CHALMERS

Parameters affecting the occurrence of bicycle accidents

A study of causes for bicycle accidents in Gothenburg, with focus on the road design

Master of Science Thesis in the Master's Programme Geo and Water Engineering

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ABSTRACT

There is an ambition to increase the amount of travels made by bicycle. However, already today many bicycle accidents occur. To be able to decrease the amount of accidents there is a need to investigate what parameters affect the occurrence of bicycle accidents, which is the aim of this project. The focus is on the design of roads. Although there are directions available on how to design bicycle roads, there is a lack of consistency in the system. That together with the unclear rules for cyclists is a problem.

STRADA is a database consisting of health care reports and police reports of traffic accidents in Sweden. During 2009 and 2010 over 700 traffic accidents in Gothenburg, involving at least one cyclist, were registered in STRADA. Investigation of reports from these accidents resulted in seven different categories of bicycle accidents; behavior related accidents, road related accidents, accidents involving two or more cyclists, accidents involving a motor vehicle, vehicle related accidents, accidents involving a pedestrian and single accidents with unknown cause.

The categories of accidents related to road, behavior or vehicle together with the single accidents with unknown cause make up the single accidents, which is 52 % of all bicycle accidents. The two most common categories of bicycle accidents are accidents involving motor vehicles and road related accidents, constituting 31 % and 27 % of all bicycle accidents.

The accidents in each category are caused by different situations and parameters. For motor vehicle related accidents the most common situation for accidents to happen is when a motor vehicle crosses a bicycle path. The most common road related parameter causing accidents is slipperiness. From the study it was found that bicycle accidents are most common on roads with mixed traffic.

Keywords: Bicycle accident, design for cyclists, STRADA

Contents

Preface

This report is a Master´s Thesis in the Master´s programme Geo and Water engineering which has been carried out at the Department of Civil and Environmental Engineering, the Division of GeoEngineering, Road and Traffic Research Group at Chalmers University of Technology, Gothenburg, Sweden. The Master´s Thesis has been carried out on initiative of Suzanne Andersson at the Traffic and Public Transport Authority in Gothenburg with supervision from Anna Jägemalm at Tyréns.

During the work with this Master´s Thesis, helpful discussions with several persons have been a great support to our work. We would like to thank our supervisor and examiner at Chalmers, Gunnar Lannér. We would also like to thank the traffic group at Tyréns and especially our supervisor Anna Jägemalm. Furthermore, we would like to give thanks for useful discussions with Suzanne Andersson and Lars-Erik Lundin at the Traffic and Public Transport Authority as well as Tomas Fredlund at the Swedish Transport Agency. Finally, thanks to our opponents Thomas Borg, Erik Ulvås and Andreas Johansson for helpful opinions about our report.

Gothenburg, June 2012

Sara Johansson and Tove Vestlund

1 Introduction

Every day approximately 10 % of all journeys in Gothenburg are done by bicycle. In Gothenburg the Traffic and Public Transport Authority is responsible for all traffic and municipal roads, including bicycle traffic and bicycle paths. The public transport authority has a goal to increase the amount of journeys by bicycle as well as their market share in relations to cars (Trafikkontoret Göteborgs stad, 2012). Around half of the journeys made by car are shorter than five kilometer, which make them possible to make by bicycle instead (Trafikkontoret Göteborgs stad, 2011).

Even though the amount of journeys by bicycle is supposed to increase, the amount of accidents should be lowered. Therefore, the Traffic and Public Transport Authority aim to improve the traffic safety and the subjective safety among other factors. Extractions from Swedish Traffic Acquisition Database show that the last years, the number of accidents has decreased according to Figure 1.

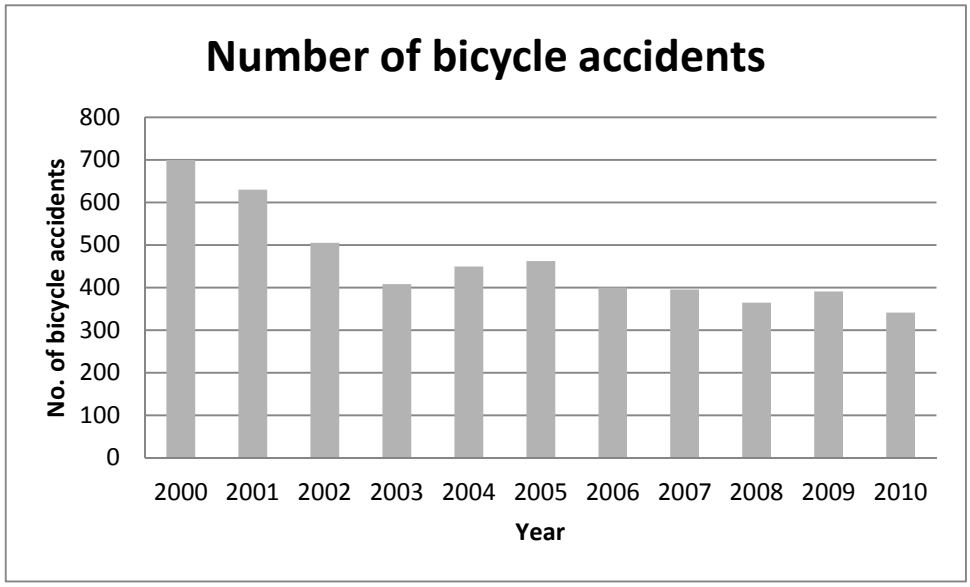


Figure 1. The number of bicycle accidents in Gothenburg during the the 21th century.

Furthermore, there is a national programme called "Vision Zero" adopted by the parliament 1997 that aims to decrease the number of fatal and severe traffic accidents, including all means of transport (Trafikverket, 2010). However, if focusing only on decreasing the number of severe accidents, there is a risk that the number of less severe accidents will remain. Even though the traffic environment becomes safer with regard to fatal and severe accidents, the risk of less severe accidents will affect the subjective safety for cyclists. A high subjective safety is important to make more people travel by bicycle, according to the striving that the City of Gothenburg has for the future.

To achieve this goal, increase the subjective safety and make it even safer to travel by bicycle, measures have to be carried out. Different measures apply in different "areas", e.g. campaigns to affect cyclists to behave in certain ways (e.g. wear helmets), changing of traffic rules or planning the design of roads in ways that will increase safety.

The design of bicycle roads and crossings can vary between different places. During the years, the Traffic and Public Transport Authority has given different directions for the designs, why design of crossings and roads for cyclists is inconsistent. It is

important to know what designs are the best ones from a safety point of view to in the future build as safe as possible. To know which design is the safest and to be able to make the most beneficial measures to increase safety, it is necessary to know the causes for accidents at different designs.

1.1 Aim

The aim of this report is to find parameters affecting the risk for bicycle accidents in general and specifically from a traffic design perspective.

1.2 Problem

In order to fulfill the aim of the report, a number of questions are to be answered:

- What previous research on bicycle accidents has been made?
- What is done in order to prevent bicycle accidents in terms of design of bicycle paths. What guidelines are there for planning and design?
- What different categories of bicycle accidents are there?
- How is the distribution of accidents between different categories?
- What parameters and situations affect accidents in each category?
- On what types of roads do bicycle accidents occur?

1.3 Delimitation

The study is based on statistics from bicycle accidents in the municipality of Gothenburg. The study will be performed for accidents that have taken place between 01.01.2009 and 31.12.2010.

1.4 Method

To investigate what affect the risk for bicycle accidents, knowledge about cycling in general is necessary which generates a need for interviews and literature studies. The study is continued by use of the database STRADA to receive information of each bicycle accident in Gothenburg from 01.01.2009 to 31.12.2010. All information is then compiled in Excel to make up the foundation to the analysis. The results from the analysis of the bicycle accidents are then compared to the fact about bicycle road design, traffic rules and subjective safety to come to a conclusion.

1.5 Outline of report

Chapter 1 – Introduction describes the background, aim, problem, delimitation and method of the project. It also includes a vocabulary.

The chapters 2 – Cycling in Gothenburg, 3 – Traffic safety for cyclists, 4 – Cyclists' subjective safety, 5 – Previous research about bicycle accidents and 6 – STRADA will read up on the background information gathered through literature study and interviews. The contents will partly be used for comparison with the result from the accident study.

In chapter 7 – Methodology, it is possible to find a detailed description of the different steps of the study. The chapter contains for example input data as well as assumptions.

The results are presented in chapter 8 - Results and are then analyzed in the following chapter, 9 – Analysis, which is divided similarly as the results chapter and pays attention to possible interpretations that might be made from the results of the study.

The report is ended with chapter 10 – Discussion and chapter 11 – Conclusion, to emphasize difficulties and sources of error as well as summing up those results that are of greatest importance.

1.6 Vocabulary

Akutsjukhus – Emergency hospital

Boverket - The Swedish National Board of Housing, Building and Planning

Cykelbana – Bicycle path

Cykelfält – Bicycle lane

Cykelprogrammet 1999 – The cycling programme 1999

Cykelöverfart – Bicycle crossing

Gågata – Pedestrian street

Gångfartsområde – Walking speed area

Historik, kunskap och analys – History, knowledge, analysis

Kommunfullmäktige - Municipal assembly

Nollvisionen – "Vision Zero"

Offentlighets- och Sekretesslagen - the Public Access to Information and Secrecy Act

Personuppgiftslagen – Personal Data Act

SKL, Sveriget kommuner och landsting - Swedish Association of Local Authorities and Regions

Tillsynsmyndighet - Regulatory authority

TPU, Trafikkontorets projekterings- och utförandeanvisningar - the Traffic and Public Transport Authority´s Planning and Design Directions

Trafikkontoret - the Traffic and Public Transport Authority

Trafikverket - the Swedish Transport Administration

Trafiknämnden - Traffic Committee

Trafiksäkerhetsprogram – Traffic safety programme

Transportstyrelsen – Swedish Transport Agency

TRAST, trafik för en attraktiv stad – Traffic for an attractive city

TTA, Trafikkontorets Trafiktekniska Anvisningar - the Traffic and Public Transport Authority´s Technical directions for Traffic planning

VGU, vägars och gators utformning - the Design of Roads and Streets

VTI - Swedish National Road and Transport Research Institute

Vårdcentral – District healthcare centre

Vägverket – the Swedish Road Administration

Åtgärdskatalog för säker trafik i tätort - Catalogue of measures for safe traffic in conurbation

Övergångsställe – Zebra crossing

2 Cycling in Gothenburg

The city of Gothenburg aims to increase the share of journeys with bicycle even more and a priority of theirs is the safety of the unprotected road users. 10 % of all journeys in Gothenburg is made by bicycle which is just over 100 000 journeys every day. This is slightly below the mean value for Sweden (Trafikkontoret Göteborgs stad, 2012).

The goals Gothenburg has for cycling origins from "The cycling programme 1999" which is focusing on safety and interest for cycling (Trafikkontoret Göteborgs stad, 1999). The programme included a goal of that 12 % of all journeys should be made by bicycle in 2010, which was not fulfilled. Nevertheless, the share of cycle traffic has increased from 7 % in 1989 (Trafikkontoret Göteborgs stad, 2008).

In Gothenburg, there are primarily two documents that are used when planning for bicycle traffic. The first document is the cycling programme from 1999 which was developed to establish goals for the bicycle traffic and guidelines for the work of the Traffic and Public Transport Authority. A new cycling programme is supposed to be carried out during 2012. The second document is the report "Traffic safety programme 2010-2020", which is the foundation for the future work with all means of traffic in Gothenburg (Trafikkontoret Göteborgs stad, 2009[1]). It states the goals of the City of Gothenburg as well as how they will be accomplished. The report "History, knowledge and analysis" is a preparatory work for "Traffic safety programme 2010-2020" and analyses all traffic accidents in Gothenburg between 2000 and 2007 that has been reported to the health care, approximately 13 000 (Trafikkontoret Göteborgs stad, 2009[2]).

Every year, "The cycling year" is published by the Traffic and Public Transport Authority to sum up the year. It presents both numbers about cycling in Gothenburg as well as the work the Traffic and Public Transport Authority has performed concerning bicycle traffic.

Except the "cycling programme" from 1999, the city of Gothenburg works towards the goals set in "traffic safety programme" which are a conclusion made after a report called "History, knowledge and analysis" where just over 16000 traffic accidents have been analyzed. The cycling programme concerns only cyclists while the traffic safety programme concern all traffic users.

The traffic committee is the political instance that Traffic and Public Transport Authority is led by and they are engaged by the municipal assembly according to the result of the election.

In Gothenburg the general bicycle road network consists of 450 kilometers bicycle roads and 140 kilometers of roads where cyclists are supposed to use the same road as the motor vehicles, which the Traffic and Public Transport Authority is in charge of. To ensure the quality of the bicycle roads, they are inspected every or every second month (Trafikkontoret Göteborgs stad, 2011).

There are 30 kilometers cycle routes with extra priority, which are the ones from the centre of Gothenburg to Partille, Mölndal, the bridge Älvsborgsbron along Södra Älvstranden and to Eketrägatan. Those roads should be as a highway for bicyclists and are maintained all year. The stretches were determined by the Traffic Committee in 2007 and no degradation of them is allowed (Trafikkontoret Göteborgs stad, 2009).

Furthermore, new projects are tested along the stretches. Cyclists should be prioritized in intersections. At some places radar detection should be installed to give the cyclist

green light without having to stop and press a button. Along the rest of the stretches cyclists should be given the first priority right after the public transportation.

To increase the safety for the cyclists the Traffic and Public Transport Authority has focused on for example elevated crossings, lighting, reducing the speed where cyclists and motor vehicles share road, adjustment of permanent obstacles and separation of cyclists and pedestrians.

The usage of helmets in Gothenburg was 2004 around 40 % which was far more than the 21 % that was the average usage in Sweden (Trafikkontoret Göteborgs stad, 2008). There has been a large and steady growth of the number, from 8 % in 1991 to 53 % in 2009 (Trafikkontoret Göteborgs stad, 2010).

To increase the amount of bicycle traffic the Traffic and Public Transport Authority are using different measures as projects and campaigns. A large project, called "Styr och ställ", includes 800 bicycles at 50 stations that are available to borrow. The aim is to increase the share of journeys by bicycle by making it easier to access a bicycle (Göteborgs stad, 2012[1]).

The Traffic and Public Transport Authority´s plan for the area within the moat is that there should be no dedicated bicycle roads. It is an idea which is interesting to investigate the outcome from due to the public opinion that it is difficult and unsafe to travel by bicycle in the city centre. Brunnsparken and Kungsportsplatsen (and Östra Hamngatan) will be in focus since they are extra complicated from a traffic situation point of view with trams and buses as well as cyclists and pedestrians all sharing the space.

3 Traffic safety for cyclists

Traffic safety can be influenced from different perspectives such as design, traffic rules, behaviour affecting measures and improvements when deficiencies are noticed. Here, the design of bicycle paths and the traffic rules for cyclists will be described.

3.1 Design of bicycle paths

Generally for traffic in Sweden, there are two standards that can be used when designing a road, VGU and TRAST. In Sweden, the design of roads should follow the guidelines in VGU. VGU means "the design of roads and streets" and is a document provided by the Swedish transport administration that gives instructions for how roads should be designed. VGU includes all means of traffic and therefore concerns bicycle traffic as a part of some chapters (Vägverket, 2004). TRAST means "traffic for an attractive city" and does not give detailed instructions regarding the design as VGU does. TRAST is a help to plan for a sustainable and attractive city made by Swedish transport administration and SKL (Swedish Association of Local Authorities and Regions) together with Boverket (Sveriges kommuner och landsting et al, 2007).

Catalogue of measures for safe traffic in conurbation is a general description of different measures used and discussed today to increase traffic safety in conurbations. Of these measures, nine consider bicycle traffic (Sveriges Kommuner och Landsting, 2009).

Specifically for bicycle (and moped and pedestrian) traffic planning, there is one national document for designing for bicycle traffic, a report called "GCM-handbok" published 2010. It is a manual used by municipals published by the Swedish transport administration and SKL (Swedish Association of Local Authorities and Regions) and is supposed to be a complement to VGU and TRAST (Sveriges Kommuner och Landsting, 2010).

Regarding traffic in the municipality of Gothenburg, the Traffic and Public Transport Authority has issued the Technical directions for Traffic planning (TTA) as well as Planning and design directions (TPU) which are supposed to be used when planning traffic in the city of Gothenburg (Trafikkontoret Göteborgs Stad, 2012[2]).

Bicycle paths should primarily be designed from aspects regarding safety and subjective safety. Secondary aspects to consider are comfort and well-being of the cyclists (Vägverket, 2004). Subjective safety is not to be achieved at expense of actual safety. There might be cases where increasing of subjective safety might affect the actual safety negatively, since the cyclist may be tempted to take greater risks (Trafikkontoret Göteborgs Stad, 2008[2]).

According to VGU, the level of separation from motor vehicle traffic is crucial for the safety of cyclists. There are different levels of separation and which to choose when designing bicycle paths is mainly dependent on the speed and density of the motor vehicle traffic (Vägverket, 2004).

Separation from pedestrians is also necessary to consider when designing bicycle paths. That is not primarily for safety reasons, but to increase the subjective safety of the pedestrians. Stretches where this sort of separation is extra important are for example where the speed and density of bicycle traffic is high as well as where the density of pedestrians with special needs is high, i.e. where children, elderly or disabled people are walking (Vägverket, 2004).

According to VGU, there are seven different kinds of separation between bicycle traffic and motor vehicle traffic on stretches; mixed traffic, bicycle lane, shoulder, separation with kerbstone, separation with division stripe, separated bicycle path along a road and bicycle path completely separated from other roads, these are illustrated in Figure 2.

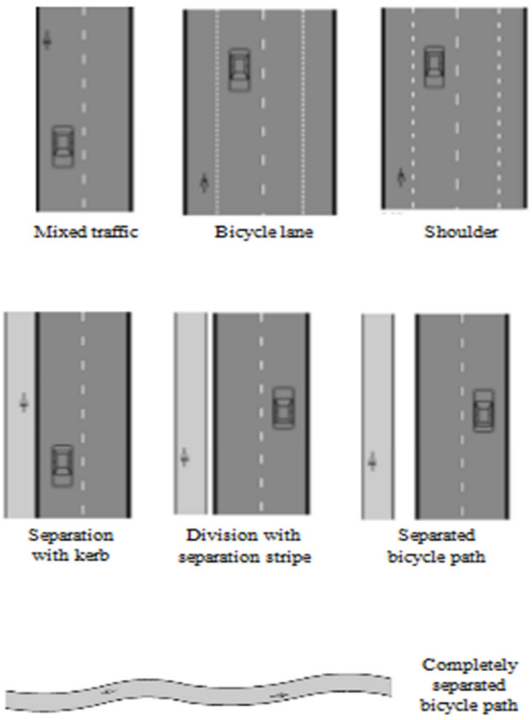


Figure 2. Separation of cyclists (Vägverket, 2004 edited)

Mixed traffic means there is no separated space for cyclists, therefore they share the roadway with motor vehicle traffic.

