominantly on comparative analysis may limit the depth and comprehensiveness of the investigation. This methodological focus may not fully capture the complex interplay of factors influencing cyclist safety or allow for a detailed exploration of causal mechanisms. To mitigate these limitations and provide a more holistic understanding of the issues at hand, future research could benefit from incorporating a broader array of analytical methods. Qualitative analyses, case studies, and statistical modelling could be employed to complement the comparative approach, offering deeper insights into the nuances of cyclist safety and the efficacy of various interventions.

Prior to the analysis proper, the collected data underwent a pre-processing procedure to ensure accuracy and reliability. This process involved several steps, including data cleaning, normalisation and categorisation. In addition, outlier detection methods were used to identify any data points that could potentially bias the analysis. This meticulous pre-processing ensured that the comparative analysis was based on high-quality, consistent data, thus enhancing the reliability and validity of the results.

3. Results

3.1. European and Global Perspective

In analysing the statistics, it is first necessary to illustrate the context, which can be achieved by referring to general traffic accident statistics. For this purpose, ITF data for the year 2020 were used [20]. It is important to note that these data also illustrate the impact of the COVID-19 pandemic and the temporary reduction in mobility that it caused. The first conclusion that can be drawn from the ITF data is that the pandemic-related restrictions on population movement had a noticeable impact. The total distance travelled by the population of each country in the world fell by an average of 12.2% year-on-year (y-o-y). One might therefore hypothesise that this is reflected in the number of fatal accidents. In this context, the term "year-over-year (y-o-y)" refers to the comparison of data or statistics for one year with those from the previous year.

In the context of the observed global downturn, data from IRTAD [21] indicated that the number of fatal accidents decreased by 8.6% in 2020 compared to the average of the years 2017–2019. Notably, in Poland, the decrease was even more pronounced, exceeding 13% for the same period. The data on a monthly basis demonstrate that the reduction in fatal accidents observed in the context of the 29-country average was manifested as a decline in the total number (averaged), without affecting the underlying trend. This reduction reflects a significant shift in traffic dynamics, potentially influenced by global events affecting mobility patterns. There was a divergence from the previous trend in Poland during the first three months, followed by a pronounced decline in accidents. This indicates a temporary divergence from the anticipated trend, which is expected to resume at the levels observed during the 2017–2019 period.

Figure 1 illustrates a clear downward trend in the number of fatal road accidents on a global scale, emphasising the notable reduction achieved in 2020. This visual representation contrasts with the previously cited data by focusing on the total number of road fatalities, thereby highlighting the progress made towards the United Nations and World Health Organization's Road Safety Initiatives goal of reducing fatal accidents by 50% from 2010 levels. The next decade of action under the follow-up of this initiative maintains this target.

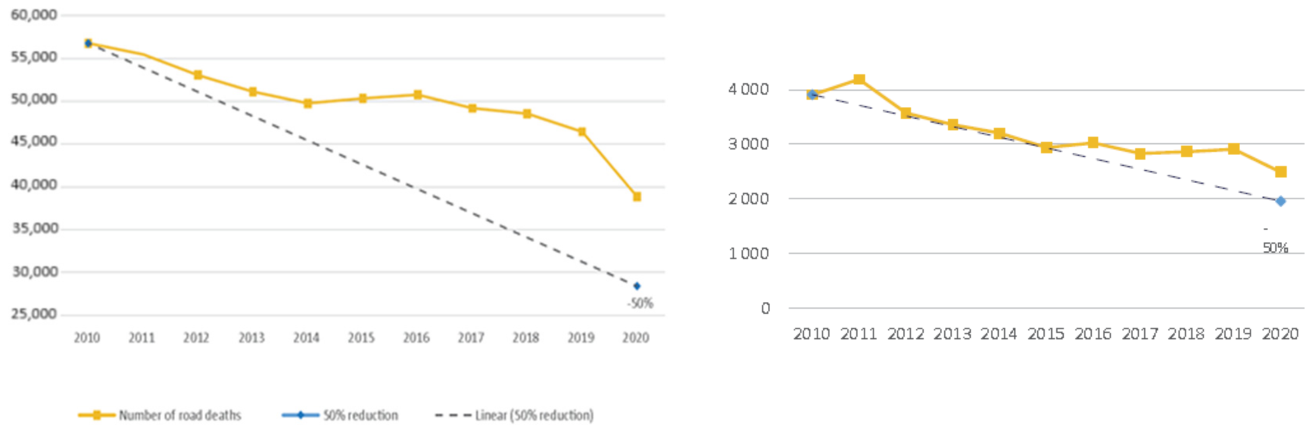

Figure 1. The total number of road fatalities—average for 29 countries (on the left) and Poland (on the right) in the context of a 50% reduction target.

Table 1 presents data indicating that the situation varied considerably from country to country. Furthermore, not all countries maintained relatively lower values of fatal road accidents recorded during the pandemic period. In light of these data, Poland emerges as a notable success story, maintaining its position among the top three countries with the greatest reduction in road accidents during the 2022/2021 and 2022/2020 periods.

Table 1. A summary of the number of fatal road traffic accidents in selected countries worldwide in the first and second quarters of 2022, 2021 and 2020.

Country	Jan–Jun 17–19 Average	Jan–Jun 2020	Jan–Jun 2021	Jan–Jun 2022	Percent Change 2022 over 2021	Percent Change 2022 over 2020	Percent Change 2022 over 17–19 Average
Austria	189	153	151	189	25.2%	23.5%	0%
Belgium	286	236	226	231	2.2%	−2.1%	−19%
Chile	811	801	751	929	23.7%	16.0%	15%
Czech Republic	265	250	220	247	12.3%	−1.2%	−7%
Denmark	84	68	46	62	34.8%	−8.8%	−26%
Finland	107	110	91	75	−17.6%	−31.8%	−30%
France	1557	1153	1253	1553	23.9%	34.7%	0%
Germany	1502	1290	1107	1267	14.5%	−1.8%	−16%
Greece	309	245	251	282	12.4%	15.1%	−9%
Hungary	267	171	207	216	4.3%	26.3%	−19%
Iceland	7	4	4	4	0.0%	0.0%	−43%
Israel	168	138	183	181	−1.1%	31.2%	8%
Japan	1869	1617	1442	1413	−2.0%	−12.6%	−24%
Lithuania	80	71	61	48	−21.3%	−32.4%	−40%
Luxembourg	13	10	6	13	116.7%	30.0%	0%
Netherlands	271	278	232	300	29.3%	7.9%	11%
New Zealand	192	145	173	186	7.5%	28.3%	−3%
Poland	1225	1087	983	891	−9.4%	−18.0%	−27%
Serbia	234	213	203	240	18.2%	12.7%	3%
Slovenia	51	45	48	51	6.3%	13.3%	0%
TOTAL	9488	8085	7638	8378	9.7%	3.6%	−12%

3.2. Poland in ITF Data

By accessing more cross-sectional data and covering the period 2010–2021, it becomes possible to better relate the data for Poland in relation to other EU countries or the world. Firstly, it should be noted that over the last 10 years, Poland has reduced the number of fatal accidents by 37.1%. Moreover, the cross-sectional data demonstrate that this is a consistent trend over the past 12 years, with no significant interruptions (Figure 2). Poland is therefore situated within a select group of countries (e.g., Italy, Japan, South Korea, or Belgium) that have demonstrated a gradual and sustained improvement in their statistics.

The orange bar represents the level that should be achieved to reduce by 50% the number of accidents by the end of the decade, counting from 2010. This value is 1954. In the context of IRTAD summary data, it is worth mentioning the reduction of fatal accidents in the youngest group: 0–14; 15–17 years, as shown in Figure 3. In the two aforementioned groups, a reduction in fatalities of 31% and 36%, respectively, was achieved over the period 2010–2019.

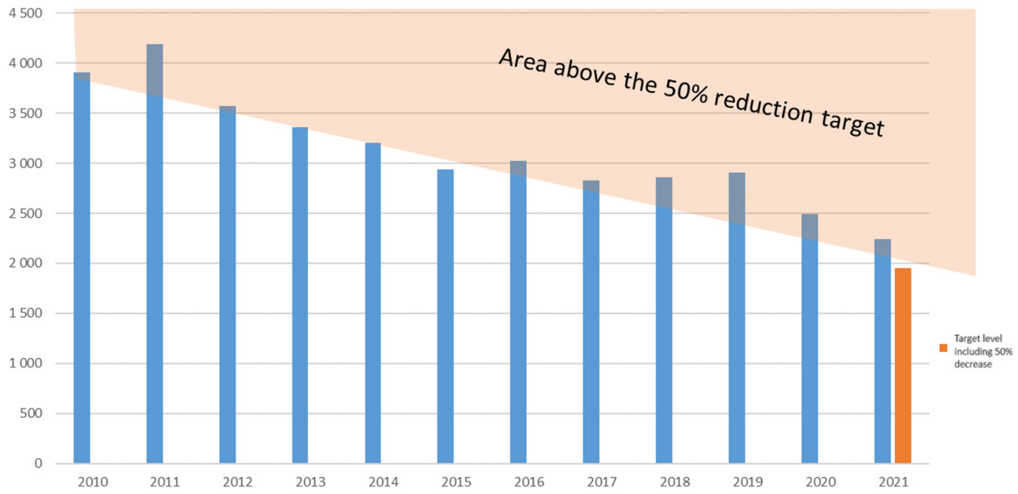

Figure 2. The number of fatal road accidents in Poland between the years 2010 and 2021.

