ARE BIKE LANES DANGEROUS? INVESTIGATING CYCLING INFRASTRUCTURE EFFECT ON SAFETY.

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ABSTRACT

The research[*] explores the relationship between the implementation of cycling infrastructure and road safety. Due to the availability of data on motor vehicle and cycling traffic intensity in street network of Prague, it was possible to construct an indicator of relative safety considering the exposure to crash risk. The relationship between different types of cycling infrastructure and cycling safety was verified on a vast dataset. Furthermore, the relationship between the provision of a cycle lane and the overall crash rate, which consists in 98% of car crashes, was verified. A positive effect on cycling safety was shown for cycle infrastructure, with the implementation of a cycle lane increasing safety by a factor of 2, and a cycle path increasing safety by a factor of 8 to 12. Contra-flow streets increase safety by factor of 2. The effect on safety was lowest for sharrows (1.3x). The introduction of cycle lanes is not automatically associated with a reduction in car accidents, but if there is traffic calming and a reduction in the number of lanes implemented as well, then safety is increased.

1. INTRODUCTION

This research report answers the question of the relationship between street layout and road safety. Based on quantitative data, it evaluates how the risk of a crash depends on the road layout and the presence of typical cycling measures such as cycle lanes and cycle paths.

There is a body of research on the issue of road safety using primarily accident databases. As a result of the use of the accident database, these studies focus only on accidents that have occurred and aspects of these accidents. This approach is necessarily limiting because it can only speak about safety from the perspective of existing accident records. However, by its very nature, it fails to give a more comprehensive account of how accidents can be prevented. Indeed, the accident itself is only at the end of the chain of events, and the requirement to improve road safety implies the need to prevent accidents in the first place and to examine the factors that contribute to accidents not happening in the first place.

This research reverses the perspective of road safety research and brings into the analysis the concept of a street section representing a type of road infrastructure and its impact on road safety. Instead of examining the crash as the primary unit of analysis, the unit of analysis is the street segment. For this research, an innovative data matrix representing the street network of selected Prague urban units complemented by a series of collector roads

[*] The paper is based on original research carried out for the City Hall of Prague. The complete research reports (in Czech) including the detailed methodology are available for download at https://www.bicyclemind.cz/cycling-infra-safety/ .

combining geographical data, traffic marking data, traffic volume data (motor vehicles and bicycles) and accident data was developed.

The report aims to answer two research questions.

RQ1: What is the relationship between cycling safety and roadway character as indicated by the presence of cycling measures?

RQ2: What is the relationship between overall road safety and the provision of cycle lanes?

The first research question focuses on cyclist safety, while the second research question looks at overall safety, which is dominated by motor vehicle crash rates.

2. METHODOLOGY

An innovative quantitative research design combining a range of data sources was designed to answer the research questions. The unit of analysis is the street segment (section). The characteristics corresponding to the observed variables are further assigned to this section according to the explanatory model.

2.1 Explanatory model for RQ1

Cycling safety is expected to be a function of the type of cycling infrastructure. Six types of this infrastructure were classified for the observed sections:

1. Sharrows – sharrows marking on a collector road
2. Cycle Lane (soft) - a "protected lane for cyclists[*]", a spatially less demanding and visually less prominent variant of the cycle lane, which can be used by motor vehicles under clearly defined conditions
3. Cycle Lane (exclusive) - "dedicated lane for cyclists" marked in accordance with the Czech standard
4. Contra-Flow - a one-way street for motor vehicles where two-way bicycle traffic is allowed
5. Cycle Path - a physically separated bicycle path
6. No Cycling Infrastructure - complete absence of any cycling infrastructure

[*] „Protected" and "dedicated" lane for cyclists are word-to-word translation of official Czech terms. "Protected" expression is misleading, there is no actual physical protection but a painted lane. Cycle lane "soft" and "exclusive" terms correspond to a OpenStreetMap concensus for this type of bike lanes.

Figure 1 – Observed types of cycling infrastructure

In addition, each road section was assigned an overall road character corresponding to the Czech standard dividing roads into functional groups of Collector Road (type B), Residential Street (type C) and Path (type D).

Road character and type of cycling infrastructure represent the independent variable. The dependent variable is cycling safety, the indicator of which is the Cycling Crash Rate, the number of crashes involving a bicycle per million kilometres cycled. Cycling Crash Rate is a variable created by combining three datasets. It includes the official accident statistics of the Police of the Czech Republic, a model of the number of cyclist crossings in the street network of Prague and the length of the monitored sections.