A bicycle lane is a solution where the cyclists are supposed to cycle on the roadway, dedicated an own space separated from motor vehicle traffic by markings on the pavement. Bicycle lane markings consist of a line of white squares with a distance between them which is equal to the side of a square. An alternative marking of bicycle lane is a solid line, used together with a symbol for bicycle traffic. If the bicycle lane is separated with the solid line, there is a legal difference from when the ordinary bicycle lane marking is used; it is allowed for other vehicles to cross an ordinary bicycle lane, while it is forbidden to intrude a bicycle lane marked with a solid line (Nilsson, 2000).

The shoulder of the road should be used by cyclists if there is no certain path intended for them to use. However it is not exclusive for cyclists; slow moving vehicles and mopeds of class 1 may use the shoulder as may other vehicles if needed to facilitate the flow for other traffic. The shoulder as well as bicycle lanes and paths can also be used by pedestrians if there is no certain path intended for them to use (Vägverket, 2004).

The four more separated kinds of paths for cyclists can be counted as three levels of safety. Separation with kerbstone or division stripe has the lowest level of safety,

followed by separated bicycle path along a road. Which separation form to choose is dependent on the size of flow of cyclists and the speed of motor vehicles on the nearby road. The separation can be complemented with a barrier. Bicycle paths completely separated from other roads have the highest level of safety relative the motor vehicle traffic (Vägverket, 2004).

There is a special type of bicycle path, the "summer bicycle path", which differs from ordinary bicycle paths basically in the respect that it has a lower standard and no winter maintenance. Summer bicycle paths have no division into different separation forms but the reason for using them is to give cyclists an option instead of using the motor vehicle road on stretches between the permanent bicycle path networks. Summer bicycle roads are often not newly constructed but may constitute of forest roads, old railway embankments etc. (Hedström, 2008).

The solution to use bicycle lanes is preferred in some cities because it is regarded as increasing safety as well as saving space (Trafikkontoret Göteborgs Stad, 2008[2]). Results from several studies show that the number of accidents was lowered with 30 % after introduction of bicycle lanes on stretches. If the flow of cyclists is larger than about one cyclist/minute, the interaction between cyclists and drivers of motor vehicles becomes better because the motor vehicle drivers is more aware of the possible presence of cyclists (Sveriges Kommuner och Landsting, 2009). An aspect to consider of bicycle lanes is that accumulation of snow might be covering them during winter time, which possibly makes cyclists use the lane for motor vehicle traffic (Vägverket, 2004). Concerning bicycle paths in the city of Gothenburg, the recommendation is to construct two-way paths for cyclists, in the same level as pedestrians. The reason is the ambition to give cyclists a higher subjective safety (Trafikkontoret Göteborgs Stad, 2008[2]).

According to the 2 § statute about road traffic definitions, a bicycle crossing is a part of a road which is designed to be used by cyclists or drivers of mopeds class II to cross a roadway or a bicycle path. It should be indicated by road marking, which consists of white squares with a space between them that are equally long as a side of a square, according to the 4 chapter 8§ way mark statute. No road sign for bicycle crossings exists at present.

In the city of Gothenburg, the elevated bicycle crossings should always have a red colour. The red colour does not have a legal meaning but it makes the passage more obvious and has a positive effect on traffic safety (Trafikkontoret Göteborgs Stad, 2008[2]).

According to several studies, the safety for cyclists in intersections is lower the more separated the bicycle path on the connecting stretch is from the motor vehicle traffic. Particularly, there is a problem when the bicycle path is completely separated and the bicycle crossing is placed with a distance from the intersection, as is a common design for two-way bicycle paths. The reason is that the interaction between cyclists and those drivers of motor vehicles which are about to make a turn is decreased, in the same way as bicycle lanes makes interaction improved, as mentioned above (Sveriges Kommuner och Landsting, 2009). Despite this, the Planning and design directions for the city of Gothenburg recommend that the space between a bicycle crossing and an intersection between motor vehicle roads or a roundabout should be long enough for a car to fit there, i.e. 5 meters.

A concept for increasing availability for cyclists, which might also help to increase the safety, is to introduce so called green waves. It means that the traffic signals in

several intersections after each other will turn green and stay green long enough for cyclists to pass all intersections without having to stop repeatedly. Introducing this concept would make cyclists travel in a more even speed and not having to drive fast to reach the next intersection in time for green light. It might also decrease the impulse for cyclists to drive against red light (Dellensten, n.d.). Green waves are used in for example Copenhagen city on Nørrebrogade where on average 30000 cyclists pass each day. The waves are set so that cyclists will adapt their speed to 20 km/h on the 2.5 km long stretch. The green wave has one direction at a time, so that cyclists going towards city centre have a green wave during mornings and cyclists going from the city centre have a green wave during afternoons (Jespersen, 2007). Introducing green waves have resulted in a change of speed for cyclists from 15.5 km/h to 20.3 km/h and those who earlier used to travel at a higher speed now adapted to the lower speed and the flow is more even (Jönsson, 2010).

3.2 Traffic rules for cyclists

Traffic rules that regard cyclists can be experienced as unclear. In situations that involve both motor vehicles and cyclists, there are sometimes requirements of both the driver of motor vehicle and the cyclist to show consideration to each other even though there at the same time is a rule saying that one of them is obligated to let the other pass. When walking and pushing the bicycles on foot, cyclists are classified as pedestrians.

Regarding situations where cyclists and motor vehicles meet in an intersection, there are different rules depending on who is turning etc. If a cyclist is coming from a bicycle path and crosses/enters a road, the cyclist has a responsibility to give way to motor vehicles. However, there is also a responsibility for drivers of motor vehicles to adapt the speed so that no danger will arise for cyclists, when passing a bicycle crossing. For motor vehicles applies also that when making a turn in an intersection and then reaching a bicycle crossing, the driver is supposed to give way to cyclists that are about to drive out on the crossing. The same rule applies also when a motor vehicle is turning out from a roundabout (Transportstyrelsen, n.d.).

In 2009, the Swedish Transport Agency came with a suggestion to introduce road signs for bicycle crossings and change the regulations of them. The signs would imply that on the crossing, drivers of motor vehicles should be obligated to give way to cyclists and cyclists would no longer be obligated to give way to motor vehicles. The reason for wanting to introduce such a rule would be to increase the availability for cyclists and create a more uniform traffic regulation (Transportstyrelsen, 2009[1]). In addition, it would contribute to giving cycling a higher status in order to make more people chose bicycle as means of transport. However, the introduction of new regulations for bicycle crossings might imply reduced traffic safety for cyclists. When introducing similar regulations for pedestrians on crossings the number of minor injuries was increased with 15-20 % and the number of severely injured was increased with 5-10 %.

Except for rules considering the interaction with other road users, there are also rules for where to cycle. There is an order of priority in which cyclists should use different separation forms if several options for bicycle paths are available. If there is no alternative, the road for motor vehicles is to be used. The shoulder of the road is to be used by cyclists when there is one. If there is a bicycle lane or any kind of separated bicycle path available, the shoulder or the roadway is not to be used by cyclists (Vägverket, 2004).

When cycling on a bicycle path, as on an ordinary road, the cyclist should cycle to the right and overtake other cyclists on the left.

Cycling on walking paths, squares and sidewalks is not allowed. However, it is allowed for cyclists to use a zebra crossing to cross a road if necessary. It is allowed to cycle on a pedestrian street or in walking speed areas, but the highest allowed speed is walking speed and cyclists are obligated to give way to pedestrians (Transportstyrelsen 2009[2]).

4 Cyclists' subjective safety

When planning for cyclists, it is desirable to try to obtain some level of comfort. Subjective safety is one part of the concept of comfort together with convenience and well-being (Ihs and Magnusson, 2000). In this context, subjective safety means the cyclists' psychological experience of how safe a situation is, while safety is the actual physical safety (Splitvision, 2010). A subjective safety that is experienced as low might affect some cyclists so much they chose not to use the bicycle as means of transport (Niska, 2007).

There are situations which cyclists experience as dangerous and there are situations which are dangerous for the cyclists and those are not always the same. One example is complicated traffic situations. Those require of the cyclists to be cautious, which generate less accidents, but the cyclists' subjective safety may be decreased.

Two different studies of cyclists' perception of safety are presented below; they are made in different cities but show similarities regarding what cyclists think affects safety.

4.1 Safety and subjective safety in Umeå and Linköping

A study made by VTI (an independent institute of research and development in the transport sector) in 2007 investigates cyclists' opinions on the standard of bicycle paths. The report pays attention to factors on and around the bicycle path, which cyclists state they experience as dangerous or irritating and hence are related to the safety and subjective safety. Factors frequently mentioned by the cyclists in the study are deficiencies in the design or maintenance of the road, cycling in mixed traffic, situations that cause need for evasive maneuvers, hesitance regarding traffic rules and conflicts with other cyclists.

The study is based on discussions that groups of specifically selected cyclists participated in, which means the result is not general. The cyclists in the study cycle regularly, which indicates they are more experienced and more familiar with bicycle traffic than the average cyclist. In addition, the participants live in cities which are relatively well planned for cyclists. The problems for and opinions of cyclists in other places may be different due to this. However, this method is a good way of showing attitudes (Splitvision, 2010) and the result of the study gives interesting indications on common factors that affect many cyclists.

Regarding the design of the roads there are many aspects that are experienced by the cyclists in the VTI study as creating a sense of insecurity. The situation that is most often considered as dangerous is when there is no dedicated bicycle path and the cyclists need to cycle among cars and other traffic. One common problematic situation for cyclists seems to be when there is uncertainty about where they are supposed to cycle. For these cases as well as for when cyclists purposely chose to cycle on a road that is not meant for them, for example because it is much shorter, clearly a sense of insecurity arises for the cyclists.

One example of a particular type of road design that seems to make the cyclists in the study feel unsafe is bicycle tunnels. This is a solution with a good purpose, to let cyclists not need to cross a road in the same plane as cars and other traffic. However, the result is that some cyclists yet feel unsafe because of the risk for conflicts with other cyclists in and around a tunnel where the visibility might be insufficient and steep slopes and narrow curves often occur.

Another factor that affects the subjective safety for cyclists is situations that cause need for evasive maneuvers, which in many cases are related to design and maintenance. Such problems that were mentioned in the study are for example kerbstones in connection to or across the bicycle path and deficiencies of the road surface. However, the reason for evasive maneuvers that the interviewed cyclists most frequently mentioned was conflicts with other road users. These conflicts, in turn, come from for example hesitance regarding traffic rules and playing children (Niska, 2007).

4.2 Safety and subjective safety in Gothenburg

Trygghet och säkerhet vid cykling i Göteborg (Splitvision Research, 2010) is a survey about the inhabitants' opinions of cycling in Gothenburg, a task from the Traffic and Public Transport Authority. The survey was based on discussions in focus groups of specifically selected cyclists and car drivers as well as depth interviews with cyclists and pedestrians (and a sample study based on telephone interviews with randomly selected citizens of Gothenburg). The factors that the participants experienced as positively or negatively affecting the safety/subjective safety are presented in this chapter. The survey did not make a difference between safety and subjective safety.

Factors that positively affect the safety and subjective safety:

- clearness (knowledge about traffic rules, clear interaction between road users)
- good visibility and separation of different road users
- roadway is free from obstacles and crossings

The number of factors, which according to the participants in the survey have a negative effect on the safety and subjective safety, is larger than the number of positive factors. These are:

- bad weather (rain, slipperiness due to ice and gravel)
- darkness
- deficiencies in the maintenance of the road pavement such as pot holes and glass on the roadway
- reduced visibility (due to vegetation)
- poor clearness (regarding traffic rules and signs)
- slopes and tunnels etc.
- locations where there are few cyclists
- intersections/crossings and exits where there are motor vehicles
- traffic light
- tram tracks
- pedestrians

Safety is a substantial factor which cyclists consider when valuing cycling. According to the study there are in total three factors (in order of priority); functionality (what needs to be done or sacrificed to be able to choose cycling), flow optimizing and safety.

The focus group discussions reveal that there are some places in Gothenburg, which several cyclists agree on that they for some reason experience as less secure.
Generally, the bicycle paths in the city centre are experienced as less secure than the

bicycle paths in the fringe areas since the traffic situation there is more mixed; different road users more often need to share space. In addition, cyclists experience that the clearness is low and that it can be difficult to know where they are supposed to cycle. Some of the particular places which are mentioned as not so good from a cyclist´s point of view are: Linnégatan, Nya Allén, Jaegerdorffsplatsen and Kungsportsplatsen.

5 Previous research about bicycle accidents

In this chapter, it will shortly be presented what similar studies have been made. The aim is for the reader to know where more information can be found.

Similar studies to the one presented in this report has previously been made. In 2009 VTI, the Swedish National Road and Transport Research Institute did a study of approximately 18 000 health care reports from bicycle accidents in Sweden between 2003 and 2006. It is interesting to present some of VTI:s result to compare them to the ones from this study. In the study by VTI it was stated that 72% of all bicycle accidents were single accidents, 17 % were motor vehicle related and 8 % involves more than one bicycle. Among the single accidents slippery surface were the most common cause and the second most common cause for single bicycle accidents were collision with kerbstone. Moreover, 1/3 of the reports from the single accidents have a lack of information and only state that the cyclist fell (Thulin & Niska, 2009).

In "History, knowledge and analysis", they state that 70 % of all bicycle accidents in Gothenburg between 2000 and 2007 were single accidents, 17 % involved a motor vehicle, 7 % involved another cyclist and 10 % were caused by bicycle failure. In addition, they state that the locations with the most accidents are the most frequented locations and the locations with a complex traffic situation. A number of locations are listed as example for where a large number of accidents had occurred e.g.:

- Vasagatan, Viktoriagatan, Östra Hamngatan and Kungsportsavenyen.
- Stampgatan, Redbergsvägen, Karl-Johansgatan and Landsvägsgatan.
- Linnégatan, Sprängkullsgatan and Övre Husargatan.
- Korsvägen and Sankt Sigfrids Plan
- Älvsborgsbron and Götaälvbron,
- Mariaplan, Djurgårdsplan and Lemmingsgatan
- Munkebäcks torg/Torpagatan and Wieselgrensplatsen (Trafikkontoret Göteborgs Stad, 2009[2]).

Moreover, as a task from the Traffic and Public Transport Authority, a company called Splitvision Research carried out a report about cyclists' subjective safety in 2010. The report is presented in chapter 4.2 "Safety and subjective safety in Gothenburg".

The conflict technique is a method for studying intersections in order to gather information of the traffic situation and hence being able to calculate the risk for accidents. It combines engineering with knowledge about human behaviour and has been developed by researchers at LTH, the Faculty of Engineering at Lund University, during a time period of 20 years.

The conflict technique is relatively easy and efficient; it is not accidents but conflicts that are studied, dangerous situations in the traffic which require of the road user to make a maneuver in order to prevent an accident. The information about conflicts in an intersection is used together with other assessment methods, such as studies of accidents and traffic counts, to create an image of the traffic safety (Lunds Tekniska Högskola, n.d.). In average, 10000 conflicts occur for every accident which is reported to the police and which has caused injuries to a person which is why the conflict data provides a good basis for estimation of risk for accidents (NTF, n.d.).

Since the course of event for conflicts and accidents has proven to be similar, the results of conflict studies can also be used for identifying causes of accidents and hence result in suggestions for prevention measures (Lunds Tekniska Högskola, n.d.).

6 Description of the data base STRADA

STRADA is short for "Swedish Traffic Accident Data Acquisition" and is an information system consisting of information from road traffic accidents which have occurred in Sweden.

Most of the information in this chapter originates from the report "STRADA Slutrapport" published by the Swedish Transport Agency. The report is from 2007 and is the most recent document regarding STRADA. The material is complemented with information from an interview with Tomas Fredlund working with STRADA at the Swedish Transport Agency (Vägverket, 2007).

6.1 History

In 1996 the Swedish Road Administration got the mission from the Swedish government to start an information system based on road traffic accidents and injuries in the road traffic system, which came to be STRADA.

There was a need for a new system since the old information about traffic accidents was insufficient in terms of lack of quality of the judgement of the injuries and only consisted of information from police reports. Because of that, there were also a large number of unknown accidents regarding unprotected road users. The aim of starting a new information system was to make it easier to use the right measure to increase the traffic safety, to support the work with traffic safety on local, regional and national level and to decrease the amount of double work. In 2009 the Swedish Transport Agency was established and took over the responsible over STRADA from the Swedish Road Administration. That was due to the fact that the Swedish Transport Agency is a regulatory authority and has the same type of supervision regarding the air, sea and rail transport.

6.2 Content of STRADA

STRADA should consist of information from all road traffic accidents in Sweden. A road traffic accident is defined as an incident that has taken place in traffic at a road. In addition, at least one vehicle had to be involved and at least one person has to be injured. In this context, a road is a road, a street, a square or another location that is usually used for traffic with motor vehicles. Additionally, it could be a route that is constructed for bicycle traffic or a pedestrian or horse street alongside a road as described above. In addition to the road traffic accidents with at least one vehicle involved, accidents where someone has been injured in road traffic environment should also be included in STRADA (Mattsson & Ungerbäck, n.d.).

The information in STRADA consists of both police reports and hospital reports. Since 2003, the police are by law required to report to STRADA when they attend to a traffic accident. The emergency hospitals need to have a contract with the Swedish Transport Agency to be required to report to STRADA. Furthermore, the patient needs to fill in a consent form to allow the hospital to pass the information to STRADA. In 2011, 94% of all emergency hospitals in Sweden had a contract with STRADA. STRADA was introduced in 1999 in Göteborg which was one of the areas where STRADA was first started. Since 1999 both Östra sjukhuset and Sahlgrenska University Hospital is acceded to STRADA and report all traffic accidents. In addition, in 2000 Mölndals sjukhus acceded as well (Transportstyrelsen, 2011).

The Swedish Transport Agency has discussed the possibility to have a law that makes it compulsory for the hospitals to report to STRADA in the same way as for the police. With a law like that, all information available could be used and a higher standard on the reports could be required. Nevertheless, there is a disadvantage with taking away the option for the patient to participate or not. If the patient has not given its permission, the information would be governed by the law for patient data (Swedish law (2008:355)) which would make it harder to give users permission to use STRADA.

Since an accident registered by STRADA has to be known by either the police or a connected/contracted emergency hospital, there are a number of unrecorded cases, i.e. injured people that either go to a district healthcare centre or do not visit a hospital at all. Tests have been made regarding to include district healthcare centre in STRADA in Skåne and in Gothenburg. In Skåne it turned out that not as many extra cases as thought were caught up. However, it probably differs a lot, in terms of number of injuries from traffic accidents, between different district healthcare centres. The ones either very far from an emergency hospital or the ones in the same building as an emergency hospital may have a larger share of patients with traffic injuries. For the first case it is because if it is too far to the emergency hospital a closer alternative is chosen, for the other case the district healthcare centre may get some of the less severe injured patients from the emergency hospital during high occupancy. Including district healthcare centres is desirable, but it is a question of resources/money.