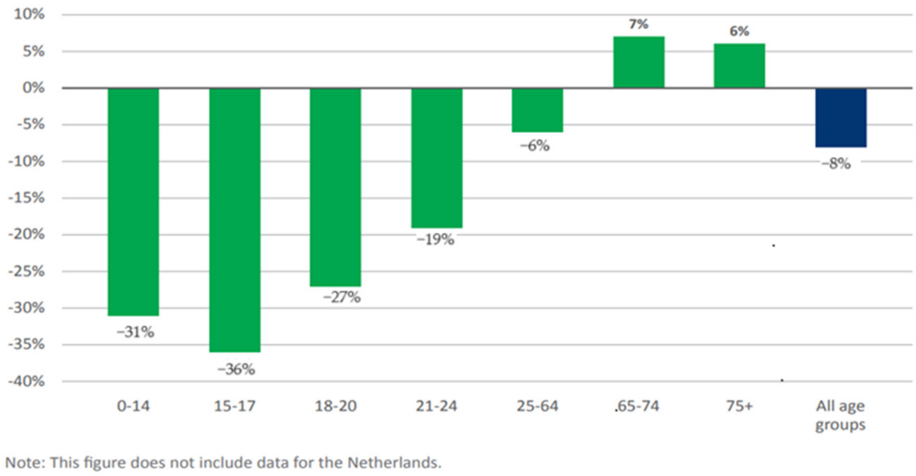

Figure 3. The changes in the number of fatal accidents in 2019 relative to 2010 stratified by age group.

In the context of Poland, the data from the International Transport Forum (ITF) indicate that there are still above-average numbers of fatal road accidents in the three age groups (18–20; 21–24 and 75+ years) (Figure 4).

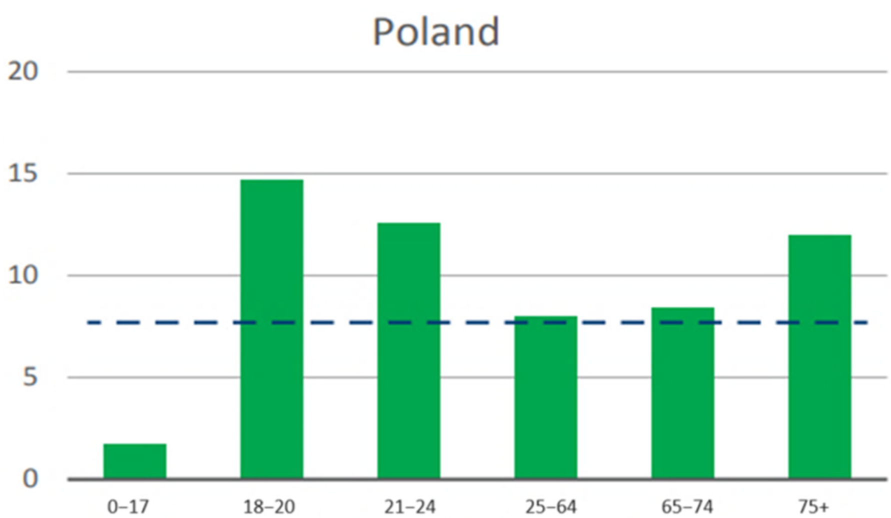

Figure 4. The number of fatal accidents in 2019 per 100,000 population stratified by age group.

A further crucial aspect of the ITF statistics is the categorisation of fatal accidents according to the type of road on which the incident leading to the fatality occurred (Figure 5).

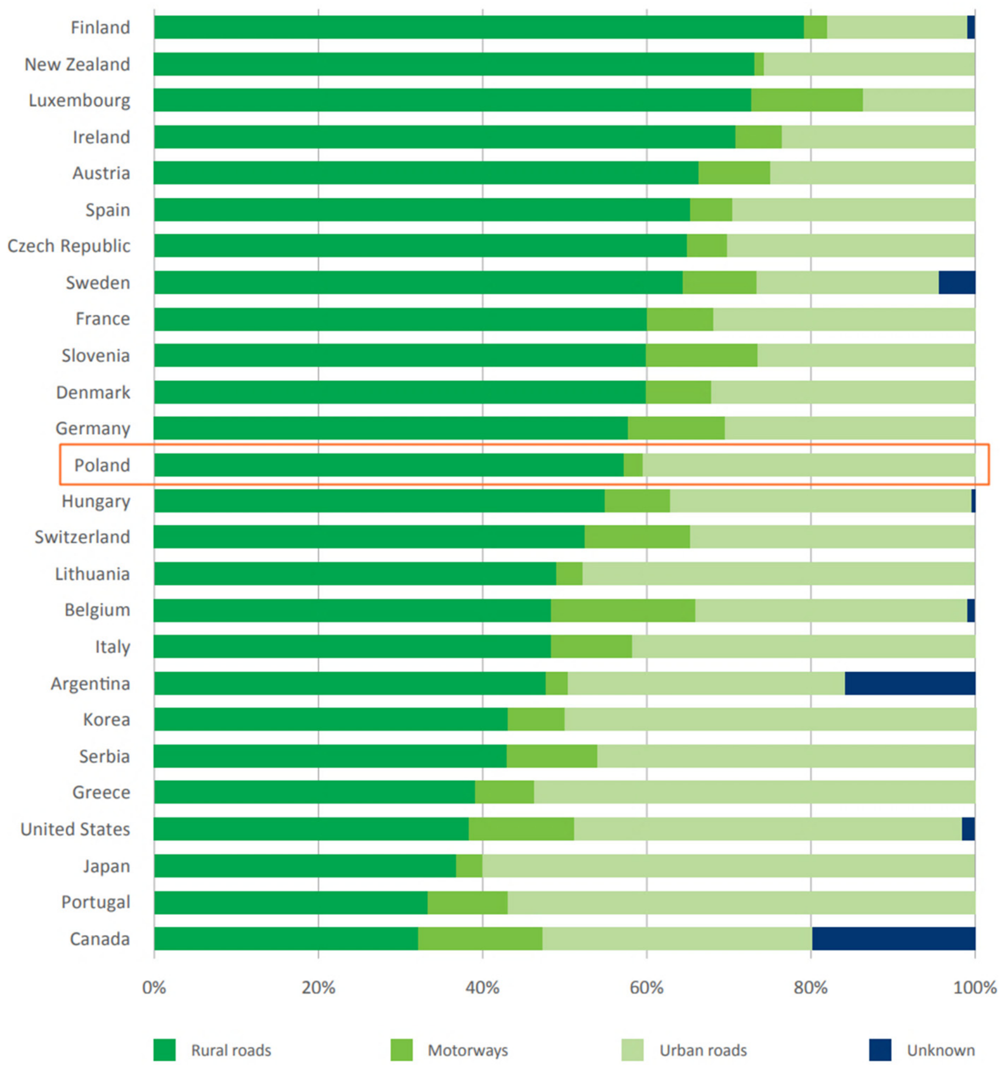

Figure 5. The structure of total fatal accidents in 2019, classified by road type.

In comparison to other countries, Poland does not exhibit a particularly high rate of fatal accidents. Approximately 60% of fatal accidents occur on roads classified as rural, which often lack the latest safety standards in terms of both infrastructure and road class. Conversely, just over 40% of remaining accidents occurred on urban roads, indicating that urban roads remain a significant risk environment for fatal accidents. The data show that this risk is lowest on motorways.

3.3. National Perspective

National road accident statistics demonstrate the structure of these incidents in terms of both the incidence of casualties and the degree of consequences resulting from these casualties (i.e., injured, seriously injured). Data for the years 2007–2021 are available for analysis, as shown in Table 2.

The national figures demonstrate an improvement in road safety, as evidenced by the ITF data. Furthermore, it can be observed that the proportion of fatalities relative to the total number of accidents remained below 10% (9.5% on average) during the period 2012–2019 and in 2021. In contrast, every accident resulted in at least one injury.