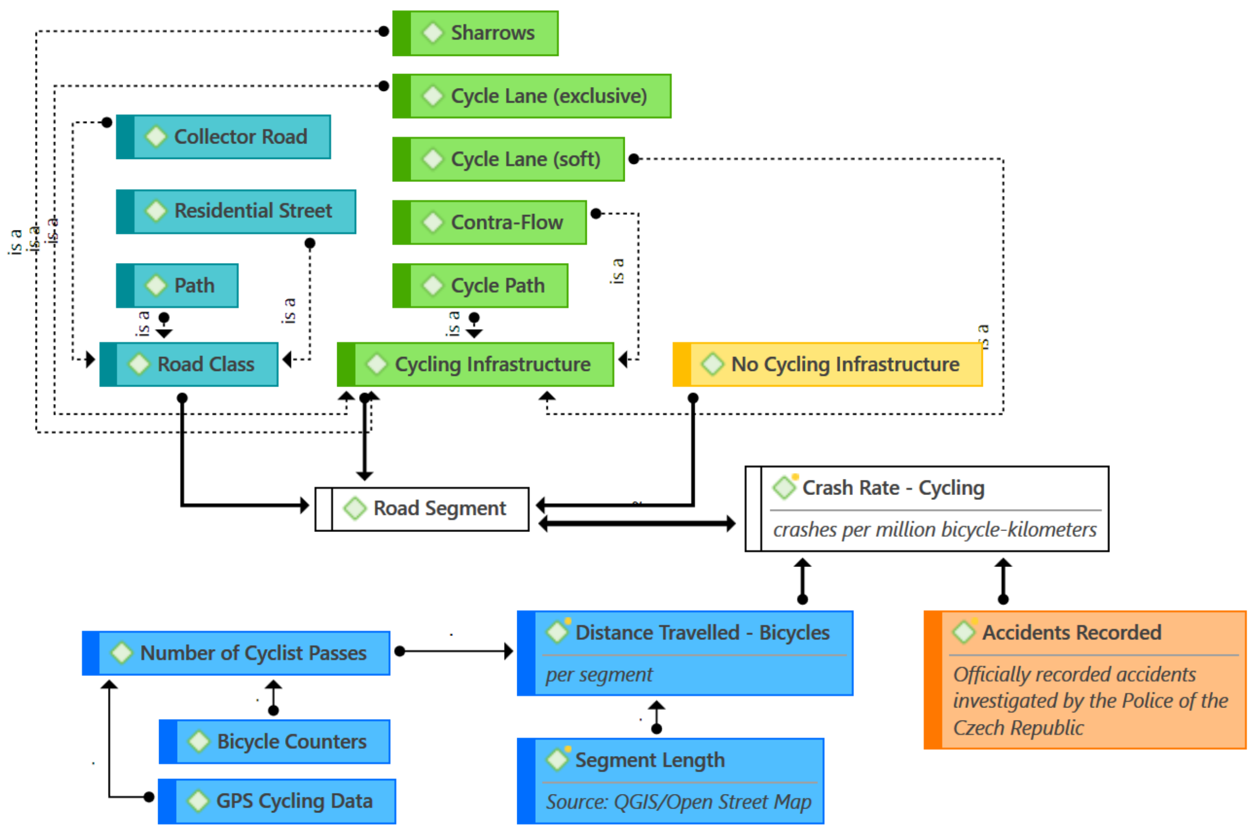

Figure 2 – Explanatory model for RQ1

2.1.1 *Cycling Crash Rate Indicator*

Three indicators of cycling crash rates according to the nature and context of the accidents are presented. The three indicators are chosen to better grasp the safety of cycling, which varies depending on the context and the situation on the road.

Collisions with fixed obstacles

One of the factors that significantly affect cycling safety are the fixed obstacles that can be hit while cycling. These include bollards, baliseets, vertical signposts, lampposts and traffic lights, temporary traffic signs, trees, and others. The distinction between crashes involving collisions with fixed obstacles and crashes without such collisions is necessary because the presence of fixed obstacles is not a primary characteristic of the monitored sections and the established bicycle facilities. Ideally, fixed obstacles should not be present at all, as is the case for motor vehicle infrastructure. Thus, filtering out collisions with fixed obstacles allows the relationship of relative accident rates with infrastructure type to be observed, regardless of how many poles, signs, bollards and other obstacles happen to be present.

Accident rate at junctions

Intersection accidents account for about one-third of the volume of accidents involving bicycles in official statistics. The effect of cycling measures on safety is therefore strongly influenced by the intersections through which the cycle lane or sharrow passes. The intersection itself presents several variables with safety implications. The number of lanes, the length of clearance time of traffic lights, the signal timing at signal controlled intersections, the volume of vehicular traffic, the prevailing stream of bicycle traffic volume and any left turns in that stream, the nature of the local traffic signs, sight distance conditions, and probably a number of other factors will influence road safety and the resulting accident rate in intersections. Due to the multiplicity of factors affecting intersection crash rates, this research presents crash rates both with and net of intersection crashes.

Cycling Crash Rate Adjusted

For the reasons described above, the third indicator chosen is the cycling crash rate adjusted for collisions with fixed obstacles and accidents at junctions. This accident rate is a useful indicator for evaluating the safety of various linear measures for guiding cyclists, where this indicator resists significant sources of accidents that are not primarily related to the types of infrastructure under consideration.

This indicator is also the only suitable indicator for comparing integration measures in the main traffic area. Based on the interim results, the dataset was extended to include all soft cycle lanes and sharrows in the Prague area. Due to the number of these sections and to achieve a balance between research capacity on the one hand and the inclusion of as many new sections as possible in the analysis on the other hand, continuous measures of at least 100 metres for soft cycle lanes and 200 metres for sharrows were included in the analysis. This mechanism has led to a significant filtering out of sections passing through intersections where cycling measures are discontinuous, or the measure composition is combined. For this reason, intersection crash rates are significantly underrepresented in the data presented for soft cycle lanes and sharrows and cannot be compared to exlusive cycle lanes, which have a significantly higher proportion of intersection segments included in the analysis.

2.2 Study Area and Time Period for RQ1

Territorially, the research is defined by the area of two larger settlements, Prague Holešovice and Karlín. All roads in the defined area of these units are included in the formation of the sections, regardless of the presence or absence of accidents in the section. Both urban units have a relatively well-developed infrastructure for cycling compared to other Prague districts.

To achieve a more robust dataset and increase the number of sections containing cycling measures, Holešovice and Karlín are supplemented by the backbone roads located in Podolí, namely the waterfront cycle path and the adjacent collector road. In addition, the study area has been significantly extended by most collector roads throughout Prague, where sharrows and soft cycle lanes are established.