For the hospitals, the collaboration with STRADA means some extra work, approximately 1.5 full time jobs in Gothenburg, converted to the cost for each report it would mean 270 SEK. Therefore, there is a need for some kind of compensation to the contracted hospitals. The Road Administration came up with a model which meant that the hospitals got paid less money per year for each year they are contracted, until they finally received nothing in reward. This turned out not to be a very good system since a hospital working with STRADA for many years could receive nothing in return, while a hospital recently connected got much more. Therefore, the hospitals now receive an equable compensation.

The main difference between the reports from the police and the health care is that the police report describes what has happened with the accident in focus, while the health care reports have the injured person as a starting point. In addition, the severity of the injuries can be seen in the health care report and in the police report is added a sketch of what had happened during the accident. Other than that, most parts of the reports consist of the same information. An important part of registering an accident for both the hospital and the police is to specify the location of the accident on a map as correctly as possible. As mentioned above, sometimes the healthcare reports could lack in terms of quality, which could be since the patients themselves fill in the report.

To guarantee the quality of the police reports, the police may in the future be able to do the registration digitally on the location of the accidents. By doing so, it will make the registering faster and the position more correct. However, as the situation is for now the policeman fills in a report on paper. There is a manual available for the police, describing how the STRADA report should be filled in, made by the Swedish Road Administration. Besides not reporting on location, there are some other shortcomings in the police reports. First of all, the sketches as well as the description of what had happened are not always good enough. Secondly, there is lack of positioning in terms of accuracy and precision. Finally, they do not have the knowledge about all accidents concerning single accidents with unprotected road

users, i.e the accidents where no one has contacted the police. The report is then sent to a central registration office where another police compiles the report into digital form. Thenceforth, the information is sent to a first STRADA database.

At the hospital, the template report is made by a group of nurses and doctors. It is filled in by the patient if possible and complemented by hospital employees. After the patient has filled in the report a nurse compiles and digitalises it and then send it to the first STRADA database. Regarding the hospital reports, the main shortcoming is that all emergency hospitals, as well as any district healthcare centre, are not connected to STRADA.

For neither the reports from the police nor from the hospital the information is checked by anyone to observe incorrect information or lack of quality in the reports. Resulting in, neither the police nor the hospital is getting any kind of reprimand if the reports do not satisfy the demand in the manual.

When the reports is in the first database of STRADA the accidents from the hospital and the police are matched to see which reports belong to the same accident. Before the information is available for users of STRADA the reports are de-identified and sent to another database. De-identified means that the civic registration number is automatically transformed to sex and age. Also, all car registration numbers are deleted.

6.3 Using STRADA to extract information

When STRADA is used to extract information, several settings can be made to obtain the accidents that are looked for. The settings concern the following:

- Geographical limitations have to be made, if not accidents from all of Sweden is wanted.
- The date and time interval for the wanted accidents is set.
- It can be chosen if the selection should result in accidents that have to be known by the health care or the police or both.
- Age and sex of the persons involved in the accidents can be selected.
- If accidents or injured people are wanted is set.
- The type of accident can be selected, for example a bicycle accident or an accident involving an animal.
- Choices can be made about involved vehicles.
- The user can search for individual words from the description of the accident.
- The type of place for the accident, for example intersection or a roundabout can be set.
- Attribute; pedestrian or bicycle crossing can be searched for.
- Specific hospital can be searched for.
- Choices about the severity of the injuries can be made.

When all settings are completed, the result is presented as a map over the chosen area with marks of all accidents in the assortment. Also, all the accidents are shown in a list where it is possible to see the mark on the map connected to it and the linked police report, health care report or both. It is possible to open a statistic report in Excel where all information concerning the selected accidents is compiled.

STRADA does not in a clear way give information about the reason for the accident, why this Master´s Thesis aims to investigate that.

6.4 Secrecy

Due to the fact that STRADA receive information from the healthcare about patients, the information in STRADA is protected by the law of "Personal Data Act" and "the public access to information and Secrecy act". To meet these requirements, all information in personal level is first coded and then de-identified. All users of STRADA need to sign a document agreeing to follow these laws. It is not allowed to pass on the information from STRADA in a way that makes it possible to draw conclusions on individual level.

"The public access to information and secrecy act" regulates the protection of personal and economic circumstances on individual level. The law entered 2009 and replaced the former secrecy act. "The personal data act" is supposed to protect peoples individual integrity from being abused from personal data. The act regulates which data that is allowed to be processed and which data that can be seen as sensitive and is not allowed to be used. There are some exceptions, for example if the person gives its permission (Transportstyrelsen, 2010).

7 Methodology

Since the Swedish Transport Administration is working towards the "Vision zero" programme, the work with traffic safety is focusing on preventing fatal and severe injuries. However, with respect to the aspiration that more people should travel by bicycle in Gothenburg it is important also to work with preventing less severe injuries. This is due to that subjective safety affects the choice to travel by bicycle or not and subjective safety can be influenced by many kinds of dangers, not only those which might be fatal. That is why this report investigates accidents with all injuries.

7.1 STRADA

To carry out the investigation of bicycle accidents, the database STRADA was used since it consists of police and health care reports from a large amount of traffic accidents. The time span for which bicycle accidents in Gothenburg were studied was set to 01.01.2009 and 31.12.2010.

7.1.1 Assumptions

To perform this study, some assumptions had to be made. Some of these assumptions differ from what is normally used in the context of traffic safety. Others are assumptions recommended for use of STRADA, which are described as a clarifying.

Firstly, it had to be determined what caused the accident in those cases where it could have depended on several reasons. For this study, it was decided that the event which should be regarded as the crucial cause, the event that took place first. An example of an accident with several causing events can be when there is a dog suddenly crossing the bicycle path, so that the cyclist needs to make an evasive maneuver and therefore runs into a lamppost. In this case the crossing dog was the first event and therefore is counted as the cause, even though some would say that if the lamppost would not have been there, the accident may not have happened (it would only have been an incident instead).

Secondly, the accidents caused by situations where the cyclist needed to do an evasive maneuver due to another road user, are not counted as single accidents. The "disturbing" road user is regarded an involved traffic element even though no crash occurred because the cyclist fell due to the other road user. The reasoning for this is the same as for the decision to count the first of a series of events as the cause of the accident since it is considered as preferable from a preventing point of view.

Thirdly, dogs that are in some way involved in accidents are regarded as humans due to that they should be watched by a human, i.e. humans have responsibility for their dogs.

Finally, for categorizing accidents where a moped is involved, the moped is counted as a bicycle. That is because the driver is using the road on the same conditions as a cyclist. For the same reason, trucks, buses, motorcycles and cars are all counted as motor vehicles.

7.1.2 Input

According to the prerequisites of this study, the selection in STRADA was made to be able to analyze the accidents of interest.

The settings made were:

- County: Västra Götaland
- Municipality: Gothenburg
- Date: 01.01.2009 and 31.12.2010
- Search for: accidents, in the whole database
- Traffic element: bicycle

A possible alternative to choose bicycle as "traffic element" would have been to make another setting called "accident type" and chose bicycle. However, by setting "traffic element" to bicycle, the obtained result is more accurate. The reason is that if sorting on accident type, those accidents involving a bicycle but are not called bicycle accident will not be presented in the result. Involved traffic elements is something which is easier to put correctly in the protocol, compared to accident type which has several options to choose from.

Furthermore, instead of choosing "search for: accidents" it would have been possible to choose to search for injured persons. The result would have been that police and healthcare reports for all persons involved in accidents were presented in a list where there is no possibility to see which reports belong to the same accident. In addition to this, there is a risk that some healthcare reports from for example accidents which involve a car and a bicycle are not in the result list. That may happen if bicycle is not "filled in" in the car driver´s healthcare report.

7.1.3 Output

The settings in STRADA resulted in a map on which all the available accidents were pointed out and a list with the healthcare and police reports from those accidents. The reports were analyzed and the important information was noted for further processing.

The information gathered from healthcare and police reports to use in the analysis was:

- Age and sex of the involved persons
- Year and month of the accident
- The course of event
- Location for the accident
- Involved traffic elements
- Degree of injuries
- Location type
- Attribute (e.g. zebra crossing)

7.1.4 Processing of output data

All output data from STRADA was used to deciding the cause as well as the design type of the location of each accident. Every accident was investigated separately with help from available sources which except from STRADA was Google maps.

The accident´s course of event was discovered from police and/or health care report and explained in own words as a sentence. After that, categories of causes were set up. That was done when knowing what seem to be common causes for accidents.

Besides determining what caused the accident, it was also investigated at what type of road the accident took place. Notes were made concerning the design type of the road

for each accident. That information came from several sources. If there was a police report connected to the accident, the type of design could be seen in the sketch. In addition, Google maps was used to state the exact design of the location. At last, some conclusions could also be made from the notes in the reports, for example if there had been a road construction at the time.

A system for describing the location for each accident was developed from the notes about the designs of the accident locations together with the available common designs of roads for cyclists. The system assigns level of separation from other road users as well as (if any) type of intersection and attributes, i.e. aspects of the road design or traffic environment that might influence the accident cause.

When the study of all accidents during the first investigated year was completed, the accidents from the first quarter of that year were studied once more. That is due to that they can be considered as a take-off distance, for trying out what approach works better.

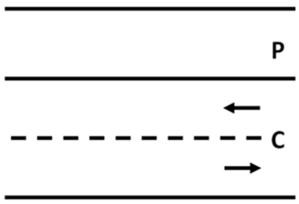
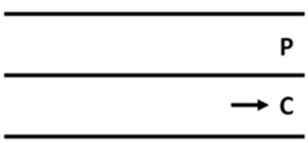
In the beginning of the project the categories were a lot more detailed than they finally became to be because the categories were too many compared to the total number of accidents. In addition, some of the categories consisted of only one or a few accidents why they were merged together.

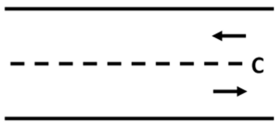
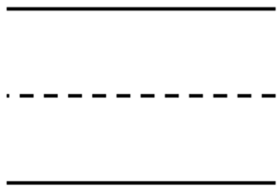
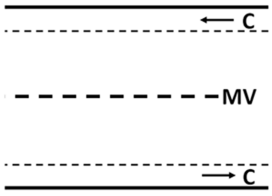
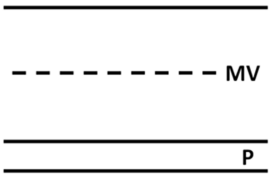
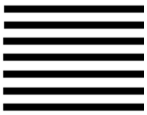
7.2 Road description

The type of road where each accident has occurred is described according to a system that assigns level of separation from other road users, contingent type of intersection (if any) and other aspects of the road design or traffic environment that might influence the accident cause, e.g. tracks, type of bicycle crossing.

The cyclists can be separated from motor vehicles and pedestrians in different ways. In Table 1 different separation forms are explained.

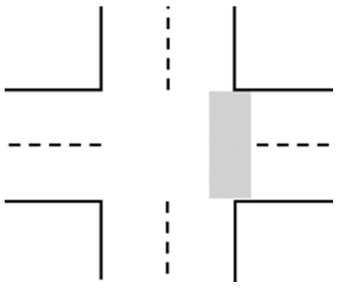
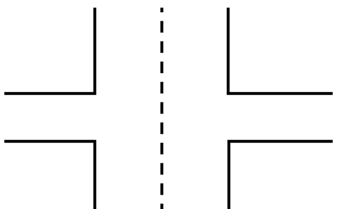
Table 1. Separation forms for cyclists.

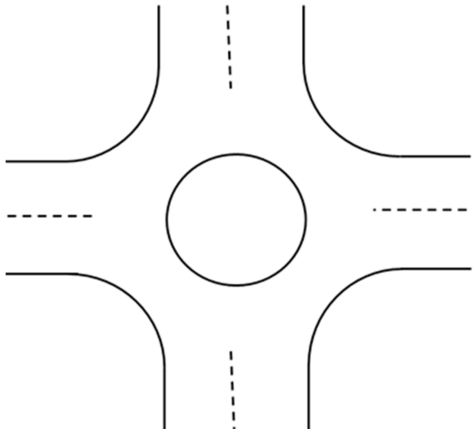
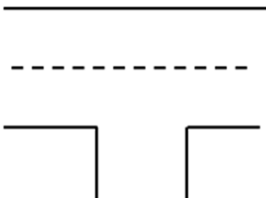
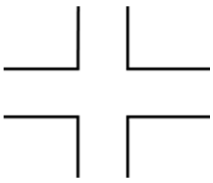
Pedestrians and cyclists are separated: Pedestrians and cyclists are separated from motor vehicles. Pedestrians and cyclists are separated from each other by a marking on the pavement. Cyclists are allowed in two directions.	
Pedestrians and cyclists are mixed: Pedestrians and cyclists are separated from motor vehicles. Pedestrians and cyclists share space.	
Pedestrians and cyclists are separated, cyclists in one direction: Pedestrians and cyclists are separated from motor vehicles. Pedestrians and cyclists are separated from each other by a marking on the pavement. Cyclists are allowed in one direction.	

Cyclists only: Cyclists are separated from both motor vehicles and pedestrians. Cyclists are allowed in two directions.	
Mixed traffic: Cyclists share space with motor vehicles.	
Bicycle lane: A road with mixed traffic. A separate lane is reserved for cyclists by means of a marking on the pavement.	
Sidewalk: Cyclist using a sidewalk or other space reserved for pedestrians.	
Zebra crossing	

In cases where there is some kind of intersection they can have different looks, as seen in Table 2.

Table 2. Intersection types.

Mixed intersection: An intersection where cyclists are mixed with or parallel to other road users.	
Separated intersection: A road for motor vehicles crossing a road for cyclists.	

Roundabout: A bicycle crossing in connection to a roundabout or a bicycle lane in the roundabout.	
Exit: An exit crossing the bicycle road.	
Cyclists/pedestrian intersection: An intersection between two roads for pedestrians and cyclists.	

At some locations, there are additional aspects of the road that might influence the cause of an accident. In addition to what is described above it is also noted if the accident were affected by tracks or parallel parking, if the bicycle track is led into the road without markings to warn the motor vehicle or if a bicycle road was available, but the cyclist did not use it.

For the accidents which took place in intersections, it was noted if the bicycle crossing is elevated, marked with red color or marked with white squares indicating a bicycle crossing.

7.3 Rejected method

In the beginning of this project, the idea was to choose a number of different locations in Gothenburg with the purpose to study the accidents that occurred at those places the past ten years.

With this method, two major problems were found. Firstly, using accidents only from specific locations would not give a sufficient foundation of information. Due to the small number of accidents, it would not be possible to draw any conclusions.

Secondly, since the period of time would be ten years or more, it would be a problem that the design of the locations could have changed during that period.

Thirdly, the rules for how accidents should be reported have been changed during the last years.

8 Result

During the two examined years 2009-2010, 719 accidents involving at least one cyclist were recorded in STRADA. Division of the causes of all the accidents resulted in seven categories of accidents. These categories are:

- Behaviour related, i.e. single bicycle accidents which in some way are caused by the cyclist's behaviour.
- Motor vehicle related, i.e. bicycle accidents where a motor vehicle in any way is involved. This includes hits as well as accidents where no hit between a motor vehicle and bicycle occurred, but where a motor vehicle in some way was in a conflict with a bicycle which resulted in a crash for the cyclist.
- Bicycle failure, i.e. bicycle accidents which are caused by a technical failure of the bicycle.
- Pedestrian related. This includes hits as well as accidents where no hit between a cyclist and a pedestrian occurred, but where a pedestrian in some way was in a conflict with a cyclist which resulted in a crash for the cyclist.
- Road related, i.e. bicycle accidents which in some way are caused by deficiencies of the road or the maintenance of the road.
- Accidents with more than one cyclist involved
- Single accidents with unknown cause.

12 of the accidents that were recorded in STRADA during 2009 and 2010 were not categorized to any of the seven accident categories above. These are for example accidents for which causes are considered to be unpredictable and impossible to prevent by means of road and traffic planning, e.g. an accident where a cyclist is afflicted with an epileptic seizure and hence falls.

In Figure 3 it is shown how big part of all accidents falls into each of the different categories.

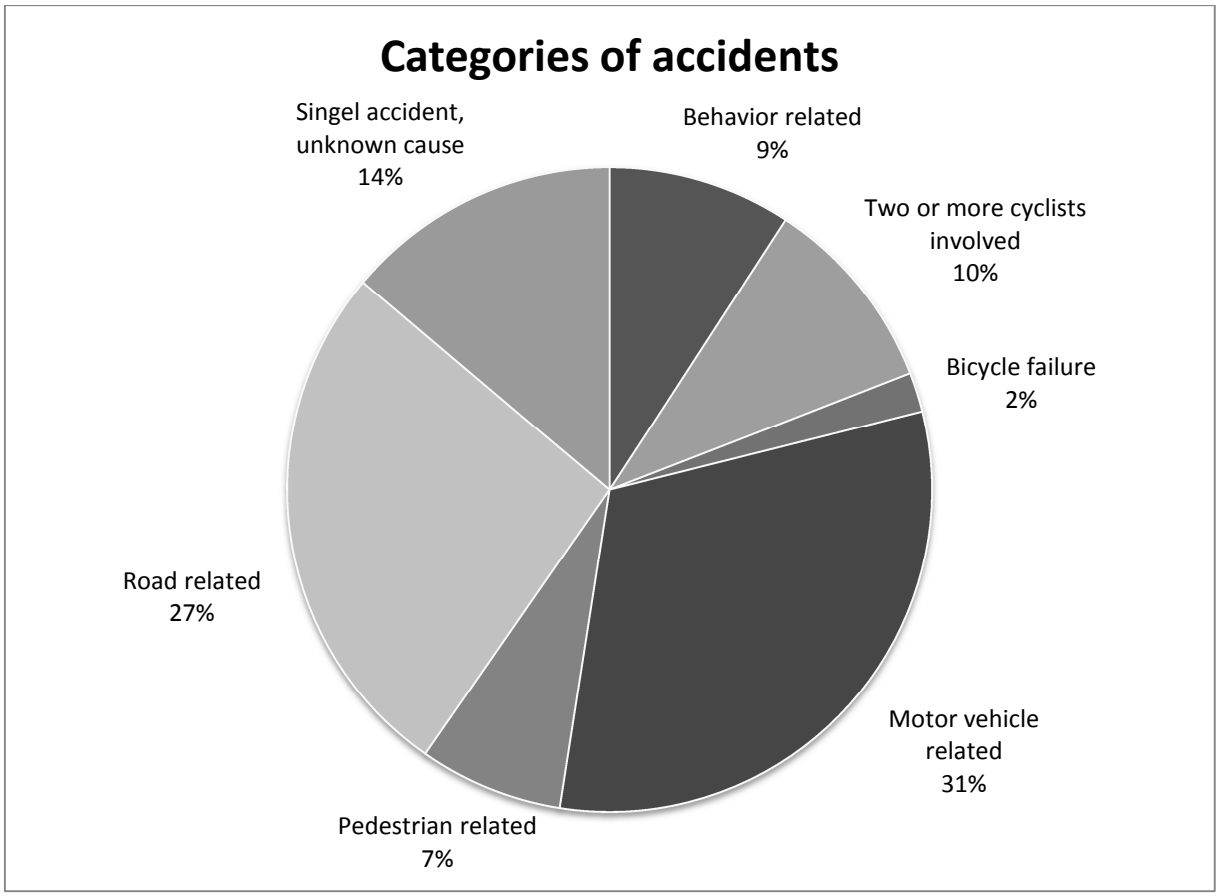


Figure 3. Bicycle accidents during 2009 and 2010, distributed on general categories.