Table 2. Data on road accidents and their victims in Poland between 2007 and 2021.

Year	The Number of Accidents	The Number of Fatalities	The Number of Injured	The Number Seriously Injured	The Number of Collisions Reported to the Police	The Population at Risk (Killed per Million Residents)	The Motorisation Indicator (Number of Personal Cars per Thousand Residents)
2007	49,536	5583	63,224	16,053	356,768	146	383
2008	49,054	5437	62,097	16,042	362,946	143	422
2009	44,195	4572	56,047	13,689	371,081	120	432
2010	38,832	3907	48,953	11,491	416,080	101	447
2011	40,069	4189	49,506	12,585	366,585	109	470
2012	37,046	3571	45,792	12,049	339,581	93	486
2013	35,847	3357	44,059	11,672	355,918	87	504
2014	34,970	3202	42,545	11,696	348,007	83	520
2015	32,967	2938	39,778	11,200	362,265	76	539
2016	33,664	3026	40,766	12,078	406,622	79	558
2017	32,760	2831	39,466	11,103	436,458	74	586
2018	31,674	2862	37,359	10,941	436,389	75	610
2019	30,288	2909	35,477	10,633	455,454	76	635
2020	23,540	2491	26,463	8805	382,046	65	648
2021	22,816	2245	26,415	8276	N/A	N/A	N/A

The PRSO data [22] for the years 2010–2016 included the presentation of publicly available reports of road accident victim statistics by the type of area in which the incident occurred (Table 3). However, for the data for 2017 and subsequent years, the publication of such summaries has been discontinued. Consequently, these data can be presented as background information, as they are not comprehensive in terms of the temporal scope of the overall analysis.

Table 3. The number of accidents and their victims in Poland between 2010 and 2016, disaggregated by area.

Year	The Number of Accidents		The Number of Fatalities		The Number of Seriously Injured	
	Built-Up Area	Undeveloped Area	Built-Up Area	Undeveloped Area	Built-Up Area	Undeveloped Area
2010	27,835	10,997	1813	2095	7405	4086
2011	29,176	10,891	1959	2228	8452	4132
2012	27,056	9990	1652	1919	8226	3823
2013	26,078	9769	1581	1776	7854	3818
2014	25,368	9602	1466	1736	7946	3750
2015	23,658	9309	1248	1690	7562	3638
2016	23,869	9795	1275	1751	8000	4078

A review of the data indicates that the number of fatalities in built-up areas is, on average, 17% lower than in non-built-up areas. However, the likelihood of sustaining serious injuries is twice as high in built-up areas compared to non-built-up areas. The data indicate that while the risk of fatality in a traffic incident in an urban area is slightly lower than outside a built-up area, the risk of serious injury is twice as high.

The ITF report under discussion also provides a comparative analysis of the reduction in fatalities due to road accidents involving cyclists (Figure 6). A comparison of the 2010 data with the 2019 data reveals that Poland has also made progress in this area, with a decrease of less than 10%. This therefore aligns with the general trend observed in all countries included in the ITF report, with the averaged data indicating a reduction in cyclist fatalities of 7%.

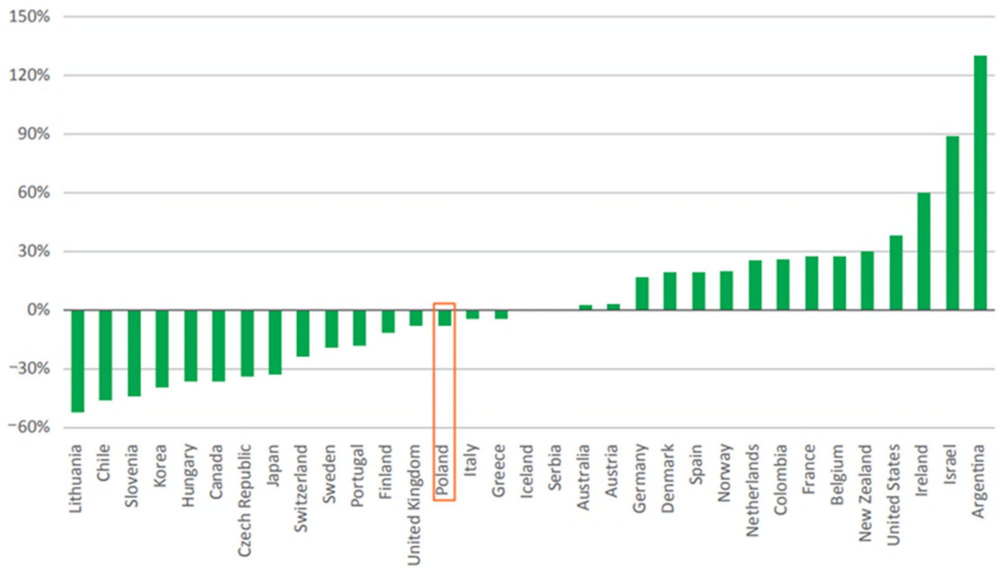

Figure 6. The changes in the number of fatal accidents involving cyclists in 2019 in comparison with those recorded in 2010.

3.4. Accidents Involving Cyclists

A review of EU statistics for 2021 (and 2010–2021 as a background) reveals a notable improvement in Poland in the context of accidents involving cyclists. Between 2018 and 2021, the number of fatalities as well as accidents in which cyclists were injured decreased significantly. This is evidenced by the data presented in the EU Road Safety Database [23]. In order to embed the above data on the number of fatalities in road accidents involving cyclists, one should refer to nthe ational data. As illustrated in Table 4, the number of fatalities resulting from road traffic accidents in Poland between 2010 and 2021, disaggregated by the type of participant involved, indicates a trend that warrants further analysis.

The referenced national data corroborate the observed trends in the context of EU data. Furthermore, they provide a more comprehensive context for the assessment of trends in the number of fatal accidents involving cyclists. It can be observed that, despite a decrease in the overall number of fatal accidents involving cyclists, their share in the total number of road accident fatalities in the period 2017–2020 was increasing (oscillating between 12% and 13%) in comparison with the period 2010–2011. In general, up to and including 2014, the share of cyclists in the group of road accident fatalities was at the level of less than 10%. In contrast, in 2015, it slightly exceeded 10%, remaining above 10% in the period 2017–2021. Consequently, two diverging trends can be observed. On the one hand, the number of fatal accidents (in terms of absolute number) is decreasing, yet their share in the total number of fatalities is increasing. This indicates that the dynamics of the decrease in fatalities in this group of road users is less pronounced than in the context of the other groups. Indeed, an analysis of the dynamics of changes in the number of fatalities in the period 2011–2021 revealed that the average dynamics of the decrease in the number of victims among cyclists was −2.7%. In the case of pedestrians, it amounted to −6.9%, while in the case of passenger cars, it was −5.7%. Table 5 presents a comprehensive analysis of accident fatalities in Poland from 2011 to 2021, categorised by type of participant, illustrating the evolution of these figures over the study period.

Table 4. The number of fatalities resulting from road traffic accidents in Poland between 2010 and 2021, disaggregated by the type of participant involved.

Year	Pedestrians	Car drivers	Passengers in Cars	HGV Drivers and Passengers	Cyclists		Mopeds	Motorbikes	Buses	Other Vehicles	Total
					Number	Share					
2010	1236	1125	728	142	280	7.2%	83	259	14	40	3907
2011	1408	1155	742	138	314	7.5%	87	292	12	41	4189
2012	1157	1025	590	104	300	8.4%	82	261	18	34	3571
2013	1140	871	577	90	306	9.1%	62	253	18	40	3357
2014	1116	869	477	92	286	8.9%	71	237	12	42	3202
2015	915	851	481	74	300	10.2%	65	208	14	30	2938
2016	868	863	554	114	271	9.0%	77	244	8	27	3026
2017	873	852	443	126	220	11.2%	55	231	3	28	1958
2018	803	848	443	119	285	13.8%	76	238	19	31	2059
2019	793	853	480	110	258	12.2%	87	295	10	23	2116
2020	631	789	373	104	249	13.4%	71	244	9	21	1860
2021	527	746	348	128	185	10.8%	54	215	11	31	1718

Table 5. Accident fatalities in Poland in 2011–2021 by type of participant—dynamics of change.