This area was examined for the time period 2013 to 2022.

The analysis included 899 street sections with a total length of 197 km, on which 34.4 million passenger-kilometres of bicycle transport performance took place in the studied years 2013 to 2022. Accident rates on this street network during this period are represented by 197 recorded accidents.

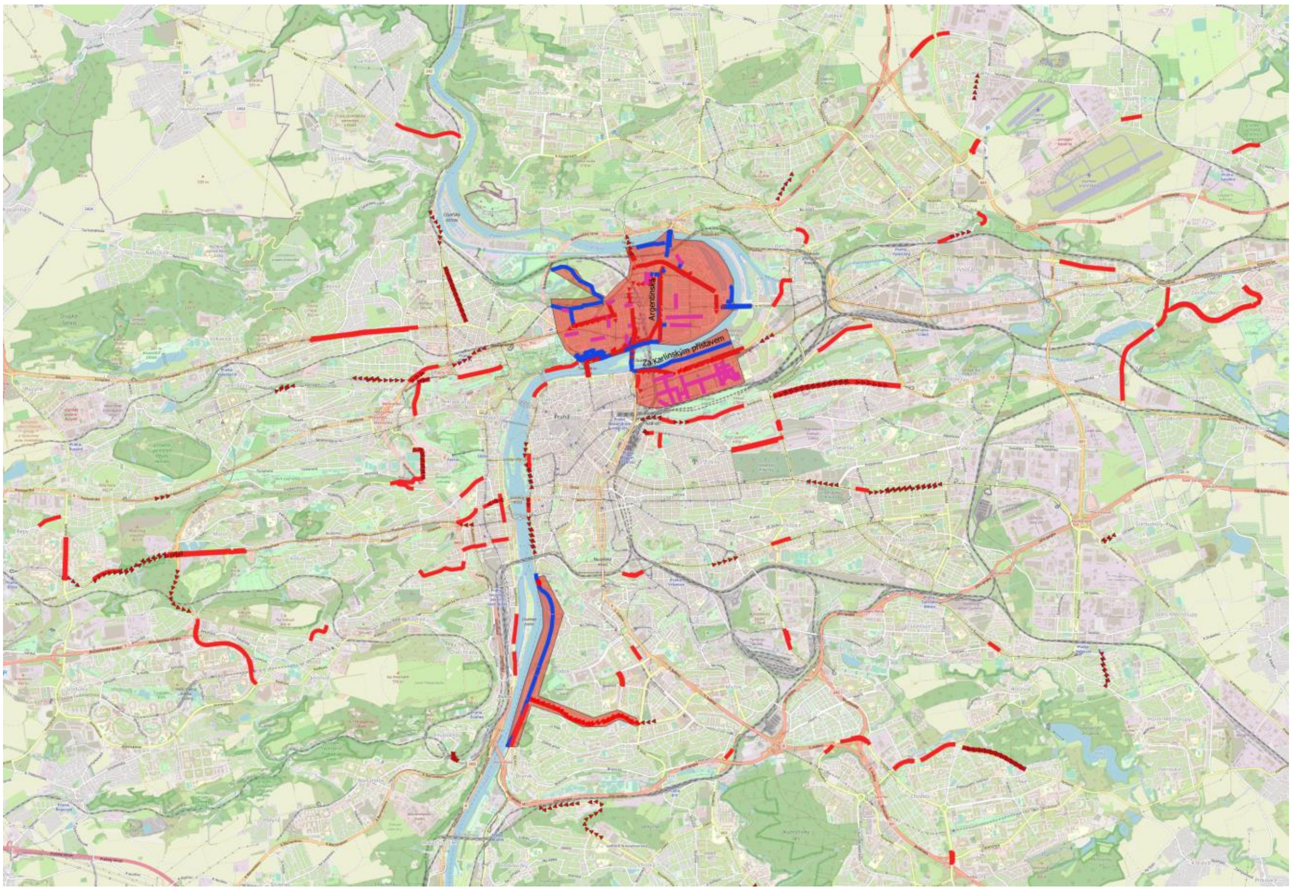

Figure 3 – Roads and Areas entering the analysis for RQ1

2.3 Explanatory model for RQ2

The aim of RQ2 was to evaluate the impact of the installed cycle lanes on overall safety. The unit of analysis in this research is a road section with predefined characteristics. The characteristics, namely recorded crashes and motor traffic volumes are further assigned to these sections where cycle lanes have been established in the past. Thus, the analysis includes sections regardless of the number of recorded accidents, as well as sections with zero accidents.

The motor traffic volumes, i.e., the number of motor vehicle passes on the road per day, together with the accident records and the length of the road, allow the construction of an indicator of the crash rate, i.e., the number of accidents on a given section per million vehicle kilometres.

Data on the intensity of cycling traffic are also available for the Prague area. This research question focuses on the total accident rate, which in 98.36% of cases takes place without the involvement of a bicycle. Therefore, due to the very low representation of accidents involving bicycles in the total accident rate, cycling rates are not used in RQ2.

The research design for the RQ2 corresponds to a natural experiment. The establishment of a cycle lane on a road is a natural experimental variable. Crash rate is the observed, dependent variable. Crash rates are monitored in the period before and after the establishment of the exlusive cycle lane, always for a period of at least one year and up to a maximum of three years, always equally before and after. The control variable is car traffic volumes, which in combination with the absolute accident rates allow the crash rates to be determined.