Considering all the categories separately, the smallest one contains the bicycle failure accidents, only 2 % of the total number of accidents. The motor vehicle related and road related bicycle accidents are the most frequent in this study, making 31 % and 27 % of the total number. In between there are the accidents related to pedestrians and behaviour, single accidents with unknown cause and accidents with more than two cyclists involved with between 7 and 14 percent each. 52 % were single bicycle accidents. These are the accidents in the categories "road related", "behaviour related", "vehicle related" and "unknown single accidents".

The type of separation for all accidents is illustrated in Figure 4. As seen, the main part of accidents has occurred where pedestrians and cyclists are separated, pedestrians and cyclists are mixed as well as where there is mixed traffic. The rest of the separation types all include less than 5 % of all accidents each.

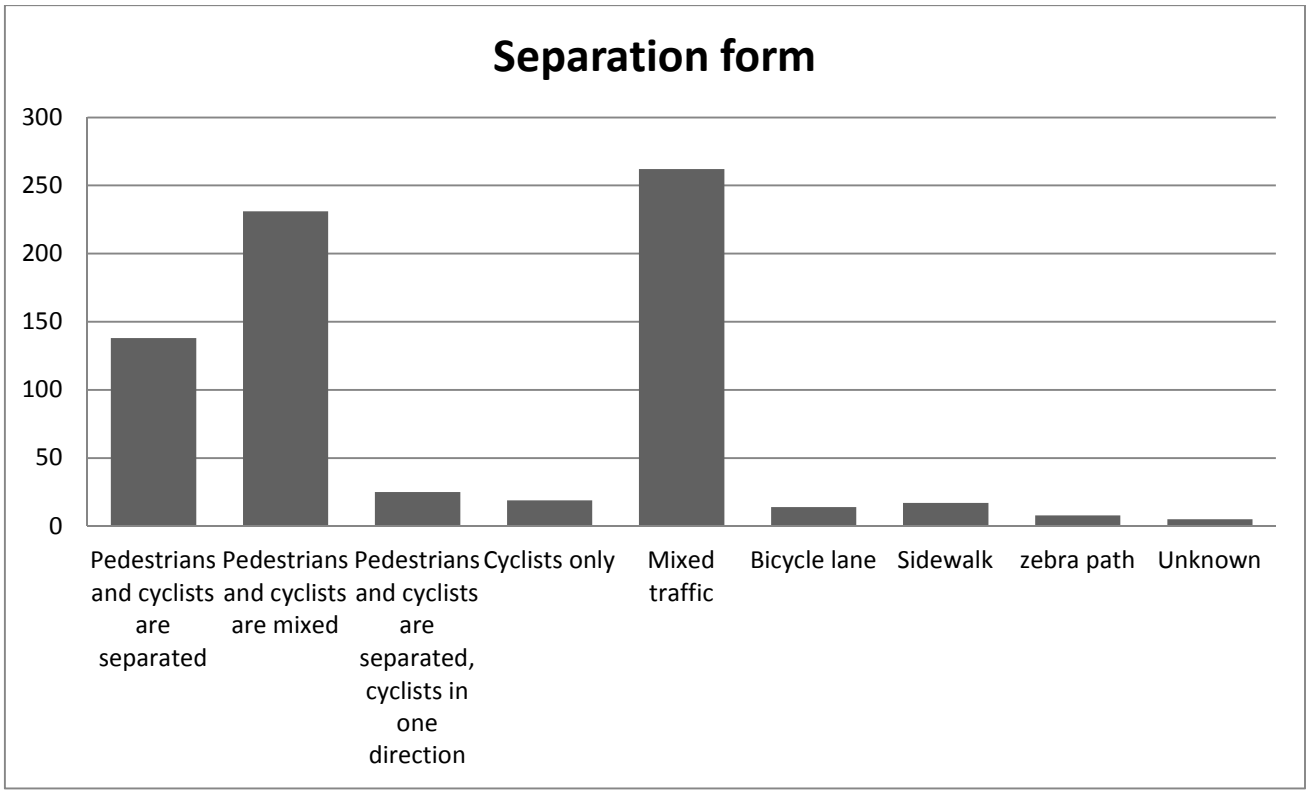


Figure 4. Separation level for all bicycle accidents.

Each of the seven categories contains a number of situations or parameters affecting the occurrence of accidents which provides a more detailed description of different accident causes.

8.1 Behaviour related accidents

The behaviour related accidents are single accidents caused by the cyclist making a mistake. All such accidents are divided into four different specific categories depending on the cause; sharp turning or breaking, object in the wheel, incautiousness, driving with a passenger. The distribution of accidents among these categories is presented in Figure 5.

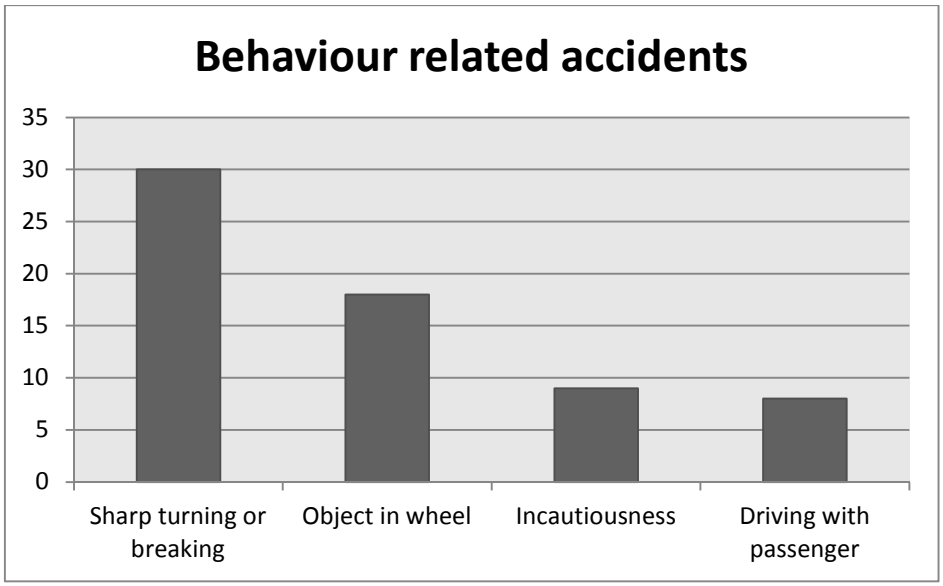


Figure 5. Division of behaviour related accidents into different parameters or situations .

As can be seen in Figure 5, the most common cause within the group of behaviour related accidents is sharp turning or breaking. The acts of turning or breaking in these cases are regarded as unjustified or depending on events that should have been expected by the cyclist, e.g. the cyclist arrived to a cross-ways and needed to switch directions. Accidents that occurred due to the cyclist turning or breaking because of an event that he/she could not anticipate, e.g. road surface deficiencies, are not included in this category.

The situation where accidents happen because of an object coming into the bicycle´s wheel contains 18 accidents. Two of these accidents involve dogs that belong to the cyclists themselves. Object can also mean bags, feet, clothes etc.

The situation of accidents due to incautiousness contains those accidents which depend only on negligence by cyclists; the cause clearly has no connection to the location or design of road etc. This cause includes for example people who fall because they were trying to get something from their bicycle basket, talking in cell phone etc.

Situations where accidents happened when the cyclist was driving with a passenger includes the accidents where the passenger was a child sitting in a child´s chair at the carrier as well as accidents where the cyclist was driving with a passenger illegally and they fell or the passenger fell off. Eight such accidents were reported during the studied period.

8.2 Single accidents, unknown cause

This category represents those accidents whose description in the hospital/police reports is incomplete or the cause is unknown. Often, the only description stated in STRADA is “fell”. Because of that description and the fact that the report says nothing about other involved traffic elements, the accidents are assumed to be single accidents. 98 accidents of this type were found. Many, at least 25, of the accidents took place in slopes. 52 accidents took place at a location with traffic mixed with motor vehicles. All accidents except one were at roads where there were no kinds of intersection. 26 accidents happened at locations where cyclists and pedestrians are mixed.

8.3 Accidents with more than one cyclist involved

The category with cyclist related accidents includes all accidents where two or more cyclists are involved, which are not obviously caused by another element such as deficiencies of the road surface, a motor vehicle disturbing, technical failure of a bicycle etc. A conflict in this category may have arisen due to the design of the road, confusion, one of the cyclists acting incorrectly etc. Accidents that have happened between a bicycle and a moped are also included in this category due to the fact that they are using the road on the same prerequisites.

The five situations within the group of cyclists related accidents are: two or more cyclists abreast, overtaking cyclist, oncoming cyclist, giving way for another cyclist and collision with another cyclist of an unknown cause.

Figure 6 shows the number of cyclists related accidents, distributed to the different situations. Information about how many of the accidents in each category that involve mopeds is also included.

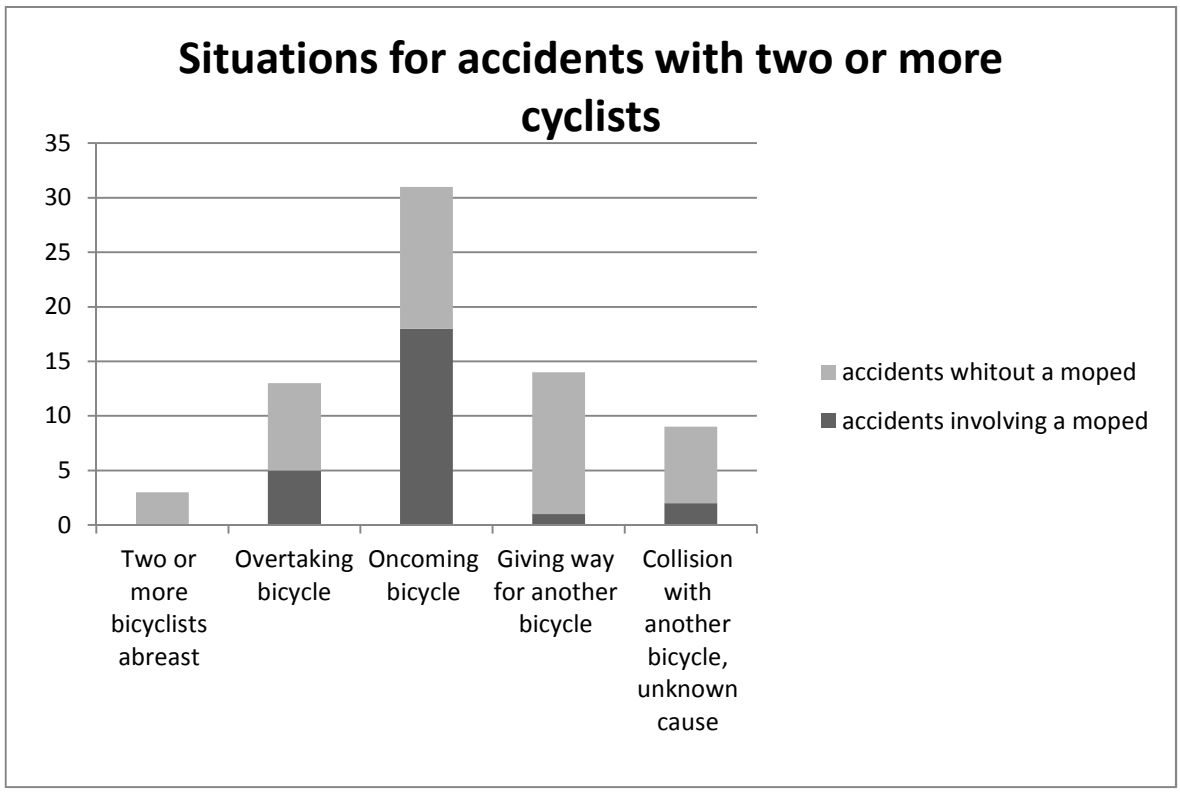


Figure 6. Accidents with two or more cyclists involved, divided into different situations.

As seen in Figure 6, only three accidents are related to cycling abreast, this were accidents where it was obvious that two people who knew each other concisely cycled abreast. Due to the low number of accidents with cyclists abreast, it is not interesting to investigate at what level of separation they took place.

What caused more accidents was an oncoming cyclist which means that two cyclists coming from opposite directions collide. More than 30 accidents happened for this reason.

The remaining three situation types includes between nine and fourteen accidents each. Overtaking bicycle includes the accidents where either a cyclist is trying to drive past another or where a cyclist just collides with another cyclist in front. The

situation “giving way for another cyclist” consists of accidents without a collision, but where a cyclist have been given way for another and therefore fallen. The rest of the accidents are caused by a reason which is unknown due to lack of information in the reports from STRADA.

Figure 7 illustrates the number of accidents with more than one cyclist involved at each level of separation and the accidents in an intersection are presented separately.

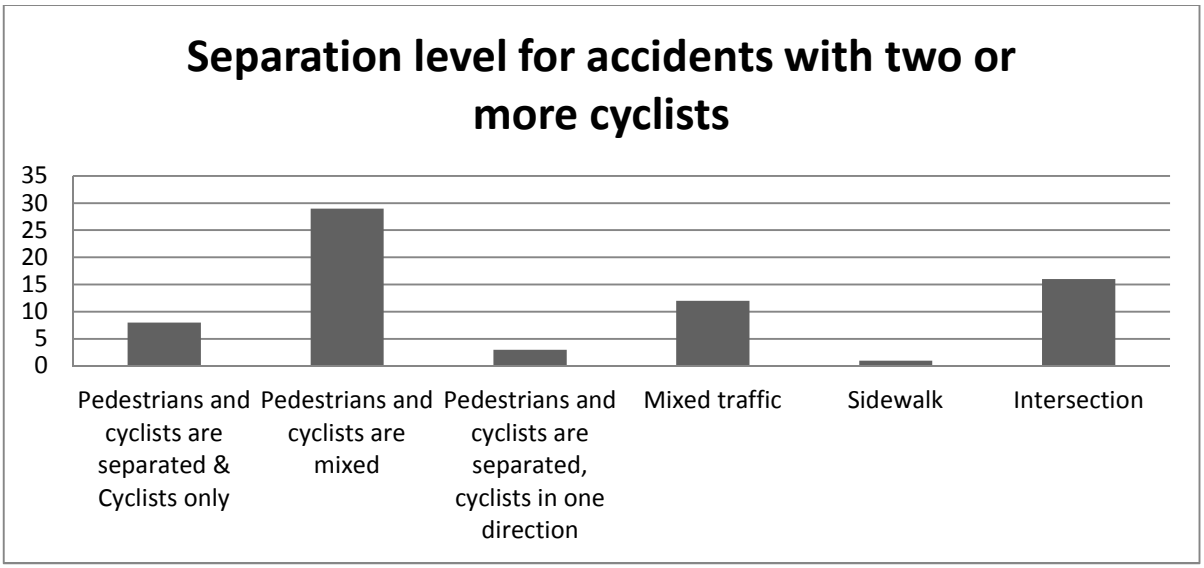


Figure 7. Distribution of accidents with two or more cyclists on different separation forms.

In the figure, accidents that occurred on paths for cyclists only are presented together with the ones that occurred on bicycle paths separated from pedestrians since it makes no difference when only cyclists are involved in the accident. All accidents on one-way paths where cyclists are separated from pedestrians are oncoming accidents. The two accidents at sidewalks involve children, who are allowed to cycle on sidewalks.

Due to the large amount of oncoming accidents it is interesting to look at them separately. In Figure 8 it is shown on what separation form the accidents with an oncoming cyclist have occurred. As seen, over 40% of the accidents took place on a road with no marking. On the streets where it is more obvious which space is for which direction, fewer accidents have occurred. Almost 30% of the accidents happened in an intersection. 10 % of the accidents happened where cyclists were only allowed in one direction.

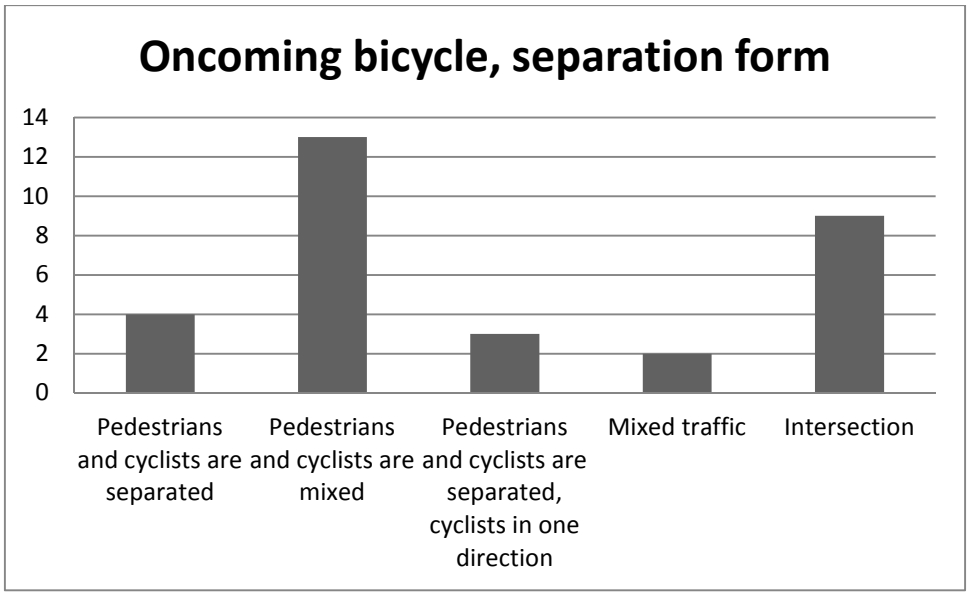


Figure 8. Distribution of oncoming bicycle accidents on different separation forms.

For the rest of the situations for accidents with two or more cyclists, the amount of accidents is small, why a chart of each of them is not presented.