Year	Pedestrians	Car Drivers	Passengers in Cars	HGV Drivers and Passengers	Cyclists	Mopeds	Motorbikes	Buses	Other Vehicles
2011	13.9%	2.7%	1.9%	−2.8%	12.1%	4.6%	4.8%	12.7%	−14.3%
2012	−17.8%	−11.3%	−20.5%	−24.6%	−4.5%	12.1%	−5.7%	−10.6%	50.0%
2013	−1.5%	−15.0%	−2.2%	−13.5%	2.0%	8.5%	−24.4%	−3.1%	0.0%
2014	−2.1%	−0.2%	−17.3%	2.2%	−6.5%	−2.0%	14.5%	−6.3%	−33.3%
2015	−18.0%	−2.1%	0.8%	−19.6%	4.9%	14.3%	−8.5%	−12.2%	16.7%
2016	−5.1%	1.4%	15.2%	54.1%	−9.7%	−12.3%	18.5%	17.3%	−42.9%
2017	0.6%	−1.3%	−20.0%	10.5%	−18.8%	25.5%	−28.6%	−5.3%	−62.5%
2018	−8.0%	−0.5%	0.0%	−5.6%	29.5%	23.2%	38.2%	3.0%	533.3%
2019	−1.2%	0.6%	8.4%	−7.6%	−9.5%	−11.9%	14.5%	23.9%	−47.4%
2020	−20.4%	−7.5%	−22.3%	−5.5%	−3.5%	9.8%	−18.4%	−17.3%	−10.0%
2021	−16.5%	−5.4%	−6.7%	23.1%	−25.7%	−19.6%	−23.9%	−11.9%	22.2%
Average	−6.9%	−3.5%	−5.7%	1.0%	−2.7%	4.7%	−1.7%	−0.9%	37.4%

Thematic reports from the PRSO provide a more comprehensive understanding of the nature of road accidents involving cyclists. Therefore, it is beneficial to present these data in Table 6.

In the context of accidents involving cyclists in an unbuilt area, i.e., between towns and cities, approximately 11–15% of all accidents involving cyclists occur. It is noteworthy that their share in the total number of accidents involving cyclists generally fluctuates around 13%, periodically rising or falling below this figure. The period from 2010 to 2022 represents an exceptional case, with the number of accidents in undeveloped areas involving cyclists constituting only 11.8% of all incidents of this type.

Table 6. The number of accidents involving cyclists in total and in unbuilt areas, classified according to the type of victim.

Year	Total			Undeveloped Area					
	Accidents	Killed	Seriously Injured	Accidents	% of Total **	Killed	% of Total **	Seriously Injured	% of Total **
2012	4624	300	1205	697	15.1%	136	45.3%	187	15.5%
2013	4690	306	1288	700	14.9%	125	40.8%	211	16.4%
2014	4806	286	1399	667	13.9%	138	48.3%	221	15.8%
2015	4611	300	1341	618	13.4%	126	42.0%	200	14.9%
2016	4737	271	1488	662	14.0%	119	43.9%	218	14.7%
2017	4212	220	1214	567	13.5%	100	45.5%	174	14.3%
2018	4713	285	1442	627	13.3%	131	46.0%	186	12.9%
2019	4426	258	1371	615	13.9%	123	47.7%	212	15.5%
2020	3768	249	1242	536	14.2%	105	42.2%	184	14.8%
2021	3513	185	1108	457	13.0%	95	51.4%	129	11.6%
2022	3688	170	1132	435	11.8%	81	47.6%	141	12.5%

** % of total road accidents involving cyclists, % of total fatalities, and serious injuries in accidents involving cyclists in a given year.

In contrast, the situation in built-up areas differs slightly. These include not only towns and cities but also smaller settlements not officially recognised as cities. It can be observed that accidents in built-up areas account for approximately 85–86% of all accidents involving cyclists. This may be attributed to the fact that cycling is frequently utilised for short distances and often in an urban environment. Consequently, the density of cyclists in built-up areas within urban traffic is likely to be higher, which is reflected in the aforementioned statistics. Table 7 presents a breakdown of the number of accidents involving cyclists, both overall and within built-up areas, categorised according to the type of victim. This provides a comparative perspective on the incidence rates.

In summary, the evidence indicates that a cyclist in an urban environment is statistically more likely to be involved in a road traffic incident than if they were cycling outside the city. Furthermore, crashes in built-up areas account for more than half of all fatalities. This trend remains unchanged throughout the analysis period. In addition, in the context of seriously injured people, accidents in built-up areas account for more than 85% of all incidents with casualties of this type. Similarly, no discernible shifts can be observed over the course of the analysis period, as illustrated in Table 8. On a promising note, however, between 2021 and 2022, the number of cyclists killed and seriously injured in crashes in built-up areas declined, and a notable milestone was surpassed (killed—two-digit number; seriously injured—three-digit number).

The data from the Police Headquarters and the ITS are sufficiently detailed to permit an analysis of accidents involving cyclists only in urban areas, which is of significance to this study. This is presented in Table 9. The data show that accidents involving cyclists in cities account for almost 80% of all accidents involving them in built-up areas. Therefore, this confirms the earlier conclusion. Furthermore, an upward trend can be observed. Between 2012 and 2022, there was a notable increase in the proportion of cycling accidents that occurred within city boundaries as part of the total incidents. This evidence suggests that cycling traffic and thus the number of accidents involving cyclists is clearly concentrated in cities.

Table 7. The number of accidents involving cyclists in total and in built-up areas, classified according to the type of victim.

Year	Total			Built-Up Area *					
	Accidents	Killed	Seriously Injured	Accidents	% of Total **	Killed	% of Total **	Seriously Injured	% of Total **
2012	4624	300	1205	3927	84.9%	164	54.7%	1018	84.5%
2013	4690	306	1288	3990	85.1%	181	59.2%	1077	83.6%
2014	4806	286	1399	4139	86.1%	148	51.7%	1178	84.2%
2015	4611	300	1341	3993	86.6%	174	58.0%	1141	85.1%
2016	4737	271	1488	4075	86.0%	152	56.1%	1270	85.3%
2017	4212	220	1214	3645	86.5%	120	54.5%	1040	85.7%
2018	4713	285	1442	4086	86.7%	154	54.0%	1256	87.1%
2019	4426	258	1371	3811	86.1%	135	52.3%	1159	84.5%
2020	3768	249	1242	3232	85.8%	144	57.8%	1058	85.2%
2021	3513	185	1108	3056	87.0%	90	48.6%	979	88.4%
2022	3688	170	1132	3253	88.2%	89	52.4%	991	87.5%

* Note: the built-up area should not be confused with a city. The built-up area can be found in non-urban settlements. ** % of total road accidents involving cyclists, % of total fatalities, and serious injuries in accidents involving cyclists in a given year.

Table 8. Data on accidents involving cyclists in built-up areas in Polish cities between the years 2012 and 2022.

Year	Accidents			Killed			Seriously Injured		
	Number	% of Total *	% of Total in Built-Up Areas **	Number	% of Total *	% of Total in Built-Up Areas **	Number	% of Total *	% of Total in Built-Up Areas **
2012	2872	62.1%	73.1%	80	26.7%	48.8%	704	58.4%	69.2%
2013	2983	63.6%	74.8%	100	32.7%	55.2%	780	60.6%	72.4%
2014	3162	65.8%	76.4%	79	27.6%	53.4%	870	62.2%	73.9%
2015	3095	67.1%	77.5%	87	29.0%	50.0%	867	64.7%	76.0%
2016	3133	66.1%	76.9%	82	30.3%	53.9%	943	63.4%	74.3%
2017	2805	66.6%	77.0%	53	24.1%	44.2%	790	65.1%	76.0%
2018	3196	67.8%	78.2%	77	27.0%	50.0%	978	67.8%	77.9%
2019	3018	68.2%	79.2%	60	23.3%	44.4%	919	67.0%	79.3%
2020	2482	65.9%	76.8%	66	26.5%	45.8%	820	66.0%	77.5%
2021	2415	68.7%	79.0%	39	21.1%	43.3%	783	70.7%	80.0%
2022	2598	70.4%	79.9%	51	30.0%	57.3%	459	40.5%	46.3%

* Note: the built-up area should not be confused with a city. The built-up area can be found in non-urban settlements. ** % of total road accidents involving cyclists, % of total fatalities, and serious injuries in accidents involving cyclists in a given year.

Table 9. Data on accidents involving cyclists in the city in places intended for bicycles (road cycling infrastructure) in the period 2016–2022.

Year	Accidents		Killed		Seriously Injured	
	Number	% of Total in Cities **	Number	% of Total in Cities **	Number	% of Total in Cities **
2016	343	10.9%	3	3.7%	111	11.8%
2017	306	10.9%	2	3.8%	97	12.3%
2018	326	10.2%	3	3.9%	118	12.1%
2019	327	10.8%	1	1.7%	114	12.4%
2020	331	13.3%	3	4.5%	124	15.1%
2021	340	14.1%	3	7.7%	126	16.1%
2022	407	15.7%	3	5.9%	114	24.8%

** % of total road accidents involving cyclists in cities; % of total fatalities and serious injuries in accidents involving cyclists in cities in a given year.