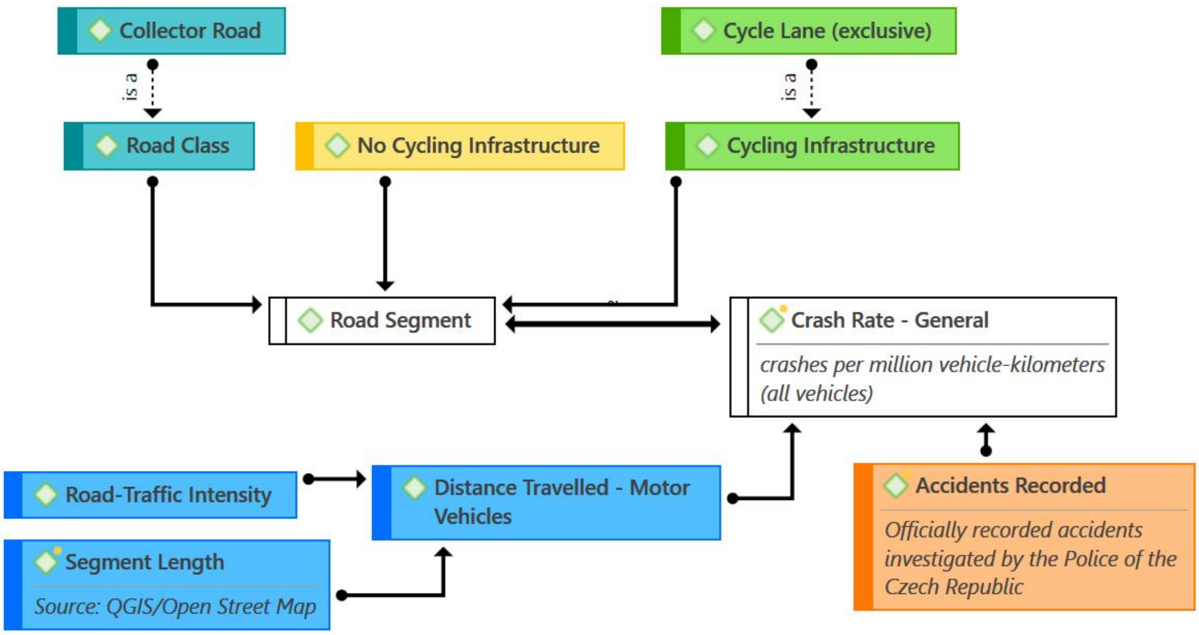

Figure 4 - Explanatory model for RQ2

2.3.1 *Exclusive and Soft Cycle Lane Selection*

There are two types of cycle lanes in Czechia, exclusive cycle lane and soft cycle lane. Exlusive cycle lanes were introduced in the second half of the 1990s and in the last two decades Czech municipalities frequently install those lanes on collector roads. The possibility of establishing soft cycle lanes was introduced in February 2016 with an amendment to Act No. 361/2000 Coll. on Road Traffic, and methodological support came a year later in May 2017 with the publication of the Ministry of Transport's Technical Specifications TP 179 Design of Roads for Cyclists. Soft cycle lanes are thus relatively young compared to other cycle measures and have only started to be established on a larger scale in recent years.

Analysis for RQ2 only looks at exclusive cycle lane for two reasons. The first is their historical availability. Exlusive cycle lanes have been established in Prague since 2006 at the latest and have been continuously established throughout the study period from 2010 to 2020. The second reason for choosing exlusive cycle lanes for the analysis is the differences between exlusive and soft cycle lanes. Soft cycle lane can have variable parallel lane widths, whereas exlusive cycle-lane represents more standardised road marking allowing for more robust comparison.

2.4 Study Area and Time Period for RQ2

As of May 2022, a total of 68 km of exclusive cycle lanes have been established in Prague. Due to the research design, the sections suitable for analysis had to meet a number of conditions, after which 16.6 km of sections with an established exclusive cycle lane remained suitable for analysis. Those 16.6 km are represented by 34 specific street segments scattered across Prague area.

It was necessary to filter out sections with cycle lane that were created in 2009 and earlier and 2021 and later. Since January 2009 there has been a significant decrease in recorded accidents due to a change in the legal requirement to report accidents to the police depending on the amount of material damage. The amount of material damage required for compulsory accident reporting has increased from 50,000 to 100,000 CZK since January 2009. As a result of this change, the number of recorded accidents in Prague fell by half, from 30,251 in 2008 to 15,583 in 2009. For this reason, accident data is not comparable between 2008 and 2009 and it is not possible to produce a reliable accident indicator for sections with cycle lane established in 2009 and earlier for the period before a cycle lane was established. For sections with cycle lane established in 2021 and later, it is not possible to produce an accident indicator because the period that has elapsed after the establishment of the cycle lane is too short and is less than one year.

3. RESULTS

3.1 RQ1 – Descritpive statistics

Table 1 – Type, length, and traffic volume of analysed segments

Type of Cycling Infrastructure	Length	Share of Length	Traffic Volume (bicycle kilometres)	Share of Volume
No Infrastructure	60.7 km	31%	8 927 036	26%
Formerly No Infrastructure	17.0 km	9%	813 668	2%
Contra-Flow	6.3 km	3%	729 029	2%
Cycle Lane - Soft	57.9 km	29%	2 089 819	6%
Cycle Lane - exclusive	9.2 km	5%	987 975	3%
Sharrow	31.5 km	16%	3 531 389	10%
Cycle Path	14.1 km	7%	17 283 876	50%
Total	196.8 km	100%	34 362 792	100%

Overall, across the dataset, 31% of the length of all sections is without cycling infrastructure, with a further 9% of sections originally without cycling infrastructure. Among the cycling measures, the longest in the study area are the soft cycle lanes (29% of the length) and the sharrows (16% of the length). This is followed by cycle paths (7% of the length), exlusive cycle lanes (5%) and contra-flow streets (3% of the length).