8.4 Bicycle failure

14 accidents were found to depend on lack of quality of the bicycle. Most common was problem with the breaks which caused nine accidents. Other occurring faults are gear problems, broken fenders etc.

8.5 Motor vehicle related accidents

The presentation of results for accidents with motor vehicles involved starts with some general results regarding course of events, separation etc. and continues with more specific comparison between different parameters, for example investigating how elevated crossings affect the risk for accidents.

8.5.1 Course of event

Totally, there were 222 accidents involving at least one motor vehicle. Figure 9 below shows how many accidents of each course of event that were found. The courses of events are classified as follow:

- Motor vehicle on bicycle path
- Motor vehicle turns and crosses bicycle patch
- Motor vehicle crossing bicycle path
- Motor vehicle crossing bicycle path and turns
- Motor vehicle and bicycle coming from opposite direction collide
- Giving way for a motor vehicle on a narrow road
- Collision with a motor vehicle in connection to parallel parking
- Collision with a motor vehicle coming up from behind
- Collision with a motor vehicle, unknown cause

What these courses of events mean is described later on in this chapter.

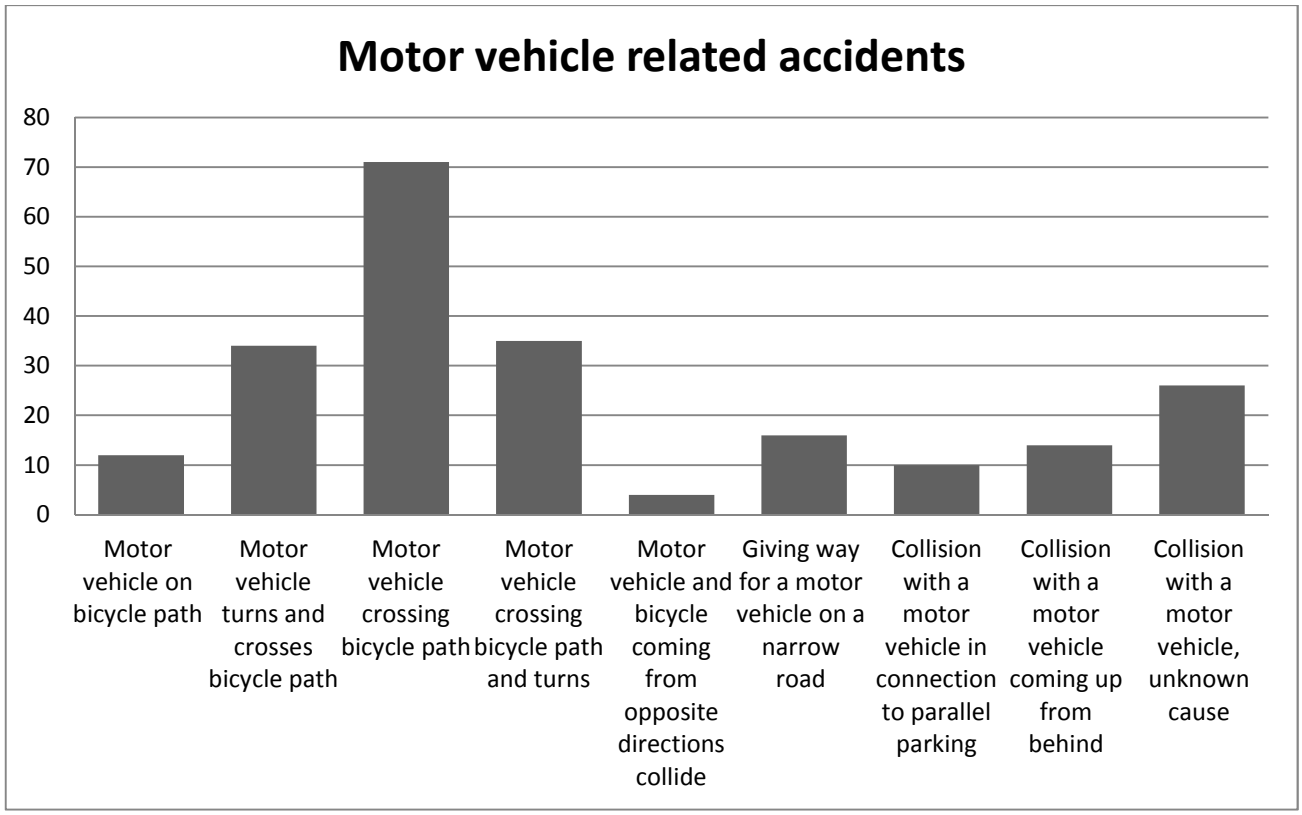


Figure 9. Distribution of different situations for motor vehicle accidents

However, accidents with a motor vehicle seem to be most common when the motor vehicle crosses the bicycle path. Additionally, the second most common type is similar; the motor vehicle crosses a bicycle path and afterwards turns.

Furthermore, a large part of these accidents has an unknown course of event, 12%. The rest of the courses of events include approximately ten accidents each and due to the low number it is hard to draw any conclusions.

Motor vehicle turns and crosses a bicycle path

There are four different types of situations where a motor vehicle first makes a turn and thenceforth crosses a bicycle path, the motor vehicle can turn right or left and the cyclist can come from the same or opposite direction. The different courses of events are seen in Figure 10. For all of these situations, the motor vehicle turns and then crosses the bicycle path. Totally, 34 accidents of this type occurred during the studied period. In 14 of them the motor vehicle turned right and came from same direction as the cyclist, in ten accidents the motor vehicle turned right and came from opposite direction as the cyclist, in eight accidents the motor vehicle turned left and came from opposite direction as the cyclist and in two accidents the motor vehicle turned left and came from the same direction as the cyclist.

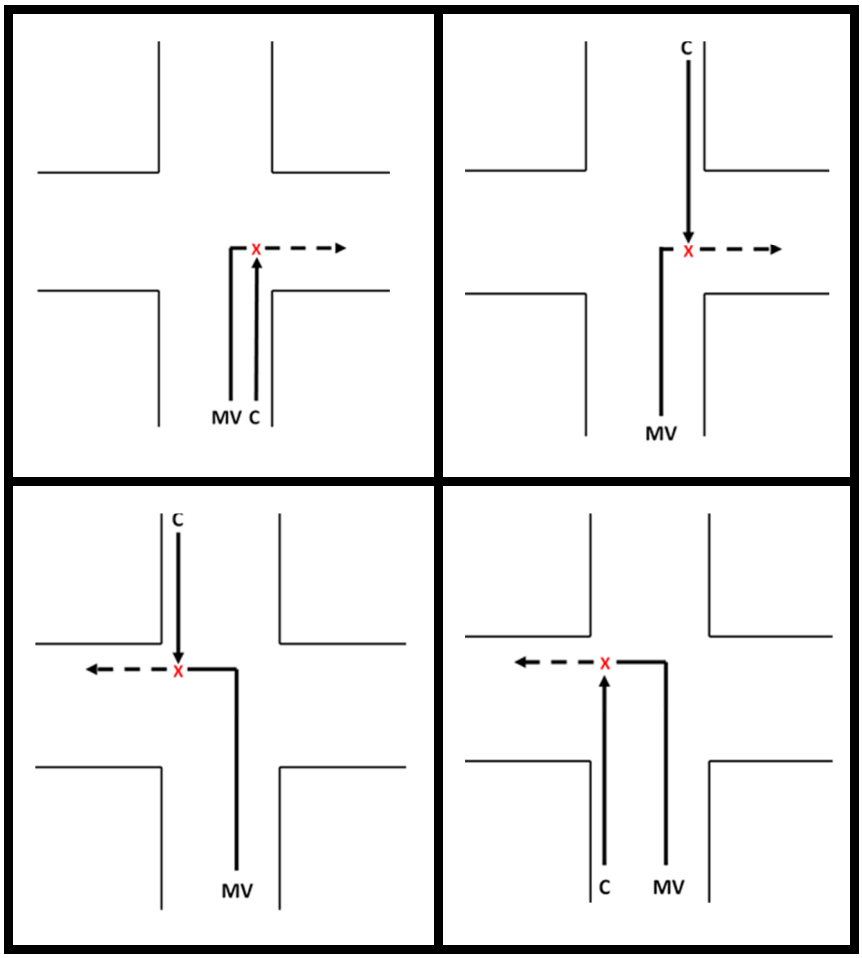


Figure 10. Four situations where a motor vehicle turns and crosses a bicycle path.

While performing the study it showed that in the intersection between Banehagsgatan and Karl Johansgatan in Majorna several accidents have occurred during 2009 and 2010. The majority of the accidents have happened with the same scenario; a car coming from north-west on Banehagsgatan meets a cyclist coming from south-west on the bicycle lane along Karl Johansgatan on the bicycle crossing in the intersection, where a crash occurs. Figure 11 shows a photograph of the intersection. The car comes from under a tunnel and the cyclist comes from a slope which might affect the accident risk. This example also applies for the course of event where a motor vehicle crosses a bicycle path and turns.

Figure 11. Bicycle crossing in the intersection between Karl Johansgatan and Banehagsgatan.

Motor vehicle crosses bicycle path

In this course of event, the motor vehicle drives straight through an intersection as seen in Figure 12. The road the motor vehicle crosses can be either for only cyclists and pedestrians or for motor vehicles as well. 71 accidents have taken place with this course of event.

The accidents with the course of event "motor vehicle crosses the bicycle path" are equally distributed between roundabouts, intersections between a road for motor vehicles and a road for only cyclists and intersections between a road for motor vehicles and a road for both cyclists and motor vehicles.

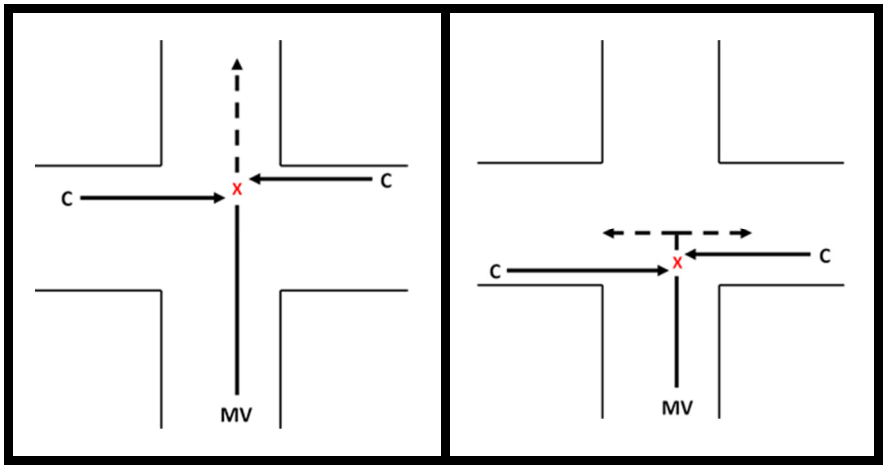


Figure 12. Two situations where a motor vehicle crosses a bicycle path and where it crosses a bicycle path and turns.

Motor vehicle crosses bicycle path and turns

As can be seen in Figure 12, this course of event happens in intersections of some kind and includes 35 accidents. Almost 1/3 of these accidents occurred at exits. There is a certain type of intersection which has been recognized in several accidents during the study. The intersections concerned are of the type where a road is connecting to a

one-way road; hence it is only possible for motor vehicle traffic to turn in one direction. Along the one-way road for motor vehicle traffic is a two-way bicycle path which motor vehicles need to cross when entering the road. Three specific examples of such locations are the exit from Mässans gata to Örgrytevägen outside hotel Gothia Towers, the exit from Blå stråket to Guldhedsgatan at the main entrance of Sahlgrenska and the intersection between Ringögatan and Hjalmar Brantingsgatan close to the Göta Älv Bridge. A photograph of the exit from Blå stråket to Guldhedsgatan can be seen in Figure 13.

Figure 13. Exit to Guldhedsgatan at the main entrance of Sahlgrenska.

The intersection between Delsjövägen and Töpelsgatan in Örgryte is a small intersection which could be seen as perfectly designed with a traffic light available. Yet several accidents have been found to occur there. The majority of the accidents have the scenario that the motor vehicle turns from Delsjövägen to Töpelsgatan and crosses the bicycle path along Delsjövägen. There is a traffic light in the intersection, which might give a false sense of security. The traffic only turns red when a pedestrian is about to cross Delsjövägen.

Parallel parking

Accidents caused by this situation can be connected to parallel parking and have mostly been on a road with mixed traffic. Seven accidents were caused by a motor vehicle door that was opened in front of the cyclist and three accidents were caused by a car turning out from a parallel parking that collided with a cyclist. All accidents happened in mixed traffic.

Motor vehicle on bicycle path

This situation occurs when a motor vehicle for some reason is located on a road dedicated for cyclists. 12 accidents with this course of event were found in this study. It includes accident both where the motor vehicle have parked on the bicycle road and where the motor vehicle has made a turn and used a part of the bicycle road.

Motor vehicle and cyclist coming from opposite directions collide

Four accidents have occurred when the cyclist and motor vehicle came from different directions and collided. All four accidents occurred on roads with mixed traffic.

Giving way for a motor vehicle on a narrow road

This situation includes accidents where a cyclist needed to make an evasive maneuver and there were no collision. 16 accidents with this situation occurred. All except one took place on a road with mixed traffic.

Collision with a motor vehicle coming up from behind

14 accidents occurred during overtaking.

Collision with a motor vehicle, unknown cause

The accidents classified as unknown have from the police and healthcare reports an unknown course of event. In this study there were 26 accidents where the cause could not be found.

8.5.2 Separation

For accidents between cyclists and motor vehicles, three levels of separation are found to be important.

- Mixed traffic where motor vehicle and cyclists share the same road.
- Separated traffic where the cyclists have an own path separated from the motor vehicles
- Bicycle lane where the cyclists use the same road as the motor vehicles but have an own lane.

As seen in Figure 14 most of the accidents involving a motor vehicle happened at roads where motor vehicles and cyclists were separated.

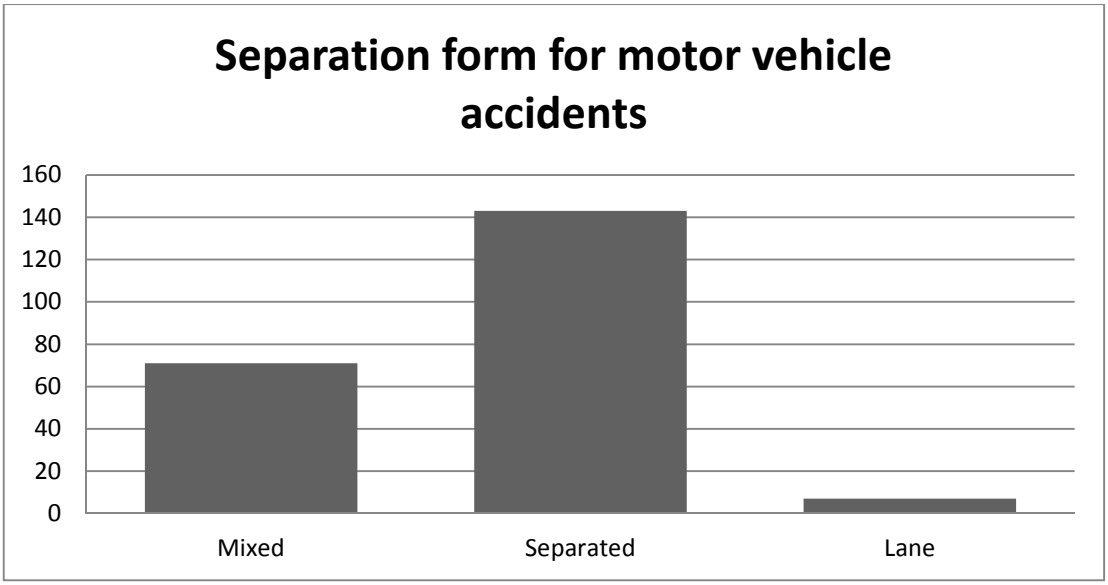


Figure 14. Separation form for bicycle accidents involving a motor vehicle.

One accident had an unknown location.

The accidents that happened where the road for motor vehicles and cyclists were separated, all occurred in intersections except the ones with the course of event: motor vehicle on a road for cyclists.

8.5.3 Type of intersection

An accident with a motor vehicle can take place in all the different intersection types presented in the methodology chapter.

Mixed intersection is a crossing between two roads for motor vehicles where cyclists are either using the same road as the motor vehicles or a separated one alongside depending on the separation level.

Separated intersection means that the motor vehicle crosses the bicycle path, but not a road for motor vehicles. This intersection is set apart from a regular one with motor vehicles on both intersecting roads since the crossings appearance could be less obvious for the driver when not making a conscious maneuver. Examples of specific intersections in Gothenburg where this type applies and where several accidents have occurred are Bohusgatan/Sten Sturegatan, Kobbarnas väg/Redbergsvägen, Första Långgatan/Stigbergsliden and Virvelvindsgatan.

For a roundabout, the accident could have occurred in three different locations. For the accidents where the cyclists are separated from the motor vehicles the accidents are located at a crossing either right before or right after the roundabout. For the accidents in mixed traffic the accidents have occurred in the roundabout and these are accidents with a motor vehicle coming up from behind.

The difference between the intersections and exits is the size of the road crossing the bicycle path. For the exits it may be possible that the cyclist does not notice that they are crossing a motor vehicle road. The accident can have occurred both in an exit and at an entrance.

In Figure 15 it is shown that it is most common for a motor vehicle and a cyclist to be in conflict in an intersection in general and an intersection with motor vehicles in both directions in specific.

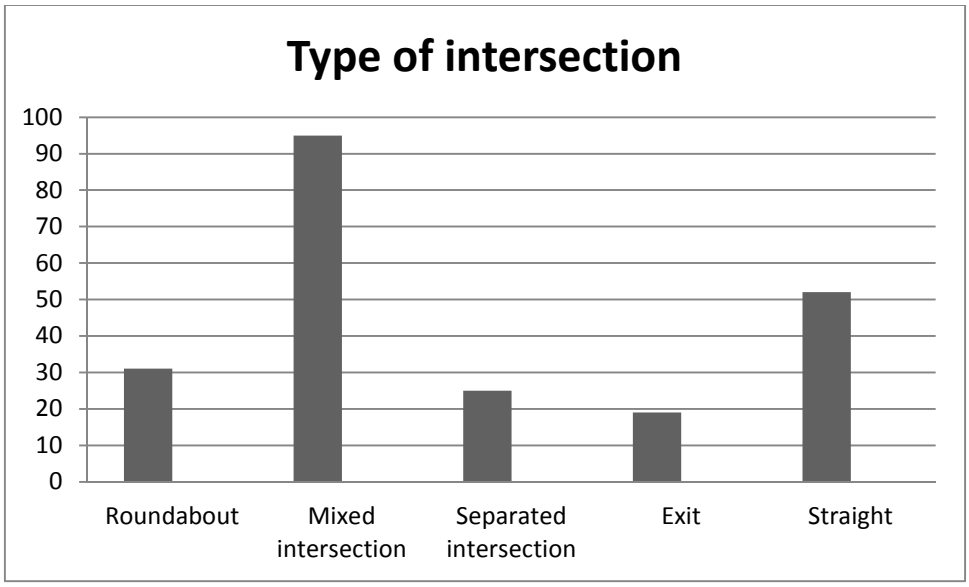


Figure 15. Distribution of motor vehicle accidents on different intersection types.