Furthermore, the data reveal a concerning trend: the proportion of accidents involving cyclists in urban areas resulting in the death of a cyclist has increased from 48.8% in 2012 to 57.3% in 2022. This represents a significant rise in the number of fatalities among cyclists in urban areas. In terms of the total number of people killed in accidents involving cyclists, this increase is also visible, rising from 26.7% (in 2012) to 30% (in 2022). It should be noted that, in urban areas, the number of cyclists killed is nominally decreasing, reaching 51 in 2022.

In the context of seriously injured cyclists, the number of cyclists involved in urban accidents is variable and oscillates in the range of 800–900. This is still a considerable number; however, in relation to the total number of accidents involving cyclists, there is a clear decrease in their share. In 2012, 58.4% of seriously injured cyclists were involved in an accident within the city. Conversely, in 2022, only 40.5% were involved. This translates into a decrease in the proportion of seriously injured cyclists involved in an accident within the city to the total number of cyclists with the same type of injury involved in a road traffic incident in a built-up area. In 2012, this was 96.2%, and in 2022, it was only 46.3%. The data indicate that incidents involving cyclists within the city are slightly more likely to result in serious injury than death in the context of all accidents involving cyclists. However, when only the built-up area is considered, the probability of losing a life on a bicycle is higher in urban areas. Consequently, the issue of urban cyclist safety is of particular importance.

Since 2016, more detailed data on the locations of accidents involving bicycles in cities have been collected in the Accident and Collision Register System database. This provides the opportunity to analyse the described accidents in terms of factors related to the environment in which the traffic incident took place, as shown in Tables 9–11.

Table 10 presents data on accidents involving cyclists in urban areas at sites not specifically designated for bicycles, including pavements and pedestrian roads. The data spans from 2016 to 2022.

Table 11 presents data concerning incidents involving cyclists in the city at locations not allocated for bicycle use, specifically pedestrian crossings, for the years 2016 to 2022.

The statistics presented cover approximately 55% of all accidents involving cyclists in cities. This includes 55% of all cyclists who lost their lives and 85% of cyclists who were seriously injured. Therefore, they provide a general overview of the situation.

Figure 7 illustrates that the majority of incidents involving cyclists in urban areas occur outside dedicated infrastructure for bicycles or pedestrians. This suggests that a cyclist riding on a road alongside cars is more likely to be involved in an accident than if they were using dedicated cycling infrastructure. The data also indicate that the highest percentage of accidents involving cyclists at designated cycling locations occurs at level crossings, which represent points of contact with car traffic.

Table 10. Data on accidents involving cyclists in the city in places not designated for bicycles—pavements, and pedestrian roads from 2016 to 2022.

Year	Accidents		Killed		Seriously Injured	
	Number	% of Total in Cities *	Number	% of Total in Cities *	Number	% of Total in Cities *
2016	262	8.4%	2	2.4%	44	4.7%
2017	249	8.9%	1	1.9%	50	6.3%
2018	312	9.8%	1	1.3%	73	7.5%
2019	264	8.7%	1	1.7%	54	5.9%
2020	227	9.1%	4	6.1%	61	7.4%
2021	243	10.1%	1	2.6%	54	6.9%
2022	244	9.4%	1	2.0%	50	10.9%

* % of total road accidents involving cyclists in cities; % of total fatalities and serious injuries in accidents involving cyclists in cities in a given year.

Table 11. Data on accidents involving cyclists in the city in places not designated for bicycles—pedestrian crossings from 2016 to 2022.

Year	Accidents		Killed		Seriously Injured	
	Number	% of Total in Cities *	Number	% of Total in Cities *	Number	% of Total in Cities *
2016	220	7.0%	10	12.2%	67	7.1%
2017	221	7.9%	7	13.2%	52	6.6%
2018	224	7.0%	9	11.7%	60	6.1%
2019	214	7.1%	10	16.7%	47	5.1%
2020	151	6.1%	12	18.2%	47	5.7%
2021	190	7.9%	5	12.8%	58	7.4%
2022	167	6.4%	12	23.5%	48	10.5%

* % of total road accidents involving cyclists in cities; % of total fatalities and serious injuries in accidents involving cyclists in cities in a given year.

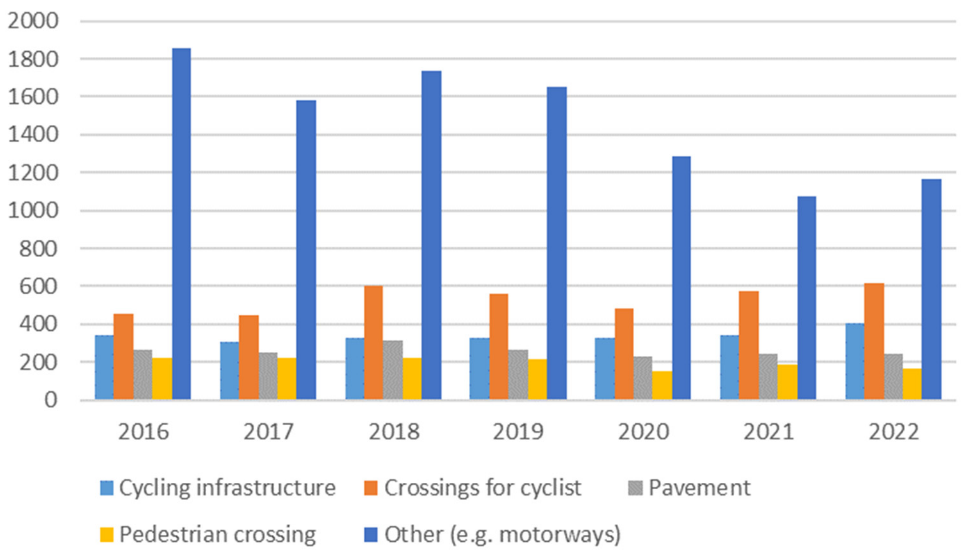

Figure 7. The number of accidents involving cyclists in urban areas between 2016 and 2022, with the data broken down by location.

Figure 8 presents a temporal analysis of fatal accidents involving cyclists in urban areas from 2016 to 2022. The data is segmented by location to provide a nuanced understanding of the geographical distribution of these incidents.

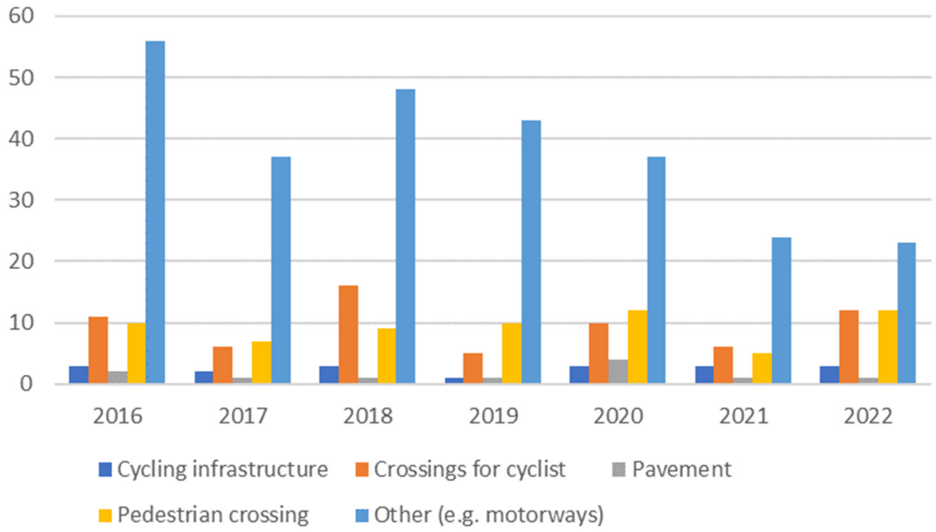

Figure 8. The number of fatal accidents involving cyclists in urban areas between 2016 and 2022, with the data broken down by location.

In the context of urban cyclist fatalities, it is evident that the majority of fatalities occur in locations that are not specifically designed for cycling or pedestrians. Once again, the highest number of cyclists are killed at cycle crossings and pedestrian crossings. This corroborates the earlier conclusion that the most dangerous places for cyclists are the points of contact with car traffic. Figure 9 presents a temporal analysis of the incidence of accidents with serious injuries involving cyclists within urban settings from 2016 to 2022. The data is disaggregated by specific locations to identify areas of higher risk.