Across all section types, it is cycle paths that carry half of the traffic. A quarter of the output is carried out on roads with no or initially no cycle infrastructure. The total transport output in the study area between 2013 and 2021 was 34.4 million passenger kilometres.

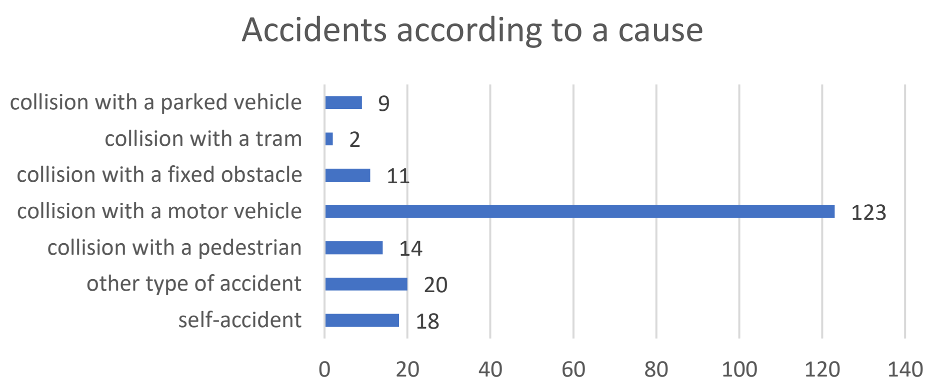

Figure 5 – Accidents according to a cause

The most frequent cause of accidents is a collision with a moving motor vehicle, with a total of 123 such accidents entering the analysis. The cause of the crash listed as a self-accident is a is typically a fall from a bicycle, where injuries were sustained and the ambulance service was called, which has a duty to notify the police in these cases. Pedestrian crashes, of which there are fourteen in the dataset, most often occur on cycle paths. A collision with a fixed obstacle may be a bicyclist striking a portable traffic sign, bolard, pole, or tree on a bike path.

3.2 RQ 1 – Cycling Crash Rates

Table 2 – Cycling Crash Rate according to type of road

	Cycling Crash Rate		
	no intersections, no fixed obstacles	with intersections, no fixed obstacles	with intersections, with fixed obstacles
Collector Roads	**5.05**	8.70	8.91
Residential Streets	**8.66**	11.18	12.62
Paths	**0.81**	0.81	1.04

Cycling crash rates are lowest on paths that exclude motor vehicle traffic, typically cycle paths. On these roads, there is one reported accident per 0.81 million passenger kilometres travelled. On roads in other functional groups the relative accident rate is multiple times higher.

Table 3 – Cycling Crash Rate according to type of cycling infrastructure

	Cycling Crash Rate		
Type of Cycling Infrastructure	**no intersections, no fixed obstacles**	with intersections, no fixed obstacles	with intersections, with fixed obstacles
No Infrastructure	**6.16**	9.97	10.42
Formerly No Infrastructure	**3.69**	9.83	9.83
Contra-Flow	**2.95**	5.89	8.84
Cycle Lane - Soft	**3.35**	*	*
Cycle Lane - Exclusive	**3.04**	7.09	8.10
Sharrow	**4.67**	*	*
Cycle Path	**0.81**	0.81	1.04

Table 4 – Comparison of effect on safety of cycling infrastructure

How many times does cycling infrastructure improve safety compared to roads without cycling infrastructure			
Type of Cycling Infrastructure	**no intersections, no fixed obstacles**	with intersections, no fixed obstacles	with intersections, with fixed obstacles
No Infrastructure	**1.0x**	1.0x	1.0x
Contra-Flow	**2.1x**	1.7x	1.2x
Cycle Lane - Soft	**1.8x**	*	*
Cycle Lane - Exclusive	**2.0x**	1.4x	1.3x
Sharrow	**1.3x**	*	*
Cycle Path	**7.6x**	12.3x	10.0x

Separated cycle paths are the safest form of cycling infrastructure and are 8 to 12 times safer than riding on the road without cycling infrastructure. Measures placed in the roadway (cycle lanes, sharrows) are significantly less safe compared to cycle paths, but still significantly increase safety compared to the complete absence of cycle lanes. Omitting intersection sections, dedicated bike lanes (2x) and protected bike lanes (1.8x) increase safety the most. Sharrows increase safety only 1.3 times.

Due to the design of the dataset, it is not possible to compare the cycling crash rates for the soft cycle lanes and sharrows including intersection accidents, where the data for soft cycle lanes and sharrows are significantly skewed by the absence of intersection sections and the cycling crash rate in these cases shows a lower rate than the actual accident rate is.

3.3 RQ2 – General Crash Rates

The effect of the cycle lane itself on safety has proven to be ambiguous. A more detailed analysis showed that other variables need to be included to explain changes in crash rates, namely the reduction in the number of lanes, and the year of the cycle lane introduction, which has received increased attention in the discussion chapter of this paper.