Approximately 1/3 of the accidents in separated intersections happened on a crossing which was not marked, approximately 1/3 happened at an intersection with traffic lights and approximately 1/3 at an elevated crossing.

Bicycle crossings

Of the 222 accidents involving a motor vehicle, 164 occurred on some type of crossing. All crossings could be described by different attributes depending on how they are marked. Here, four levels of marking have been chosen to be compared in Figure 16. Crossings that have traffic light, elevated crossings which are most often also red, crossings marked with white boxes and unmarked crossings. In the figure, it is shown how many accidents that were found on the different crossing types. In addition, Figure 16 illustrates how many accidents on each crossing type happened in mixed traffic, separated traffic or when bicycle lanes were available.

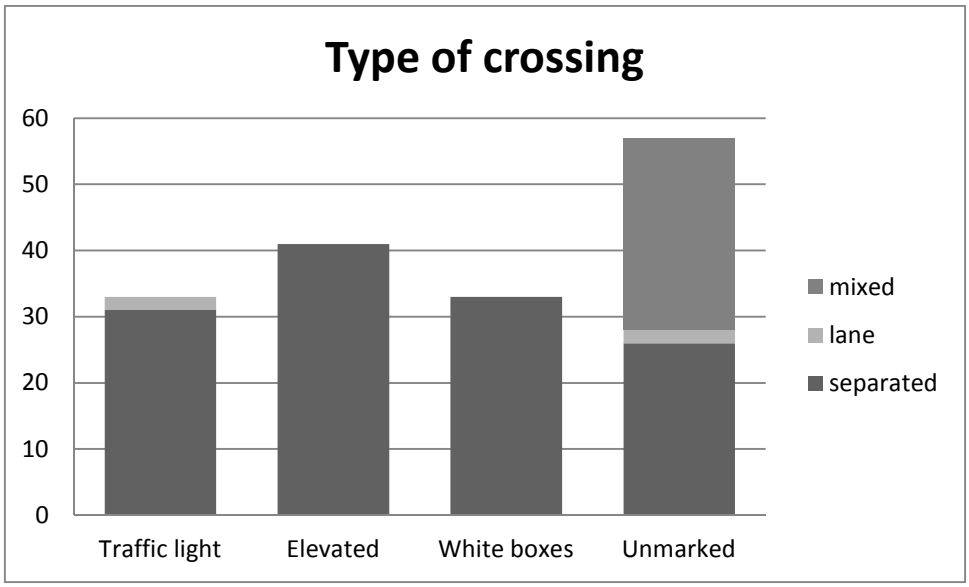


Figure 16. Distribution of bicycle accidents on different types of bicycle crossings.

Four of the accidents on unmarked crossings occurred where the bicycle path was led on to the motor vehicle road. During the study, a few places of this type have been found. Example of this is the intersection between Redegatan and Fågelvägen and on Virvelvindsgatan as seen in Figure 17.

Figure 17. Virvelvindsgatan.

For the accidents on crossings with traffic lights, none have taken place in mixed traffic. In crossings with traffic lights it is for some course of events possible for the motor vehicle and cyclist to have green light at the same time.

Looking only at the accidents in separated traffic, the numbers are quite similar between the different kinds of crossings. The total number of each crossing type in Gothenburg is unknown.

Roundabouts

As can be seen in Figure 15 above, 31 accidents occurred in roundabouts. Almost all the accidents happened in separated traffic. Of the four accidents in mixed traffic, three were accidents connected to overtaking. There was only one accident where the cyclist was using a bicycle lane.

All the 27 accidents in separated traffic happened on marked crossings, three of them were zebra crossings and six were elevated. The rest were marked with white boxes. Almost the same amount of accidents occurred at a crossing before a roundabout as after. There were twice as many accidents where the cyclist came from right compared to from left.

Korsvägen is a complex roundabout with a large traffic flow. One bicycle crossing has caught extra interest during the study due to its design which is a typical example of a solution that is known not to be optimal regarding the safety of cyclists and pedestrians. The crossing in question is the one closest to Liseberg, between the tram stop on the roundabout and Liseberg/Universeum. What is special with this crossing is

that it reaches over two lanes without a traffic island in between them, see Figure 18. This might be considered as a problematic design since when a car in the closest lane is stopping for a crossing cyclist it is not sure that a car driving in the outer lane and the cyclist recognizes each other and the risk for a crash is increased.

Figure 18. Bicycle crossing at roundabout on Korsvägen.

Two similar roundabouts proved to have been the location for many bicycle accidents; one of them on Otto Elanders gata in Högsbo and the other one on Deltavägen close to Backaplan. What is interesting about these places is that although the cyclists have dedicated bicycle paths with crossings that look good and safe, there must be some problem since so many accidents occurred there. Except for the design of the roundabouts and the bicycle crossings, the common factor for these two places is that they are located in industrial areas with shopping malls nearby them (which generates a large traffic flow).

8.6 Pedestrian related accidents

In the pedestrian related accidents there has either been a collision between a pedestrian and a cyclist or an accident has occurred when a cyclist gave way for a pedestrian. It is not clear whose fault it was in all cases.

A dog is counted as a pedestrian since a human is supposed to have control over the dog, however this has only happened at three occasions. In addition, there has also been one accident each involving a person using a longboard and a scooter.

Not always has there been an injured cyclist reported in STRADA in these accidents. In these cases the information is from a hospital report for the pedestrian or from a police report. However, the involved cyclist could have been hurt even if they have not visited a hospital. Additionally, they have been in a conflict with a pedestrian and this should have been a disturbing moment why it should be counted as a bicycle accident anyway.

Totally, 51 accidents of this type have occurred. As seen in Figure 19, 15 of the accidents happened at a road shared by pedestrians and cyclists. The responsibility to avoid accidents lie on both the pedestrians and the cyclists why it is hard to know

what caused the accident. 23 accidents occurred at a road where pedestrians and cyclists are supposed to be separated by the road design, which means that someone has intruded to the others space. This means all accidents on separation forms where pedestrians and cyclists are separated as well as where they are separated and the path for cyclists are one-way.

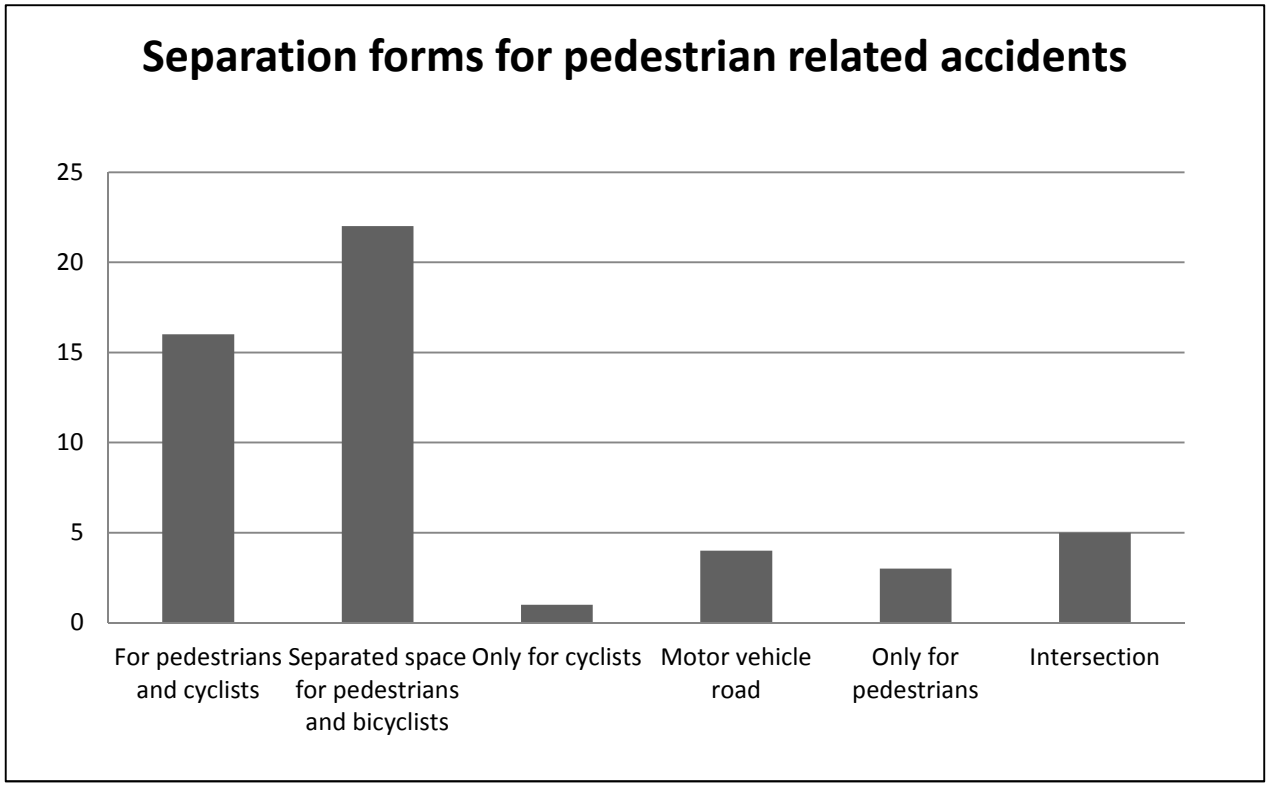


Figure 19. Distribution of accidents involving pedestrians, on different separation forms.

Only five accidents have taken place in intersections. Moreover, in one of the accidents in intersections, the bicycle was using a bicycle lane hidden behind a bus. For this category with accidents with pedestrians, intersections have been presented as an own type of road, since it is where cyclists and pedestrians are supposed to meet.

Three accidents happened on a sidewalk, in those cases it is obvious that the cyclist made a mistake. There were six accidents at roads shared with motor vehicles, but two of the accidents could be explained by happening in an intersection between the road and footpath and is therefore categorized in that class. Two of the straights had parallel parking which could have limited the sight.

Of all the accidents in this category, there were 35 collisions and 16 accidents where the cyclist gave way for a pedestrian.

8.7 Road related accidents

The group of road related accidents contains ten parameters. These are accidents caused by permanent obstacles, kerbstone, deficiencies of the maintenance, slipperiness due to gravel, ice, leaves or water, deficiencies of the road pavement, tracks and road works.

The numbers of bicycle accidents for the different road related categories are presented in Figure 20 below.

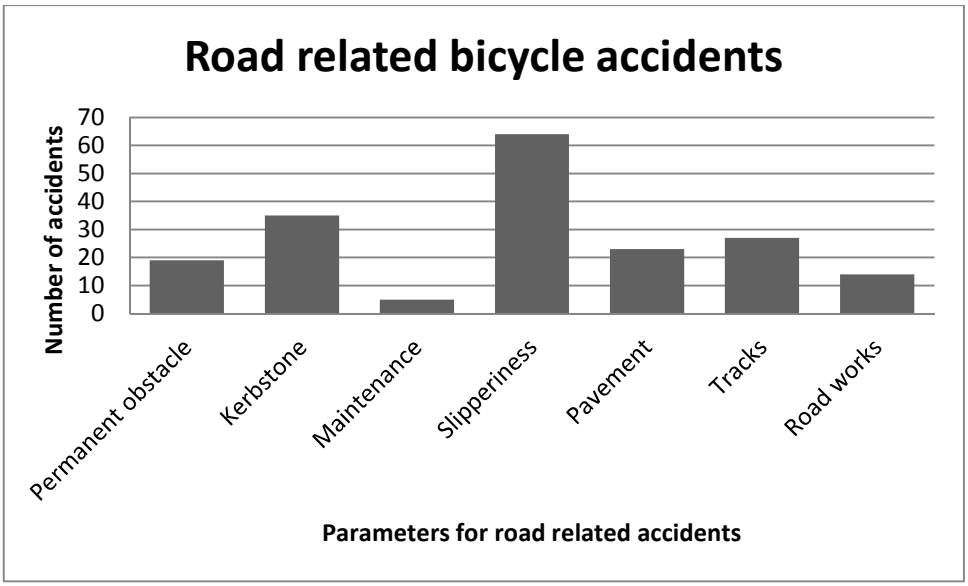


Figure 20. Distribution of different parameters for road related bicycle accidents.

As can be read from Figure 20, the total number of road related accidents is 187. However, the number of injured persons is 191, in four accidents there are two injured persons.

The most common parameter for road related accidents is cyclists falling due to slipperiness of the pavement. Two other common causes are kerbstone as well as tracks, which the cyclists have either stuck in or slipped on. The data for accidents due to different parameters related to the road will be presented more thoroughly below.

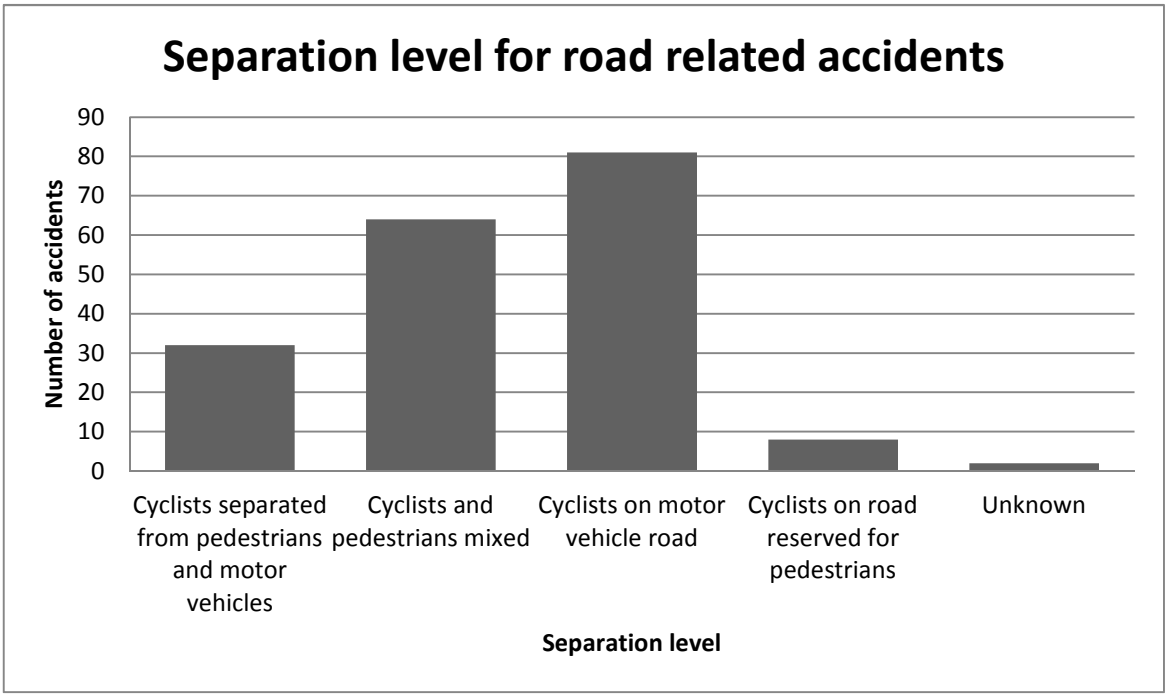


Figure 21. Distribution of road related accidents, on different separation forms.

Some separation levels in Figure 21 are aggregations of the original separation levels. "Cyclists separated from pedestrians and motor vehicles" includes all accidents that have occurred on paths where cyclists and pedestrians are separated, paths where cyclists and pedestrians are separated and cyclists are allowed in one direction as well

as paths for cyclists only. “Cyclists on motor vehicle road” means mixed traffic and bicycle lanes, and “Cyclists on road reserved for pedestrians” includes sidewalks and zebra crossings.

As can be seen in Figure 21, the most common separation level for road related accidents is motor vehicle roads, where 81 accidents happened. 64 accidents took place on paths where pedestrians and cyclists are mixed, which is the second most common separation level for this category of accidents. These two separations are the absolutely dominating for this category in general.

Slipperiness is an occurrence that is the cause for 64 of the accidents during the studied period. Figure 22 shows the accidents because of slipperiness due to gravel, ice, leaves and water altogether, and their distribution among different separation forms. The number of accidents for different slipperiness parameters is 25 due to gravel, 31 due to ice, six due to leaves and two due to water.

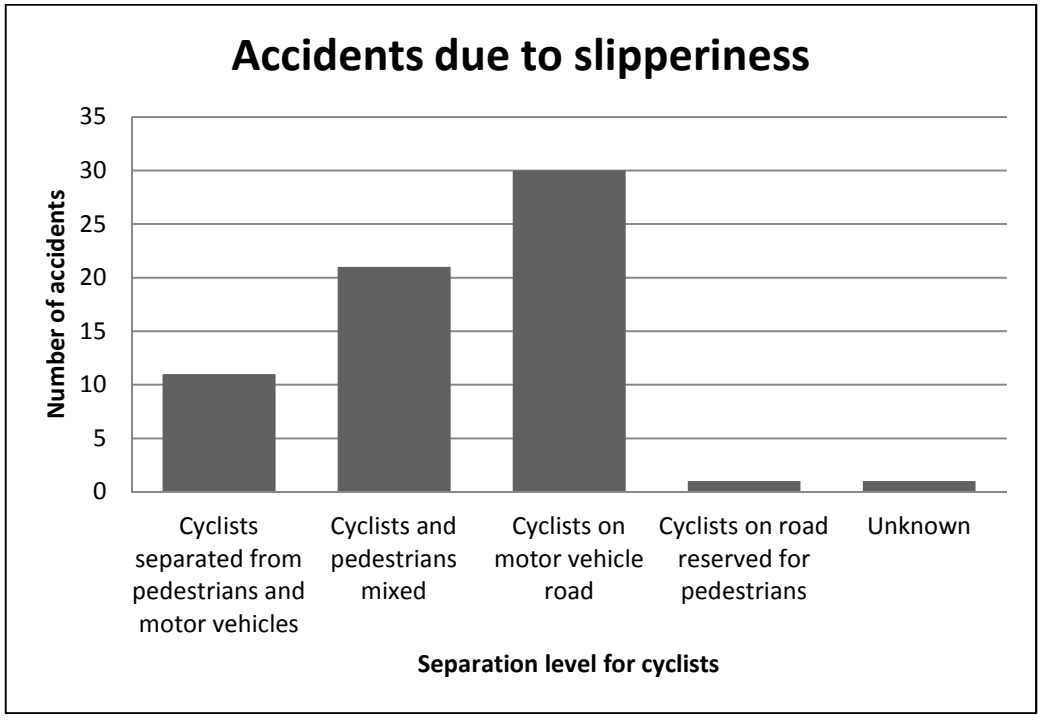


Figure 22. Separation forms for accidents caused by slipperiness.