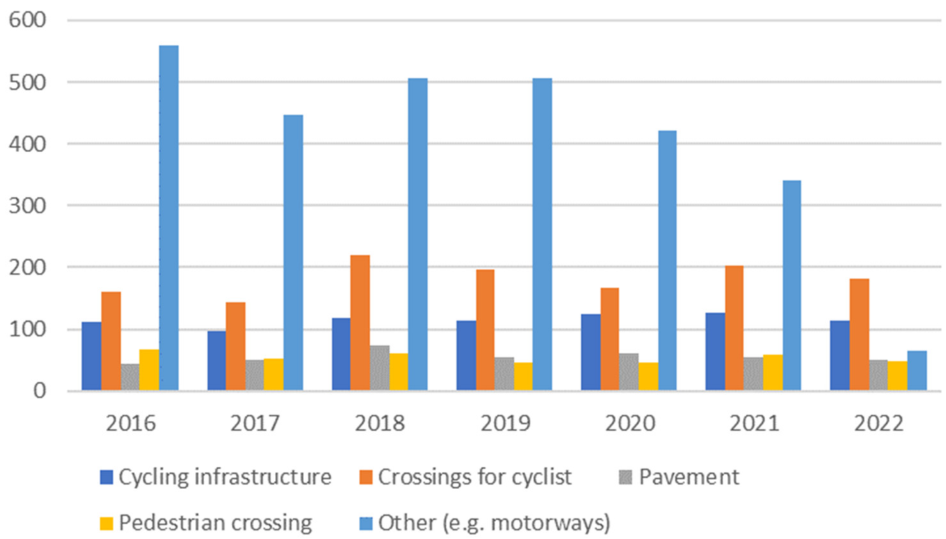

Figure 9. The number of accidents with serious injuries involving cyclists in urban areas between 2016 and 2022, with the data broken down by location.

In the context of seriously injured cyclists, apart from confirming the earlier observations and conclusions, another interesting observation may be formulated. It turns out that among cyclists using cycling or pedestrian infrastructure (which in principle should not be the case when dedicated infrastructure is available), it is the cycling infrastructure that is the site of more accidents than, for example, pedestrian pavements. Of course, it is still third in terms of accidents throughout the analysis period.

3.5. Assessment of the Safety of Cyclists in Road Traffic—An Attempt to Identify the Elements Influencing the Risk

The issue of assessing the risk factors for cyclists in urban road traffic is largely constrained by the paucity of reliable and comprehensive data, which impedes the accurate identification of the extent of risk associated with specific types of injuries or accidents. While statistical data on accidents provide some insight into the identification of risks, the challenge persists in determining the actual scale of these risks in relation to the volume of cycling traffic [24]. The issue of accessing data that can be used to determine the actual level of threats posed by specific risks in relation to the type of cycling infrastructure and the points at which it is located in the city is a concern that has been highlighted by numerous researchers [25,26]. Nevertheless, a number of initiatives have been undertaken in individual cities to record and collect data with greater precision in this regard. These data allow, for example, the identification of cyclist accident risk exposures at specific times of day, week, and location in the city [27]. The benefit of such studies is the identification of so-called "hot spots" in a city's road infrastructure. This is extremely important information for designers of infrastructure and traffic in the city. From the perspective of cycling, this tool is invaluable in enhancing the safety of cyclists in urban areas.

Other studies on cycling and pedestrian safety in cities have demonstrated the non-linearity of risk for cyclists and pedestrians in urban environments. It has been found that the greater the number of pedestrians and cyclists in a given area, the lower the risk of them being involved in a traffic accident [28]. Conversely, the greater the number of cars on the road, the higher the risk of being involved in a traffic accident. The results of these studies provide one of the most compelling arguments in favour of reducing car traffic and in favour of cycling in towns and cities or their surrounding areas.

It is a challenging task to identify, review, and analyse the risks involved in cycling in an urban environment. There are numerous approaches to identifying and managing risks, which can be successfully applied to transport. Furthermore, risk factors in cycling can be sought in a multitude of areas. One such factor is the emotional state of the cyclist, which was taken into account in one of the studies conducted in Finland [29]. However, the majority of studies focus on infrastructure elements such as intersections [30]. In the context of this study, such an approach is not optimal, as the objective is not to analyse individual infrastructure elements and their relationship with the risk of an accident for the cyclist. This area has already been extensively studied in numerous cities worldwide, and it is more beneficial to examine the problem from a different perspective.

The perspective of the cyclist as a vehicle and road user has been adopted, which means that the process of identification and review of the most important road traffic risks for cyclists will include factors from several areas. These factors originate from both elements of the environment and the behaviour of other road users and can be identified from an analysis of the causes of accidents and the typical sources/causes of these risks, as shown in Table 12.

Table 12. A summary of the most frequent causes of danger and risk for cyclists in urban traffic.

1. Cyclists—behaviour			
1.1	No warm-up	1.11	Drunk driving
1.2	Poor preparation for cycling (physical/psychological)	1.12	Ignoring signs
1.3	Fatigue while driving—loss of pace and concentration	1.13	Overestimating one's abilities
1.4	Use of headphones while driving	1.14	Riding above ability
1.5	Using the phone while driving	1.15	Poor driving technique (poor skills)

Table 12. *Cont.*

	1. Cyclists—behaviour		
1.6	Distraction	1.16	None/Low traffic experience
1.7	Lack of concentration and attention to surroundings	1.17	None/Low experience of driving on dedicated infrastructure
1.8	Cyclists breaking the rules (speeding)	1.18	Unplanned route (unpredictable behaviour, becoming lost)
1.9	Cyclists who do not know the rules	1.19	Loss of control of the bicycle
1.10	Breaking the rules	1.20	Failure to maintain the distance
	2. Interaction with other users		
2.1	Aggression on the road—pedestrian	2.7	Unpredictable behaviour of cyclists
2.2	Aggression on the road—cyclist	2.8	Unpredictable behaviour of pedestrians
2.3	Aggression on the road—cars	2.9	Unpredictable behaviour of drivers
2.4	Driving against the flow	2.10	Riding kick scooters and motor scooters on the cycle path
2.5	Driving against traffic	2.11	Parked vehicles on the cycle path/cycle lane
2.6	Sudden braking or stopping		
	3. Technical cyclists		
3.1	Ill-fitting bicycle	3.5	Lack of cycle lighting
3.2	No helmet	3.6	Bicycle out of order
3.3	No protectors	3.7	Inappropriate dress (being invisible)
3.4	No bell	3.8	Improper transportation of belongings
	4. Environment		
4.1	Obstructions at the roadside	4.8	Poor visibility (surrounding elements obscure)
4.2	Badly parked vehicles	4.9	Poorly marked junctions and crossings
4.3	Getting out of the driver's seat (door)	4.10	Poor lighting of cycle routes and junctions
4.4	Air pollution	4.11	Lack of traffic lights for cyclists
4.5	Road pollution	4.12	Railway and tramway crossings poorly secured
4.6	Potholes	4.13	Lack of cycle routes
4.7	Pavement in poor condition	4.14	Strong gusts of wind
		4.15	Slippery surface

The above compilation is a synthesis of findings from scientific and popular articles pertaining to road safety for cyclists, the safety of cyclists as users of vehicles, and the safety of cyclists as athletes [9,31–45]. It encompasses a diverse array of incidents that can pose risks to cyclists. These incidents are grouped into four main categories. Cyclist behavior: this category encompasses situations and risks created by cyclists themselves, through their actions, omissions, or disregard. These behaviours create direct risks for the cyclists themselves as well as for other road users and contribute to the increase in the probability of an accident. Interactions with other users are also a significant factor in the occurrence of accidents. These are actions of cyclists themselves, as well as of other road and cycling/walking users, which are the sources of the aforementioned risks that may result in accidents with varying degrees of harm to the cyclist or other participants of the event. Technical cyclists may be defined as individuals who engage in risky behaviours connected with the technical equipment or condition of their bikes or the way they are used. These behaviours may include deficiencies in certain elements of equipment. These factors may directly contribute to the creation of dangerous situations or even be the cause of an accident with serious consequences. The surrounding environment is a further factor that can influence the safety of cycling in urban areas. This encompasses the condition of infrastructure, its layout, maintenance, and other elements that may affect the safety of cyclists.

A critical analysis of the aforementioned groups allows for the identification of five principal types of threats (risks) that may be encountered in the context of urban cycling. These include the following:

- Car crash.
- Bicycle collision.
- Collision with a pedestrian.
- Collision with a tram.
- Fall/loss of bike control.

Each of the types of risk identified is a kind of aggregate of the factors/events presented in Table 12. Consequently, the summary presented above is also characterised by a certain degree of subjectivity on the part of the author.