Table 5 - Change in crash rates for sections with lane reduction

			reduction of number of lanes			**crash rate**		
section ID	**street name**	**cycle lane installed**	**before**	**after**	**change**	**before**	**after**	**change**
739	Bubenská	2016	4	2	-2	6,84	2,88	-3,97
740	Bubenská	2016	4	2	-2	5,67	2,68	-2,99
753	Na Strži	2015	4	2	-2	0,43	1,33	0,90
716	Novodvorská	2013	4	2	-2	0,77	1,14	0,37
717	Novodvorská	2013	4	2	-2	0,72	1,36	0,64
730	Počernická	2010	4	2	-2	1,61	1,82	0,21
735	Veselská	2020	4	2	-2	1,24	0,56	-0,68
737	Vrbenského	2019	4	2	-2	1,70	1,23	-0,48
738	Vrbenského	2019	4	2	-2	2,40	1,55	-0,85
	total					1,89	1,52	-0,38

For sections where the road layout was changed from four lanes to two lanes, there was an overall reduction in the crash rate of 0.38 accidents per million vehicle kilometres. Of the nine sections in this set, five sections experienced a reduction in accident rates, while the remaining four experienced varying degrees of increase in accident rates.

Table 6 - Effect of lane reduction on cause of accidents

	no lane reduction					with lane reduction				
	number of accidents		crash rate			number of accidents		crash rate		
cause of accident	**bef.**	**aft.**	**bef.**	**aft.**	**change**	**bef.**	**aft.**	**bef.**	**aft.**	**change**
collision with a moving motor vehicle	26	33	0,80	1,01	0,22	42	25	1,50	0,88	-0,62
collision with a parked vehicle	1	3	0,03	0,09	0,06	4	8	0,14	0,28	0,14
collision with a fixed obstacle	0	2	0,00	0,06	0,06	5	6	0,18	0,21	0,03
collision with a pedestrian	3	0	0,09	0,00	-0,09	2	3	0,07	0,11	0,03
collision with a forest animal	0	0	0,00	0,00	0,00	0	0	0,00	0,00	0,00
collision with a domestic animal	0	0	0,00	0,00	0,00	0	0	0,00	0,00	0,00
collision with a train	0	0	0,00	0,00	0,00	0	0	0,00	0,00	0,00
collision with a tram	4	6	0,12	0,18	0,06	0	0	0,00	0,00	0,00
self-accident	1	0	0,03	0,00	-0,03	0	0	0,00	0,00	0,00
other type of accident	0	1	0,00	0,03	0,03	0	1	0,00	0,04	0,04

The reduction in the number of lanes with the introduction of cycle lane is associated with a reduction in the crash rate caused by collisions involving moving motor vehicles by 0.6 accidents per million vehicle kilometres. Other changes in the accident pattern by accident type are only slight, with no reduction in lanes there is a slight increase in collisions with a moving motor vehicle, and with a reduction in lanes there is a slight increase in collisions with a parked vehicle.

Table 7 - The effect of lanes reduction on the consequences of an accident

	no lane reduction					with lane reduction				
	number of accidents		crash rate			number of accidents		crash rate		
consequence of an accident	**bef.**	**aft.**	**bef.**	**aft.**	**change**	**bef.**	**aft.**	**bef.**	**aft.**	**change**
accident resulting in injury or death	6	3	0,18	0,09	-0,09	8	4	0,29	0,14	-0,14
accident with material damage only	29	42	0,89	1,29	0,40	45	39	1,61	1,37	-0,23
consequences of the accident - status within 24 hours	**bef.**	**aft.**	**bef.**	**aft.**	**change**	**bef.**	**aft.**	**bef.**	**aft.**	**change**
persons killed	0	0	0,00	0,00	0,00	0	0	0,00	0,00	0,00
persons seriously injured	1	0	0,03	0,00	-0,03	2	0	0,07	0,00	-0,07
persons slightly injured	6	3	0,18	0,09	-0,09	8	4	0,29	0,14	-0,14

In both cases, without and with lane reduction, there was a slight decrease in accidents resulitng in injury. In the case of accidents with material damage, the accident rate increased for the sections without lane reduction and decreased for the sections with lane reduction.

Accident rates with life or health consequences decreased in both cases, with lane reduction decreasing slightly more than without reduction.