Two of the cyclists involved in accidents due to slipperiness used a road for motor vehicle traffic when there was a road dedicated for cyclists in the proximity.

23 of the accidents due to slipperiness happened in road curves and nine in slopes. Four of these happened at a location with a combination of slope and road curve.

When looking at the two most frequent causes for slipperiness accidents, gravel and ice, a difference between them can be seen regarding the number of accidents on different separation levels. Figure 23 shows the share of accidents due to gravel and ice, which have occurred on different separation levels.

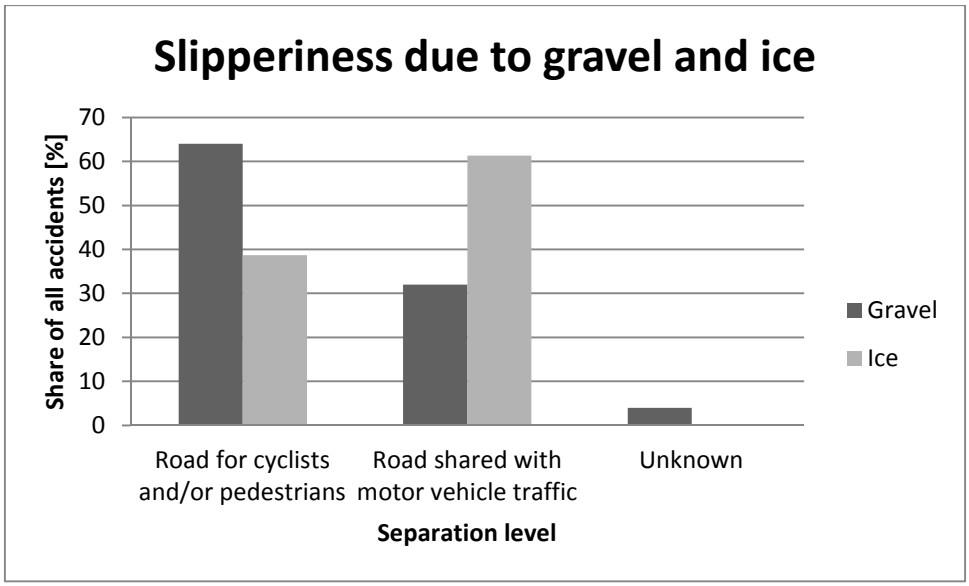


Figure 23. Separation form for accidents caused by slipperiness due to gravel or ice.

A different aggregation of the original separation forms is used in Figure 23; "Road shared with motor vehicle traffic" includes mixed traffic, bicycle lane and zebra crossing while "road for cyclists and/or pedestrians" includes all other separation forms. It can be seen that for accidents caused by slipperiness due to gravel the majority of the accidents, 64 %, have occurred on roads for either cyclists or pedestrians or roads shared by cyclists and pedestrians. For accidents caused by slipperiness due to ice, on the other hand, the majority, 61%, of the accidents occurred on roads shared with motor vehicle traffic.

Falling due to a crash with/evasive maneuver because of a *kerbstone* is the case in 35 accidents. The distribution of accidents on the different separation levels can be seen in Figure 24.

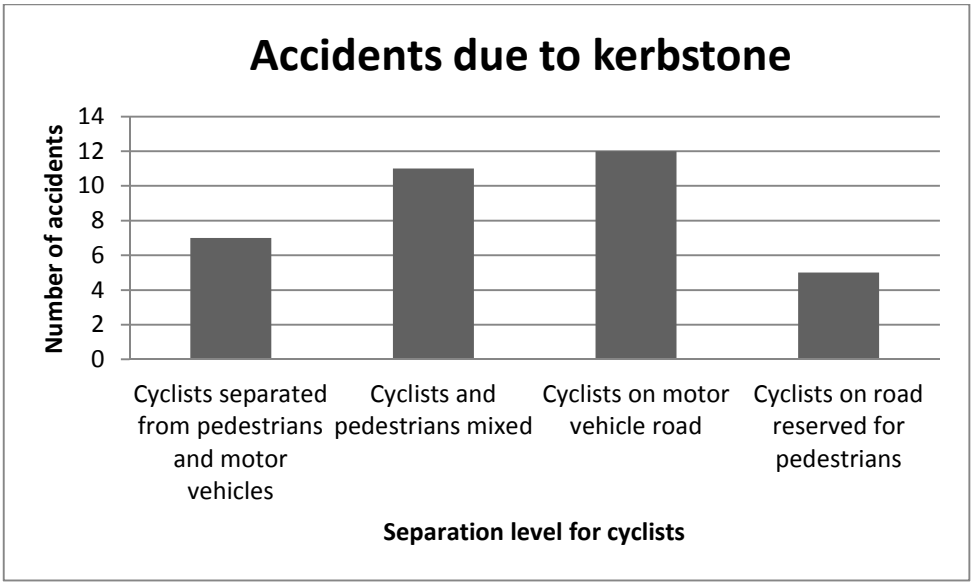


Figure 24. Separation forms for accidents due to kerbstone.

As can be seen in Figure 24, the two most represented separation levels when it comes to accidents due to kerbstone are where cyclists are mixed with pedestrians and where

they are mixed with motor vehicles. In two cases it is noted that the accident has happened at an intersection.

There are a few accidents that have happened when a cyclist crashed because of a kerbstone that has no connection to a sidewalk. A typical such example is roads where there is a kerbstone in the middle of the road, to separate traffic in different directions. Examples of places where such a kerbstone exists are outside Sahlgrenska, on Kungsportsavenyn and on Sankt Pauligatan.

Tracks for either trams or trains have caused 27 accidents where the cyclists have either stuck in or slipped on the tracks. Eight accidents happened at locations where tracks cross a straight bicycle path with a non-perpendicular angle. Two accidents happened where the cyclist cycled along the tracks. Seven accidents happened at intersections where the road/bicycle path crosses the tracks perpendicularly. Ten accidents happened at intersections where there are tracks turning, so that the cyclists need to cross them with a non-perpendicular angle.

Three of the separation forms are represented in this specific category of accidents; paths where pedestrians and cyclists are mixed, paths for cyclists only and roads with mixed traffic with four, two and 21 accidents respectively.

There are a few places where train tracks unexpectedly cross the bicycle path. Examples of such locations where accidents have occured are Exportgatan, in Arendal and at Kruthusgatan; all places in industrial areas.

As seen in Figure 25, the intersection between Kobbarnas väg and Redbergsvägen includes tram tracks along Redbergsvägen. An askant bicycle path crosses the tracks, which is a place where many accidents have proven to occur. The intersection is only between tracks and bicycle path; no motor vehicles are allowed to cross the tracks at this place. There is a traffic light in the intersection so that cyclists and trams should never be allowed to pass simultaneously.

Figure 25. Askant bicycle path crossing Redbergsvägen.

23 accidents occurred due to *deficiencies of road pavement*, which mainly consists of pot-holes. The number of accidents on different separation forms can be seen in Figure 26.

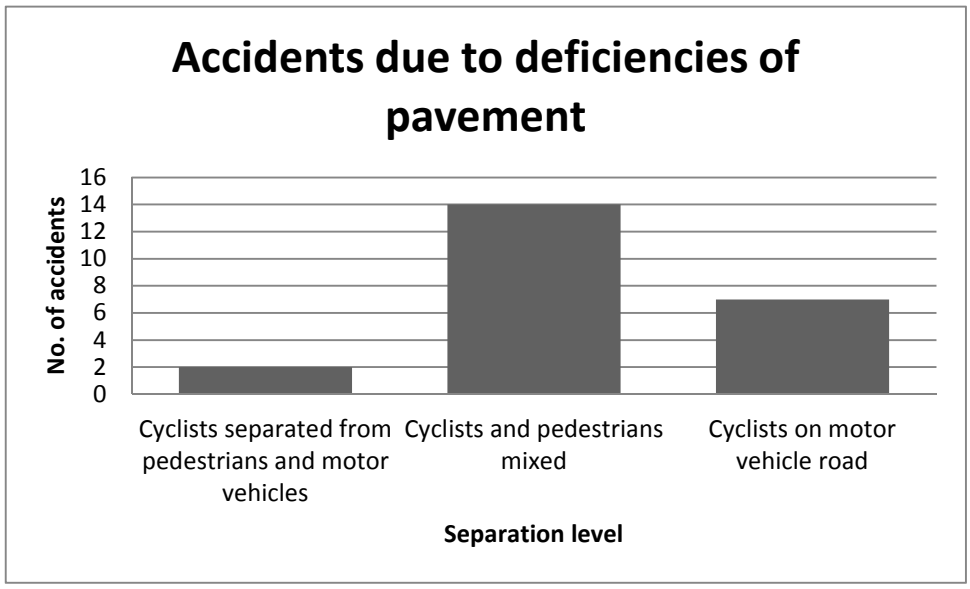


Figure 26. Separation form for accidents due to deficiencies of road pavement.

The most common separation form for accidents of due to deficiencies of pavement is paths where cyclists and pedestrians are mixed. Half as many accidents took place on motor vehicle roads.

19 accidents occurred due to *permanent obstacles*. As permanent obstacles count objects that are placed on or in connection to the road, which serve a purpose for the traffic environment. Examples can be bumps, lamp posts, fences or barriers which caused three, four, four and six accidents respectively. The most common separation level was paths where cyclists and pedestrians are mixed. The distribution of accidents on different separation forms can be seen in Figure 27 below.

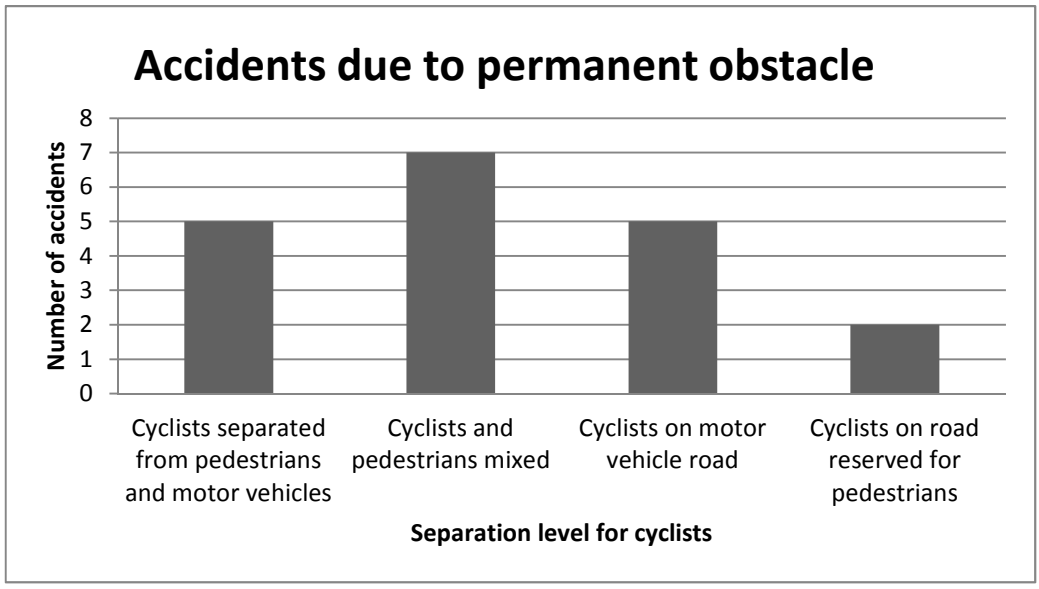


Figure 27. Separation form for accidents due to permanent obstacles.

The category *road works* contains accidents for which the reason can be for example that the road was too narrow due to ongoing road works, that the pavement was

scraped away or that there was no sign to warn cyclists for the road works. 14 accidents of this category took place during the investigated time period. In very few of the reports of these accidents is it stated how the road works were marked. The distribution between different separation forms is even, according to Figure 28 below. If comparing the number of accidents on all kinds of bicycle paths with the number of accidents on roads where cyclists are mixed with motor vehicle traffic, it seems that about twice as many accidents have occurred on bicycle paths as on motor vehicle roads.

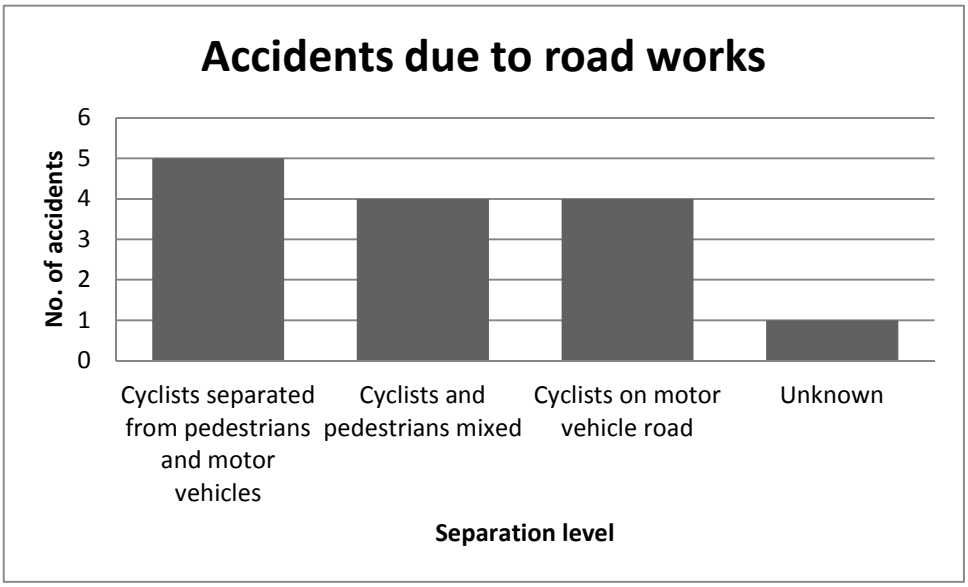


Figure 28. Separation form for accidents due to road works.

The category *deficiencies of the maintenance* include the accidents, which happened due to such deficiencies that do not regard slipperiness because of gravel, ice or leaves on the road. Deficiencies of the maintenance could be accumulation of water on the road or vegetation. Five accidents of this category were found. Two of the accidents occurred on a road with mixed traffic and three of them on a path where pedestrians and cyclists are mixed.

9 Analysis

From the results, it seems that the interaction with motor vehicles as well as deficiencies in the road is what makes the largest impact on the risk for accidents.

Due to lack of information in the STRADA reports, the single accidents with unknown cause make up the third largest category possibly influencing the share of the other categories compared to the reality. If the cause for these accidents would have been known, they would probably belong to one of the categories behaviour related, vehicle related or road related giving those categories larger shares since it seems to be only one vehicle involved in those accidents.

This study indicates that 52 % of all bicycle accidents in Gothenburg are single accidents. Previous research has presented other numbers such as 72 % (Thulin, Hans & Niska, Anna, 2009) and 70 % (Trafikkontoret Göteborgs stad, 2009[2]). The differences refer partly to the assumptions made in this study, i.e. accidents due to evasive maneuvers are in this study not counted as single accidents.

Moreover, this study shows that 31 % of the accidents involve a motor vehicle. Also this number differs a lot from the other studies which both present a result of 17 %. This difference is due to the same reason as above; it is the accidents with evasive maneuvers that make the share of accidents with a motor vehicle lager in this study.

The accidents involving more than one cyclist has a similar share in all three studies; 7, 8, 10 %, and the differences are explained by that different basic data have been used, i.e. geographical and in aspect of time.

One of the other studies (Trafikkontoret Göteborgs stad, 2009[2]) state that 10 % of the accidents are due to bicycle failure compared to 2 % from this study. The variation could be due the smaller amount of basic data in this study.

Regarding the level of separation where the accidents have taken place, Figure 4 could give the impression that mixed traffic, bicycle path with both pedestrians and cyclists and bicycle path with pedestrians separated from cyclists are the designs where an accident is more likely to happen. However, the reason for the large amounts of accidents is the fact that these seem to be the most common designs.

The small percentage of accidents at sidewalks could be an indicator that not many are cycling on sidewalks and that it is not a big problem.

It would have been advantageous to know how often the different types of designs are used and how frequented they are. However, no such numbers are available why it is difficult to know if the share of accidents on different designs is depending on the frequency or the safety of them.

Accordingly, the few accidents on bicycle lanes could be either because of the infrequency of them or they could be safer than other designs. The first indication that bicycle lanes seem safe was weakened by the fact that the Traffic and Public Transport Authority does not want to use this type of solution for cyclists in Gothenburg. Moreover, it seems to be fewer accidents on the roads with an unusual design which is probably since not as many journeys are made on this types.

Furthermore, on the type of bicycle paths where cyclists are only allowed in one direction there have been few accidents. It could be due to that it is not as common as some other types. However, it could increase the status of cyclists making the path

more similar to a motor vehicle road. In addition it could increase the safety if it is well known which direction the cyclists are coming from.

9.1 Behaviour related accidents, single accidents with unknown cause and vehicle related accidents

The accidents that are behaviour and vehicle related will not be focused on since they cannot be prevented by infrastructural measures. For the accidents that are vehicle related it is obvious that it is the vehicle itself that has to be improved. The accidents could in some cases have been prevented if the cyclist had checked the breaks before using the vehicle. The behaviour related accidents must be prevented by making people more aware of the risks they are taking by for example information, education and campaigns.

The large part of unknown single accidents is a problem in regard to the statistical results. If the reports from STRADA had been completed to a larger extension the basic data for this project could have led to more certainty in the result.

9.2 Cyclist related accidents

In the chapter about the accidents involving more than one bicycle, it is the situations that are described. What was the actual cause of the accidents is not possible to know from the STRADA reports. However, it is probable that at least two parameters have affected the occurrence of these accidents with at least two cyclists involved. Firstly, it is likely that the limited space for cyclists has influenced on the risk for accidents. Secondly, the fact that the design of bicycle paths are inconsistent and do not follow the same logic everywhere could be confusing for the cyclists and result in for example using the wrong part of the road.

For the share of accidents where mopeds were involved it seems like the velocity could have been a contributing factor to the occurrence of the accident. To prevent those accidents, velocity reducing measures may lower the risk for accidents making it easier to detect the other vehicle in time. The fact that mopedists and cyclists are sharing space even though mopeds could have a higher speed and is a motor vehicle is not an optimal solution.

For the accidents with oncoming cyclists on paths where cyclists are only allowed in one direction it is obvious that someone has cycled in the wrong direction. Even though this kind of path seems to be a good design in regard to other types of accidents, it could be confusing for less experienced cyclists since it is not as common as a path in both directions. Consequently, some cyclists may not notice or understand the one way path and some possibly just does not care about them since they could sometimes mean a detour.