In order to map the aforementioned top ten risks to cyclists in urban traffic, the well-known Risc-Score method, which is used to assess risks in the work environment as part of a risk assessment, was employed [46,47]. This method allows the creation of a risk map, which is the basis for risk management in the workplace. This method has been successfully used since 1971, when it was developed for the US Navy [48]. The method is inherently subject to uncertainty due to the randomness of events and the consequences of traffic accidents [49]. It is a qualitative method based on the product of three factors. The following equation (Equation (1)) applies to the analysis:

$$R = S \times E \times P \tag{1}$$

where:

R—estimated risk;
S—the value of the possible consequences of the event;
E—hazard exposure time;
P—probability of occurrence of the event.

In the context of our study, Equation (1) illustrates the method used to calculate the risk exposure of cyclists in urban environments, incorporating factors such as traffic density, average speed, and the proportion of bicycle lanes in the total road network.

Table 13 shows the limit values for the individual parameters, with adjusted threshold parameters for these values. This is the author's adaptation of the method, which enables its application to risk assessment in urban traffic for cyclists.

Table 13. The S,E,P parameter values and an interpretation of estimated risk in the modified Risc-Score method.

S-Value	Losses	Description of Losses		
		Human Losses		Material Damage
100	A major disaster	Several fatalities		Above PLN 500,000
40	Catastrophic	Casualty		PLN 100,000–PLN 500,000
15	Very large	Serious injury		10,000–100,000 million
7	Large	Light bodily injury		PLN 1000–10,000
3	Medium	Provision of first aid		PLN 600–PLN 1000
1	Small	Abrasions, contusions		up to PLN 500
E-value	Frequency of exposure	*p*-value	Description of probability	Chance [%]
10	Constant (every hour)	10	Very likely	50
6	Frequent (daily)	6	Quite possibly	10
3	Occasional (once a week)	3	Unlikely, but possible	1

Table 13. *Cont.*

S-Value	Losses	Description of Losses		
		Human Losses		Material Damage
2	Occasional (once a month)	1	Only occasionally possible	0.1
1	Minimal (several times a year)	0.5	Conceivable	0.01
0.5	Negligible (once a year)	0.2	Virtually impossible	0.001
		0.1	Only theoretically possible	0.0001
Risk category	Risk value *R*	Description of actions following risk categorisation		
Acceptable	≤0	It is recommended to control the risk so that the risk remains at the current level		
Small	21–70	Risk control required		
Relevant	71–200	Improved conditions are required		
Large	201–400	Immediate improvement of conditions is required		
Very large	>400	Work involving risk must be stopped		

In the context of modifying the Risc-Score method and applying it to the risks for cyclists in urban road traffic, it is worth recalling the statistics of accidents involving cyclists, taking into account the place of the accident (Table 14). These data are presented as a relation to the total of a given type of accident.

Table 14. Proportion of accidents involving cyclists in the city by location of accident and consequences in 2020–2022.

	Cycling Infrastructure			Crossings for Cyclists		
	Total accidents	Killed	Seriously injured	Total accidents	Killed	Seriously injured
2020	48.1%	43.9%	48.7%	19.6%	15.2%	20.4%
2021	55.7%	38.5%	56.3%	23.6%	15.4%	25.9%
2022	55.1%	54.9%	85.6%	23.6%	23.5%	39.4%
	Pavement			Pedestrian crossing		
	Total accidents	Killed	Seriously injured	Total accidents	Killed	Seriously injured
2020	9.1%	6.1%	7.4%	6.1%	18.2%	5.7%
2021	10.1%	2.6%	6.9%	7.9%	12.8%	7.4%
2022	9.4%	2.0%	10.9%	6.4%	23.5%	10.5%
	Other (e.g., motorways)					
	Total accidents	Killed	Seriously injured			
2020	51.9%	56.1%	51.3%			
2021	44.3%	61.5%	43.7%			
2022	44.9%	45.1%	14.4%			

Firstly, it is evident that a considerable proportion of accidents and fatal accidents involving cyclists occurred on roads designed for motor traffic. Consequently, the risk to cyclists on such roads is considerable. The probability of a tragic incident occurring on a road for cars is high, and the chance of the cyclist suffering serious injuries is also high. An accident with the highest probability of a cyclist sustaining serious injuries is most likely to occur on the cycling infrastructure. Conversely, the probability of being involved in an accident is also higher for cyclists utilising the cycling infrastructure than for those using the car road (slightly). The probability of a fatal accident at a pedestrian crossing is increasing, and on the pavement the probability of being seriously injured is high. A higher probability may occur at cycle crossings. Consequently, all indications are that the interface between pedestrian/bicycle road infrastructure and motor vehicle infrastructure represents the highest risk point. Conversely, a serious accident for a cyclist may also occur on a cycle path. Based on the above observations and previous analyses of road accidents involving cyclists in urban environments, it is possible to formulate an assessment according to the Risc-Score method (Table 15).

Table 15. Risc-Score for the top five threats/risks for cyclists in urban traffic.

Threat	Parameter S	Parameter E	Parameter P	Type of Risk	
Collision with a car	40	2	6	480	Very large
Collision with a bicycle	15	6	6	540	Very large
Collision with a pedestrian	3	6	3	54	Small
Collision with tram	40	2	3	240	Large
Fall/loss of control of the bicycle	1	6	10	60	Small

Table 15 presents data that can be used to construct a risk map, which is depicted in Figure 10. This approach allows for the visualisation and enhanced comprehension of potential risks and their impact. It is a pivotal instrument in the risk management process, facilitating the effective identification and prioritisation of areas of concern.

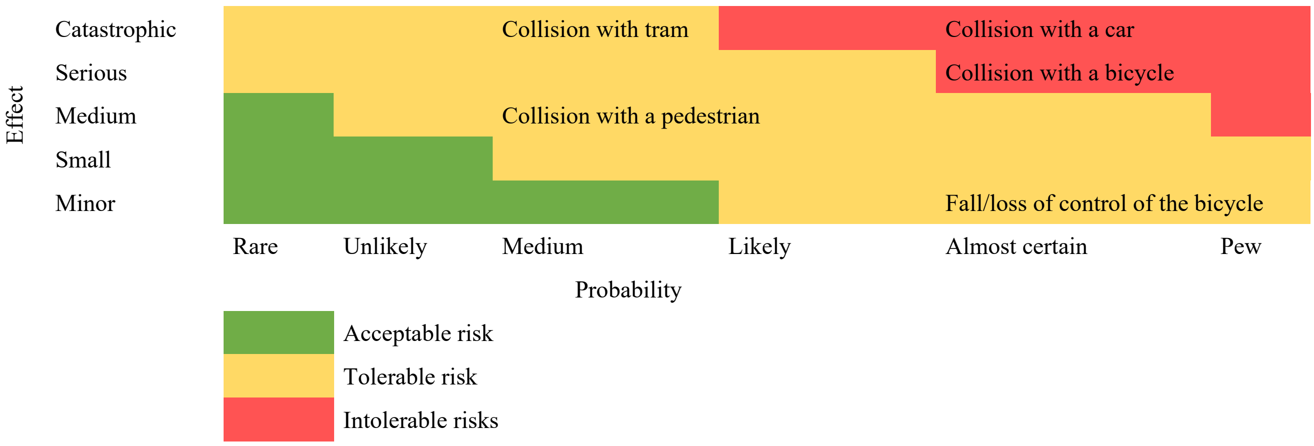

Figure 10. Proposed risk map for the top five threats/risks for cyclists in urban traffic.

The risk map and the Risc-Score method indicate that the risk of a collision with a car and a bicycle should be eliminated. The Risc-Score method also rated a collision with a tram as high when the risk map suggests that it is a risk that can be tolerated due to its low probability of occurrence.

The application of these methods to assess the risk for cyclists in urban traffic highlights the importance of correct planning and design of cycling infrastructure. Moreover, it corroborates the earlier conclusion that the most significant risk for cyclists in urban traffic is that posed by motor vehicles.

The application of risk mapping and Risc-Score methods in the context of cycling in a city is both feasible and efficacious. Consequently, these tools should be employed with greater frequency at the stage of infrastructure planning, as they will enable the optimal prioritisation of investments.

The problem of identifying, estimating, and assessing risks in urban and non-urban cycling traffic is a complex and multidimensional task. It encompasses not only the aspects related to the cycling infrastructure itself but also the behaviour of all traffic participants, including cyclists. It is not only the elements that have been identified in the framework of identifying potential causes of danger for cyclists that are of importance. For example, awareness of safety and risk, the need for prevention, and methods of prevention are also of great importance. Furthermore, there are issues of driving culture and the use of urban space. Therefore, the infrastructure itself is only one element of the issue. It is evident that the quality and the manner in which the infrastructure is planned and designed may influence the potential risks to which cyclists are exposed on a given stretch of that infrastructure.