Table 8 - All sections sorted by change in crash rate

rank	section ID	section name	cycle lane installed	lane reduction	number of accidents		crash rate		
					bef.	aft.	bef.	aft.	change
1	739	Bubenská	2016	-2	18	8	6,84	2,88	-3,97
2	757	Janáčkovo nábřeží	2011	0	7	1	3,75	0,51	-3,23
3	740	Bubenská	2016	-2	10	5	5,67	2,68	-2,99
4	718	Novodvorská	2020	-1	1	0	1,43	0,00	-1,43
5	741	Bubenská	2018	-1	10	4	2,22	0,98	-1,24
6	720	Modřanská	2020	0	7	3	1,56	0,66	-0,90
7	738	Vrbenského	2019	-2	5	4	2,40	1,55	-0,85
8	735	Veselská	2020	-2	2	1	1,24	0,56	-0,68
9	752	Jeremiášova	2020	0	1	0	0,56	0,00	-0,56
10	722	Modřanská	2020	0	4	2	0,98	0,48	-0,49
11	737	Vrbenského	2019	-2	5	4	1,70	1,23	-0,48
12	758	Zborovská	2010	-1	1	1	2,43	2,21	-0,23
13	742	nábřeží Kapitána Jaroše	2018	-1	19	19	3,25	3,16	-0,09
14	751	Jeremiášova	2020	0	0	0	0,00	0,00	0,00
15	750	Na Radosti	2010	0	0	0	0,00	0,00	0,00
16	729	Počernická	2010	0	2	2	1,56	1,67	0,11
17	730	Počernická	2010	-2	2	2	1,61	1,82	0,21
18	719	Modřanská	2020	0	3	4	0,74	0,96	0,23
19	721	Modřanská	2020	0	2	3	0,73	1,09	0,36
20	716	Novodvorská	2013	-2	5	7	0,77	1,14	0,37
21	733	Tupolevova	2010	0	0	1	0,00	0,37	0,37
22	717	Novodvorská	2013	-2	5	9	0,72	1,36	0,64
23	753	Na Strži	2015	-2	1	3	0,43	1,33	0,90
24	745	Rohanské nábřeží	2015	0	2	3	1,53	2,51	0,98
25	734	Tupolevova	2011	0	1	3	0,38	1,37	0,99
26	731	Českomoravská	2010	0	5	8	1,76	2,77	1,01
27	743	Rohanské nábřeží	2012	0	1	4	0,36	1,47	1,11
28	744	Rohanské nábřeží	2012	0	1	3	0,56	1,73	1,17
29	732	Českomoravská	2010	0	9	15	1,94	3,18	1,23
30	754	nábřeží Kapitána Jaroše	2018	-1	14	21	2,61	3,86	1,25
31	728	Počernická	2010	0	0	1	0,00	1,27	1,27
32	756	Hořejší nábřeží	2011	0	11	17	2,30	3,74	1,44
33	727	Počernická	2010	0	2	6	1,23	3,75	2,51
34	755	Hořejší nábřeží	2011	0	8	16	4,82	10,16	5,34

If we look at an overview of all the analysed sections sorted by the change in accident rate, it appears that younger implementations are more likely to have a positive effect on safety.

The first ten sections with the most significant improvement in relative accident rates had cycle lane implemented in 2016 and later (except for Janáčkovo nábřeží section). Presumably, the quality of the traffic sign change projects in which cycle lanes are installed is increasing, and these projects generally lead to improvements in road safety.

On the contrary, in the last ten we find, with the exception of the nábřeží Kapitána Jaroše section, sections where cycle lane was established between 2010 and 2012. Among these sections we can also find Hořejší nábřeží, where the original change of traffic signs was of rather lower quality mixing old and new layout resutling in confusing lane indication.

4. DISCUSSION

4.1 Intersections Effect

The fact that the installation of cycle lanes alone may not be enough to increase safety is shown by the case of Českomoravská Street, where the general crash rate increased after the installation of cycle lane on both monitored sections. The crash rate on this street is primarily related to a specific type of intersection where the crossing occurs on a kind of interspace on the tramway rails, with cars crossing over this interspace in several directions (see figure below). However, there is no local traffic regulation in place, confusing situations arise, and the accident rate is significantly increased.

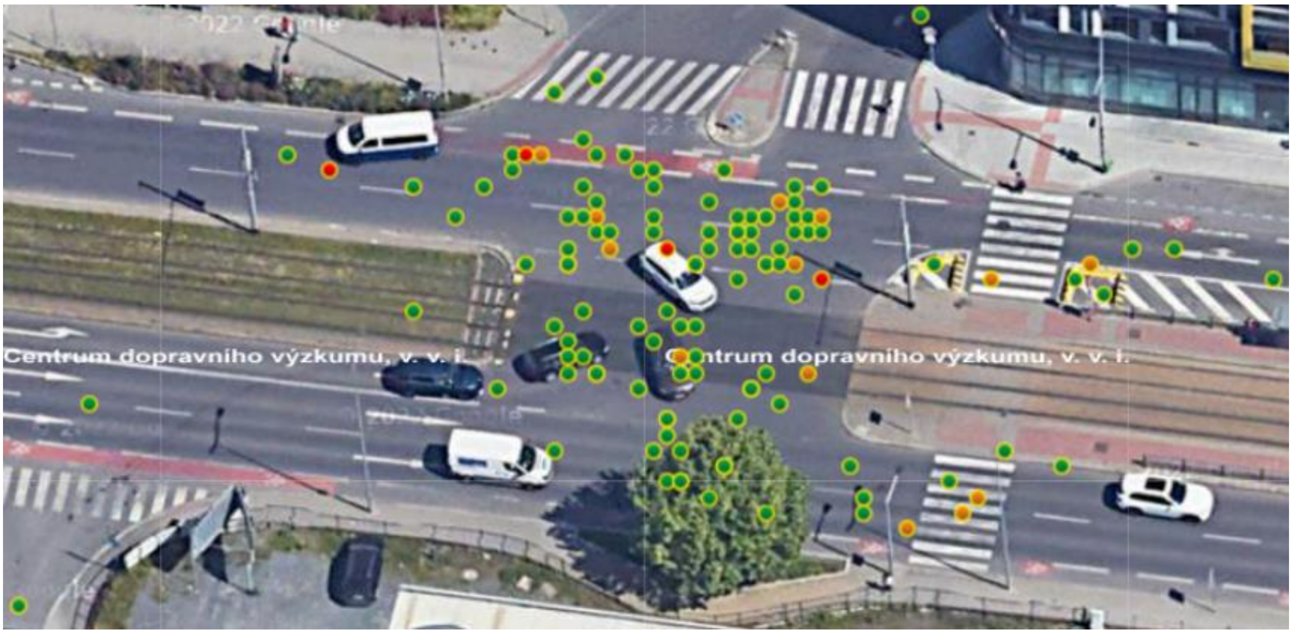

Figure 6 – Českomoravská – Ocelářská intersection, dots indicate recorded crashes between 2009 and 2022.

In this case, it is difficult to expect a link between the installation of cycle lane and the accident rate in the section, since the source of the accident rate itself - a cluttered intersection without local traffic regulation - is not affected by the installation of the cycle lanes.

4.2 Complexity of Traffic Sings Arrengement

The data analysis for RQ2 showed that the installation of a cycle lane alone as an explanatory variable for overall crash rate has its limits and it was necessary to add other explanatory factors to the analysis, such as the change in the number of lanes or the year of implementation of the measure. Both factors, change in the number of lanes, and year of implementation of the measure, have a common denominator, which can be described as the complexity of the traffic signs arrangement. A change in the number of lanes typically involves using the width of the roadway in one direction to change from a two concurrent lane arrangement to an arrangement in the form of longitudinal parking, a cycle lane, and a motor vehicle lane. The later implementations then differ from the earlier ones from 2010 to 2015 in that they take a more comprehensive approach to the change in road markings.

Future research should focus on tracking the impact of traffic organisation on safety, including capturing a wider range of road markings, not just integrative measures for cyclists. A possible direction for research may be to focus on accident intersections and the nature of local arrangement to evaluate the factors that enhance road safety at intersections.

4.3 Reported and unreported cycling accidents

The official accident database maintained by the Police of the Czech Republic is used as the source of accident data in this research. Not all events are included in this database, for example in the case of vehicle collisions there is an obligation to report the accident only if the damage exceeds CZK 100,000 or if people are injured. If accidents involving a bicycle are involved, then there is likely to be a significant difference between the official and actual accident rates. The author of this research conducted a one-off investigation in the form of an online survey examining the accident rate of people on bicycles. 161 people had participated in this survey, describing a total of 290 accidents that had happened to them over the past five years. In this survey, accidents involving bicycles in collisions with motor vehicles were investigated by the police in 21% of cases, while the remaining 79% went unreported. Across all accident types 90% of cases went unreported to the police. A more detailed analysis of the data from this survey is yet to be published in the Mestem na kole magazine (www.mestemnakole.cz).

This online survey can only serve as an approximate litmus test of the relationship between the official and actual accident rate of cyclists in Czechia. To ascertain the real accident rate of cyclists and its relation to the official accident rate, it would be necessary to conduct a geographically and socially representative survey that would eliminate the methodological shortcomings of the online survey. However, if it turns out that only 10 to 20% of cycling accidents make it into the official statistics, then this would imply a many times higher cycling crash rate than the values presented by this study.

5. CONCLUSION

Safety-enhancing cycling infrastructure is key to increasing the share of cycling in the modal split in cities with high car use. Although in theory there is nothing to prevent people from cycling in mixed motor traffic as drivers of non-motorised vehicles, experience shows that such cycling is acceptable to one or two per cent of the population, typically younger, fearless men. Although road safety, and therefore of cycling, should be guaranteed by compliance with the road code, the reality is different, and crashes happen despite the rules.

A crucial tool for improving cycling safety is accident prevention and the creation of an urban traffic environment which, by its very design, prevents the creation of accident risks. Vision Zero, stating that it is unacceptable for people to die because of traffic, cannot be achieved simply by emphasising compliance with the rules, as this has historically not led to the stated goal. Vision Zero must be approached through an understanding of how transport infrastructure is linked to crash rates.

This research contributes to this understanding by evaluating how cycling measures relate to road safety. Based on data representing 9 years on 197 kilometres of roads and streets, on which Prague residents have cycled more than 34 million kilometres, completely covering the two urban areas of Karlín and Holešovice, it is clear that cycle lanes, contra-flow streets and cycle paths increase cycling safety and contribute significantly to accident prevention.

Furthermore, the effect of cycle lanes on the general crash rate, which is 98% made up of car accidents, was investigated. The best results were achieved mainly by projects implemented in 2016 and later because of their higher quality and complexity. The most significant safety improvements occurred on the monitored sections of Bubenská Street, where the crash rate decreased by more than 50% compared to the period before the cycle lanes were established. However, on Bubenská, the installation of the cycle lanes was accompanied by a comprehensive local traffic regulation and with a significant use of horizontal road markings.

Several monitored sections have experienced an increase in crash rates, especially the older cycle lane implementations from 2010 to 2012. On these roads, clusters of crashes are often linked to opaque intersections with inadequate local traffic management. In these cases, the traffic signing design only establishes a cycle lane and leaves the accident locations at the intersections unadjusted. The overall accident rate on the section, regardless of the establishment of cycle lane, is affected by intersections with inadequate or inappropriate local treatment.

The reduction in accident rates is mainly associated with the introduction of a cycle lane, which also involves a change in lane layout from a directionally divided four-lane road to a directionally divided two-lane road. In these cases, the number of collisions between moving cars has decreased significantly, which is mainly due to a significant reduction of side collisions caused by failure to give way when changing lanes. The severity of fatal and non-fatal crashes on these sections has also decreased slightly.

If the aim is to reduce accidents, then traffic signs should already be designed with this objective in mind. Some roads where cycle lanes have been implemented still suffer from clusters of accidents linked to opaque junctions that lack appropriate local traffic regulation. The local traffic management at these locations is clearly not sufficient and there are regular, repeated and expected car collisions at these locations. The provision of cycle lanes along accident-prone intersections cannot make any difference to this crash rate. A change in road markings, whether it is cycle lane implementation or other local modification, should be coupled with a basic survey of the crash rate in the area using Traffic Accidents in the Czech Republic on-line application, and address this crash rate in an appropriate manner, keeping in mind the safety of all road users.

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