With regard to the recommendations for actions to enhance the safety of cyclists in urban traffic, several fundamental directions can be discerned. The design of cycling infrastructure with the objective of eliminating exposure to intolerable risks. This may entail, for instance, the minimisation of the number of intersections between cycling routes and roads for cars and trams; the installation of barriers for cyclists at such crossings; and the separation of traffic directions on cycling routes.

It is recommended that the guidelines developed by the Ministry of Infrastructure for the construction and design of cycling infrastructure in cities and beyond be followed.

Furthermore, it is important to promote safe cycling behaviour among urban residents and children.

4. Discussion

Road traffic safety is a significant concern, encompassing both general car traffic and urban traffic, including cycling [50]. Road traffic safety issues are inherently complex and multifaceted [51]. On the one hand, traffic laws regulate the rules of safe movement on roads. Conversely, a confluence of factors, including meteorological conditions, the condition of the road surface, the condition of the vehicle, the volume of traffic, the psychophysical state of the driver, and the behaviour of other road users, exerts a significant influence [52].

The analysis of data related to road accidents for the period 2010–2021 allows for the establishment of a general trend in road safety, including those with the most dramatic consequences (i.e., fatalities). These data allow for a general assessment of positive changes towards the improvement of road safety in Poland. The number of fatal road accidents has been gradually decreasing in the analysed period. The greatest reduction in fatal road accidents occurred in 2020. However, this level is still not in line with the target for this decade set by the United Nations and the World Health Organisation's Road Safety Initiatives. Nevertheless, it is close to the target of a 50% reduction in such accidents. Poland is one of the few countries to have come close to this target. This testifies well to the measures taken to improve road safety in the country. Furthermore, analysis of the IRTAD data allows for the identification of the age group that achieved the most favourable results: those aged 0–14, 15–17, 18–20, and 21–24. A notable decline in fatalities was observed among the youngest and least experienced road users. It is noteworthy that individuals in the 0–14 and 15–17 age groups are predominantly pedestrians and users of bicycles or scooters. However, in the 18–20 and 21–24 age groups, the number of fatalities per 100,000 inhabitants remains the highest. Despite the notable decline, the youngest road users continue to represent the most vulnerable demographic in terms of fatal road accidents.

In contrast, national data indicate that the risk of a fatal accident in the city is approximately 17% lower than outside the city. This implies that urban environments are safer than roads outside cities. However, it is noteworthy that accident victims suffer serious injuries twice as often in cities than outside of them. Consequently, the urban environment is not entirely free of hazards for road traffic participants. The issue of cyclist safety in urban traffic is of particular importance in this context, as cyclists lack any passive protection as participants in this traffic. Official data indicate that, since 2018, the number of cyclist fatalities is decreasing within the EU. National data show a similar picture, with the exception that the reduction in fatal accidents shows greater fluctuations than the data for the EU. Nevertheless, they are decreasing from 2019 onwards. It is, however, a cause for concern that this is accompanied by an increase in the proportion of cyclists among fatalities. It is encouraging to note that in 2021, their share fell to the level of 10%, with the total number of road accidents with fatal consequences at the level of 1718. In the built-up area itself, the number of accidents involving cyclists is also falling, although at a slower rate. Nevertheless, it is noteworthy that the proportion of these incidents in the overall number of road accidents in the country declined to 12.5% in 2021. From the perspective of cyclists, the situation with regard to participation in road accidents, particularly those resulting in fatalities, is improving.

As the least protected road users, cyclists are also involved in accidents in cities. Data indicate that in 2021, 52% of all cyclists who were killed in a road traffic accident were victims of such an accident in an urban environment. Furthermore, 87% of all seriously injured cyclists also suffered an accident in an urban environment. This demonstrates two key points: (1) cyclists cycle more frequently and in greater numbers in urban areas; (2) cyclists in urban areas are more likely to be involved in road accidents with serious consequences. Given that incidents involving cyclists in urban areas are slightly more likely to result in serious injury than in death in the context of all accidents involving cyclists, the issue of safety for urban cycling users is crucial. Cities prove to be dangerous for cyclists mainly at specific points of the cycling infrastructure. Firstly, roads are either designed for car traffic or shared with bicycles. Secondly, the crossings for cyclists. Consequently, at the interface between cycling and car traffic, the highest number of accidents with serious consequences occur. This illustrates the importance of the design of appropriate cycling infrastructure, separation of traffic by vehicle type, and the creation of comprehensive cycle lanes. One potential solution to reduce the number of deaths and serious injuries among cyclists is to replace car traffic with cycling in certain areas of the city. This could be achieved through the separation of car and cycling traffic. While there are many ways to pursue this separation, it is important to note that it will have a positive influence on the reduction of the number of victims of road accidents with serious and tragic consequences among urban cyclists.

The risk factors for a cyclist in road traffic can be numerous and diverse. The safety of cyclists is influenced by a number of factors, both external and internal. External factors include infrastructure, traffic density, road surface conditions, and weather. Internal factors include the cyclist's psycho-physical condition, fitness, reflexes, age, and state of concentration and attention. Technical factors such as the condition of the bicycle and its equipment with lights and brakes, as well as additional means of personal protection such as a helmet, also play a role. These include factors related to concentration and attention, experience in road and cycle traffic, knowledge of the city, and technical aspects such as the condition of the bicycle, its equipment with lights and brakes, and additional personal protection measures, such as a helmet and protective gear. The risk to the cyclist may vary depending on the circumstances in which they find themselves at a given moment. A significant risk to the cyclist is the actions of other road users [53]. Due to the nature of the bicycle as a vehicle, they are more vulnerable to, for example, aggression from other road users or other unauthorised physical actions [54].

In the context of cyclists' safety, the most dramatic event in which a cyclist may be involved appears to be a road accident. This may be connected with a collision with different types of vehicles (a car, a bicycle, a tram), with a pedestrian, or with a loss of control over the bicycle. Each of these types of incidents has different characteristics and different potential consequences for the cyclist. The greater the size of the vehicle with which the cyclist collides, the more severe the consequences for them. A comparable situation occurs in the context of differences in speed: the faster a cyclist collides with a vehicle, the more severe the consequences for them [55].

Risk assessment for cyclists in urban traffic is, therefore, a complex task that requires the use of appropriate tools [56]. One such tool, which has been demonstrated to be useful in this context, is the method commonly referred to as the Risc-Score. Its application has enabled the creation of a risk map of the most significant risks for a cyclist in urban traffic. It has been determined that a collision with a car or a collision with another bicycle are risks that cannot be tolerated due to their consequences [57]. Consequently, it can be concluded that there is a clear need for the construction and design of cycling infrastructure in cities to be approached with great care and attention to detail [58].

The planning, design, and construction of cycling infrastructure in towns and cities should incorporate risk mapping and analysis. This will enable the assessment of designed solutions from the perspective of safety and risk for cyclists. It is also noteworthy to mention that partial recommendations and a catalogue of good practices for the planning process of such investments have already been developed. It would be beneficial to incorporate aspects related to the analysis and management of risks for cyclists in urban environments into the aforementioned practices.

5. Conclusions

There is a growing body of evidence that the quality and condition of the cycling infrastructure are of great importance for the safety of cycling in towns and cities [59–61]. This can also be analogically applied to traffic outside towns and cities. The number of road accidents in general is decreasing, this concerns both road accidents involving vehicles and those involving cyclists. However, there is a certain specificity of accidents involving cyclists in urban settings. Cyclists in urban areas are involved in accidents with varying degrees of consequences for their health. However, accidents with fatal or serious consequences still represent a significant proportion of all incidents involving them.

The urban environment remains a challenging environment for cycling, despite notable progress in the extension of infrastructure and improvement in traffic safety. It is, therefore, necessary to pay greater attention to the issue of safety at the planning stage of investment projects for cycling infrastructure in towns and cities. The appropriate design of solutions connected with the layout and elements of cycling infrastructure in towns and cities has the potential to further reduce the number of accidents in this group of road users. Consequently, it has the potential to increase the overall safety of cycling as an alternative means of personal transport in the city.

In parallel with the development of cycling infrastructure in towns and cities, initiatives aimed at enhancing cycling safety should be implemented. Furthermore, these activities should be conducted in conjunction with the promotion of cycling as an alternative mode of transportation in urban areas. The bicycle appears to be a viable and expedient, as well as cost-effective means of achieving the objectives of decarbonising urban transport. It has the potential to be a solution to this problem. Furthermore, the bicycle can be an effective means of meeting the growing needs of urban transport systems. The analysis of data concerning cyclists' safety in Poland indicates the necessity of further actions to improve their situation. Despite the progress that has been made, there are still areas that require attention, such as road infrastructure, public awareness, and legal regulations. The implementation of effective preventive strategies, education, and the development of infrastructure are the key directions of activities that may contribute to an increase in cyclists' safety.

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