The low number of accidents with oncoming cyclists in mixed traffic is probably a result of that everyone is aware of which side of a road for motor vehicle that should be used.

That only three accidents where two or more cycled abreast have occurred might indicate that people are careful when they cycle abreast and maybe do not do it on paths with limited space.

The accidents where someone fell due to an evasive maneuver is a large part of the accidents and according to the reports it is unknown which of the situations oncoming, overtaking or two or more cyclists abreast that the accident might have

belonged to. The same applies for the accidents in the "unknown situation". This large amount of accidents constituting these situations gives the rest of the result regarding accidents with more than one cyclist an uncertainty, the actual relation between different situations might have been different.

9.3 Motor vehicle related accidents

The most common situation for an accident is when a motor vehicle is crossing a bicycle path. However, if the aggregation would have been made differently, the result could indicate another situation as the most common.

9.3.1 Course of event

It is not taken into account which of the courses of events is the most common in general why conclusions from Figure 9 may be misleading. The result is also depending on how the courses of events are aggregated.

One reason for the high share of accidents with the course of event "motor vehicle crosses bicycle path" is that all accidents which have happened when a motor vehicle entered or exited a roundabout have this course of event.

It seems that a problem might be that some drivers of motor vehicles which are about to turn right out from the exit concentrates on watching out for other vehicles coming from the left-hand side and is less aware that cyclists might come up from the right-hand side.

Regarding parallel parking no accidents on separated bicycle path has been found. Since they occurred in mixed traffic it seems to be safer to have a separated bicycle path in this aspect.

The accidents where a motor vehicle has been on a bicycle path can be called "unnecessary" since the driver of the motor vehicle most certainly know that it is not allowed to park or drive at the bicycle path. To avoid these accidents cyclists need to gain higher status so it will not feel "okay" for the car driver to use the bicycle path. That can maybe be done by consistent rules and harder sanctions.

The accident that occurred when a cyclist was giving way for a motor vehicle could be caused by any of the described situations. However, there were no collision so the situation is unknown.

9.3.2 Separation

Since it is not known which separation is most common, it is difficult to draw any conclusions about which separation causes most accidents.

9.3.3 Type of intersection

Since it is not known how common the different intersection types are, it is hard to draw any conclusions about which separation causes most accidents.

No type of bicycle crossing stands out but it may be worrying that as many accidents occurred on elevated crossing since they are built for safety reason.

Furthermore, the accidents at bicycle crossings with traffic lights could either have happened when the vehicles both had green light or when one of them had red light why the reason for these accidents could be that someone broke the law or that they both were allowed to drive but did not notice each other.

The distance between the road for cyclists and motor vehicles could make a difference in how aware the car driver is of that he/she is crossing a bicycle path. The design could have many different looks, why simplifications have been made.

The fact that the rules for cyclists on crossings in roundabouts differ regarding who is supposed to yield the other road user the right of way, does not show in the result of this study. The investigation showed that it is not a higher risk to cross a road after or before a roundabout. Therefore it is not possible to say whether the number of bicycle accidents is affected by that cyclists should give way to motor vehicles driving in to the roundabout but are supposed to be given way by motor vehicles on their way out from the roundabout. However, since twice as many cyclists came from right, it indicates that the driver of the motor vehicle is not as aware of what happens at right since he/she is focusing on the cars which are coming from the left in the roundabout.

9.4 Pedestrian related accidents

In the category of pedestrian related accidents, both collisions between cyclists and pedestrians as well as situations where the cyclist gave way for the pedestrian and therefore fell were included. Since one third of the accidents were accidents due to evasive maneuver it indicates there might be common with evasive maneuvers which do not lead to a reported accident. Therefore, it is possible that accidents involving pedestrians are actually more common than what the statistic shows since these kinds of accidents might not be as severe.

Regarding the separation of pedestrians and cyclists, it seems unusual with accidents between pedestrians and cyclists at a road for all road users. A reason could be that this type of road with no sidewalk is likely to be low frequented so pedestrians and cyclists have not interacted with each other. There were six accidents at roads shared with motor vehicles, but two of the accidents could be explained by happening in an intersection between the road and footpath and is therefore categorized in that class. Two of the straights had parallel parking which could have limited the sight.

According to the result, there have been more accidents where the cyclists and pedestrians should be separated from each other than where they should share space. This gives the impression that separating cyclists from pedestrians is not increasing the safety, assuming the two types of paths are equally common used. A false subjective safety could be the reason for this outcome. When the design of the road separates the two groups of road users, the user think it has the space for itself and is not as observant to others although in reality it is not that unusual for both pedestrians and cyclists to intrude on the others space. Correspondingly, when the path is designed to be shared by the different road users they might be aware to the fact that a conflict might arise with another road user and therefore are more observant.

Only five accidents have taken place in intersections which could seem unexpected. However, it could indicate that these two kinds of road users can cooperate when they are aware of a possible conflict between each other as discussed above. Moreover, in one of the accidents in intersections, the cyclist was using a bicycle lane hidden behind a bus, which could have made them oblivious of the possible interaction with other road users.

In the three accidents on a sidewalk it is obvious that the cyclist made a mistake. However, there is a possibility that not all cyclists are aware of the prohibition of cycling on sidewalks.

9.5 Road related accidents

There might be a larger number of accidents in this category than is known. Situations or parameters related to the road are actually also one of the possible causes to some of the accidents in the category "single accidents, unknown cause", however that cannot be supported by any traffic accident data.

Slipperiness

Figure 23, "slipperiness due to gravel and ice", shows contradictory numbers when it comes to drawing conclusions about what separation level is more commonly represented in slipperiness accidents. One explanation of that gravel is more represented as causing slipperiness accidents on roads for cyclists/pedestrians might be that gravel roads are included in this separation form. As mentioned in chapter 3.1, VGU says that snow might be accumulated in the part of motor vehicle roads which cyclists often use, whether there is a bicycle lane or not. It is not evident from this study, but might be an explanation to the high share of slipperiness accidents due to ice/snow on motor vehicle roads.

It is probably a common conception that roads for cyclists and/or pedestrians are less prioritized than roads for motor vehicles when it comes to maintenance; they would not be graveled as thoroughly during winter or gravel would remain on the pavement for longer during springtime, therefore slipperiness would be more common on bicycle paths than on roads for motor vehicles. But the study shows that the most common separation form for all kinds of slipperiness caused bicycle accidents are roads for motor vehicles. It is possible that this can be explained by that cyclists to a larger extent chooses to use motor vehicle roads even though bicycle paths are available, if they believe that the slipperiness maintenance is better on motor vehicle roads than on bicycle paths. However, there is no information to confirm this in the study.

Except for the fact that slipperiness due to gravel and ice causes many bicycle accidents, gravel and ice on the bicycle path is one of the aspects cyclists consider to have a negative effect on the safety and subjective safety.

Kerbstone

On first thought it might be expected that a large part of the accidents for this reason have happened at the end or beginning of a separate bicycle road, when it connects with a road generating a need to cross a kerbstone. However, since there have happened only two accidents in intersections, it seems like that is not a problem. The kerbstone in intersections is supposed to be beveled to facilitate for cyclists, wheelchairs, baby strollers etc, in line with the Traffic and Public Transport Authority´s Technical directions for Traffic planning.

The two most common separation levels for accidents of this cause are roads which cyclists share with motor vehicles and roads shared by cyclists and pedestrians. That many accidents of this type happen on roads which cyclists share with motor vehicles is expected, because in between a sidewalk and a road is naturally the most common location type where there is a kerbstone. Roads which are shared by cyclists and pedestrians can be separated from the road for motor vehicles by a kerbstone, which is probably the case for accidents of this cause on that separation level.

The type of kerbstone which is placed in the middle of the road, for separating traffic, seems to be a problem for cyclists who want to turn. Does this type of design have a

very important function, or is it possible that the kerbstone in some places can be removed to let cyclists pass or replaced by a fence to constitute a more obvious obstacle. As it is now, it is a risk for cyclists at some locations since the kerbstone is not so visible and cyclists may think it is permitted to cross the road and turn into another in what looks like an ordinary intersection.

Tracks

From the number of bicycle accidents due to tracks in this study it is not possible to draw conclusions to what exact situation brings most risk for cyclists, but it seems that the problem regarding tracks generally occurs when a cyclist needs to cross tracks, cycling along tracks seems not to be as large a problem. Eliminating the need for cyclists to cross tracks in the city centre is however not possible. Separating cyclists from roads with tracks would be optimal but the space limitations make this difficult.

Compared to the tram tracks in the city centre the cyclists have a smaller chance to be aware of the risk of the tracks in industrial areas; they are on a dedicated bicycle path which might indicate that the road is open and it is ok to raise the speed while in the city centre the tracks follow the roads and are more constantly visible. If it is possible to remove or stop up tracks which are not used, if such exists, it could prevent further accidents at some locations. Road signs to warn cyclists for crossing tracks might also be a solution.

Deficiencies of road pavement

70 % of the accidents in this category occurred on separated bicycle paths or paths shared with pedestrians. 30% of the accidents occurred on roads shared with motor vehicles. Compared to the general numbers for all accidents in the study there is a slight difference in the distribution of number of accidents on different separation forms. Of all accidents, 57 % occurred on bicycle paths or paths shared with pedestrians and 38% on roads shared with motor vehicles. This difference could be an indication that bicycle paths are less prioritized regarding maintenance compared to roads for motor vehicles. Regardless what is the reason for the difference; it seems that too many bicycle accidents occur due to deficiencies of road pavement.

Permanent obstacle

In total, the number of accidents that have occurred for this cause is relatively low. However, their occurring can be regarded as very unfortunate due to that the permanent obstacles in many cases are there to actually improve traffic safety. Since it from accident reports is not possible to get detailed information about if or how the permanent obstacles were marked, it is not possible to be certain about whether the marking of permanent obstacles generally is the problem. It can also be argued that the design of road bumps etc. might be the problem.

However, there are no numbers to rely on; both aspects mentioned above are considered as a part of the explanation to the accidents. A more accurate survey would be desirable regarding marking and design of permanent obstacles which are placed on or close to a bicycle path. Otherwise the purpose of the permanent obstacles to facilitate traffic/improve traffic safety is somewhat defeated.

Road works

In very few of the reports of these accidents is it stated how the road works were marked. It might be possible that there were signs telling cyclists to walk with their bicycle, even though the cyclists did not do that. For the accidents where the cyclist

stated that they did not see the road works, obviously better warning signs would be the least measure to prevent the accidents. In some cases there is probably a need to design the temporary bicycle path in a way that forces cyclists to walk with their bicycle, signs would not always be enough. In any case, cyclists and the temporary solutions for them should be paid great attention to when there is a road works, since they are so unprotected and exposed. It might be that motor vehicles are prioritized, so that cyclists are displaced on behalf of the temporary road for motor vehicles.

Deficiencies of the maintenance

Very few accidents have happened for this cause, so the possibility to try and analyze or draw conclusions of them is small. This is one of the categories which possibly some of the accidents placed in the category "cyclist falls" should belong to if the reports from STRADA would have contained sufficient information to establish the original cause.

10 Discussion

Overall, it seems to be a problem that the same rules do not always apply for cyclists and the design of bicycle paths is varying, resulting in confusion for cyclist as well as for other road users. If cyclists' status were to be increased and the bicycle would be thought of as a means of transport equal to cars, a lot might be to gain from it. Cyclists should be treated as a separate, important road user and not need to adapt to pedestrians sometimes and to motor vehicles sometimes. Working with these questions could help bringing more attention to the work with safety of cyclists as well as making more people think about using the bicycle as means of transport.

In this chapter some aspects that regards STRADA, design of bicycle roads, traffic rules, the method of the study and sources of error will be discussed.

10.1 STRADA

Two kinds of shortcomings regarding the use of STRADA for the purpose of this study have been noticed about the STRADA withdrawals. One part of the shortcomings consists of negligence and the other part consists of things that STRADA will never be able to or is not supposed to cover.

The shortcoming regarding STRADA that have been recognized during this study and which could be adjusted is primarily the negligence about the filling in of the health care and police reports. These are sometimes incomplete or inaccurately filled in, e.g. there is an address for the accident´s location that does not even exist. Another similar example is that the position marking on the map in STRADA is completely wrong and does not cohere with the address in the report, which means for example that when executing a search for a certain area there might be several accidents that really belongs to that area but do not match the search due to the inaccurate positioning in STRADA.

Regarding the healthcare reports, the descriptions of the course of event are written by the involved persons themselves, which means the precision of them are varying. The varying precision applies also for the police reports, which indicates it might be a good idea to provide some form of education for both healthcare and police of how to fill in the reports accurately.

There are instructions for policemen of how to fill in accident reports, but these are apparently not followed by everyone. Today, there is no check of the quality of the contribution to STRADA. Would it have an effect if there were some kind of reprimand for those who do not reach a certain level of correctness for the filling in of reports? There is a need to raise the ”status” of especially bicycle accidents compared to motor vehicle accidents, to make them being treated in the same way.

Healthcare is not obligated to participate in STRADA, so the chance to make them be more thorough would perhaps be by making the payment depend on the correctness.

Another measure to making the positioning more exact would be to make policemen and ambulance staff use the GPS device as part of the method for positioning of the accidents.

A shortcoming regarding the coverage of traffic accidents reported in STRADA might be adjusted by connecting district healthcare centres to STRADA. Today, it is mainly hospitals that contribute with accidents reports. However it might be argued that injuries from smaller accidents, such as bicycle accidents might often be, are often

treated at healthcare centres, hence there is a lack of data in STRADA for this kind of accidents.

A positive adjustment is that the payment system for health care establishments has been changed so that their fee will continue to be paid if they chose to carry on with the STRADA collaboration. An alternative would perhaps be to expand the obligation to contribute with accident reports to STRADA, so that it except from the police also includes health care establishments.

Since the detail level of STRADA extracts will never be high enough to make deep and comprehensive studies of accidents causes, other options for data acquisition need to be considered. One way to go would be to use the conflict technique, described in chapter 5. We think it might be especially useful for knowledge about bicycle accidents since conflicts and minor accidents, which never are reported to health care or police, probably have a lot in common with the more severe accidents.

10.2 Design of bicycle roads

Regarding design of bicycle roads, advantages and disadvantages with all solutions can be found. For example the Traffic and Public Transport Authority has a positive attitude to elevated and red marked bicycle crossings, since they focus on reducing the severity of accidents in accordance to "Vision Zero". Considering the goal to prevent accidents, we think that reducing the severity is not enough.

A problem with this kind of crossings might be that they give a false subjective safety to the cyclists. The cyclists see the car slowing down, which makes them think that the driver of the car sees them and wants to let them pass. However, the driver of the car might be slowing down because of the road bump that the elevated bicycle crossing constitutes and the risk is that he/she does not even recognize the cyclist that approaches the crossing. In the case that a crash occurs, it is at least happening at a low speed, which is reducing the severity of injuries and hence is considered as positive under the circumstances, according to the viewpoint of the Traffic and Public Transport Authority.

Considering measures to try to prevent the accident completely, there are some aspects of these elevated bicycle crossings to consider. If the bicycle crossing were not there, the cyclist might have been more conscious of the risks and taking more responsibility to make sure no motor vehicle were approaching and hence lowering the risk for an accident. This however, would interfere with the ambition to make the subjective safety for cyclists higher. Would it even be possible that such solutions add to the sense of insecurity so much that it stops people from choosing the bicycle as means of transport? Alternative solutions for bicycle crossings might be a combination of these two examples; a road bump before the crossing instead of an elevated crossing, in order to make motor vehicles lower their speed but yet not giving cyclists a false impression of that they are lowering the speed because of them.

When designing for cyclists, a larger consistency should be practiced, both regarding the separation form and type of crossing. If the cyclists knows the design and recognizes the path everywhere, it would be easier to remember traffic rules and know how to act in different situations.

The suggestion from the Swedish Transport Agency to introduce road signs for bicycle crossings and an obligation for drivers of motor vehicles to give way to cyclists would facilitate for cyclists and make the rules for cyclists on crossings

analogous to the rules for pedestrians. However, it is probable that this would imply a safety problem and that the number of injured persons would increase as it did when introducing the rule for motor vehicles to give way for pedestrians at zebra crossings. However, this might occur only during a transition period and in the long run be a positive measure in the aspect of safety.

Some cities, e.g. Stockholm choose to use bicycle lanes, with the reference to that it implies a higher safety for cyclists. In this study few accidents on bicycle lanes are found, however that does not mean they are safe, rather that there are not so many bicycle lanes in Gothenburg.

There might be situations where the road users are acting in a certain way much because of the design of the road. It might also be that the risk taking is affected in some cases. As pointed out in chapter 9.3.1 one such case might be when car drivers are on some sort of exit or intersection and are about to enter a one-way road which has a two-way bicycle path alongside it. The risk is that the car driver that is about to turn is only looking in the direction from which he/she expects other cars, and therefore misses to watch out for cyclists coming from the opposite direction. This scenario might naturally also apply to cases where the car driver is about to turn right out to a two-way, two lane road. In that situation some car drivers might only look to the left because cars appearing from the right does not make the obvious risk, however there might be overtaking or turning cars from the right so that the cyclists in this situation are probably not equally exposed as beside a one-way motor vehicle road.

Temporary solutions that are needed at some occasions, typically when there is a road works going on, seems to be inferior for cyclists. The temporary road for motor vehicles may be prioritized at the expense of cyclists, who for example get a path which is too narrow. It might also be that no solution at all is established for cyclists. Another possible problem regarding road works is lack of information for cyclists or cyclists disregarding the information. One example is when cyclists are supposed to walk with their bicycles past the road works but they either do not understand it or just think it is not necessary and cycle anyway. Either way it might be a good idea to try to make the information more clear. For the accidents in this study the descriptions have not been detailed enough to know anything about the arrangements for cyclists at a road works, for example how the site was marked and whether or not there was a sign telling cyclists to walk.

One of the results of this study is for example that the most common location for overtaking bicycle accidents are paths shared between cyclists and pedestrians. There is no information about how the total distribution of all bicycle paths is between different separation forms; therefore it is impossible to say if the share of overtaking bicycle accidents on shared bicycle paths depend on the large share of this type of bicycle path in general. Information about the amount of each separation form of bicycle paths in Gothenburg would be useful to try to get better knowledge about if and how the separation form affects the risk for bicycle accidents, especially now since there is an aspiration to increase the share of bicycles as means of transport. In addition it would also be useful to have access to the approximate distribution between different solutions for intersections, e.g. the share of red marked, elevated bicycle crossings and crossings with a traffic light.

To make the study more correct it would also have been valuable to know something about how many cyclists that use different bicycle paths. A good thing would be

measuring of the flow at more points in the bicycle path network and knowledge about where and how long the different bicycle paths are.

10.3 Traffic rules and their clearness

We consider traffic rules for cyclists as unclear and inconsistent which causes several incidents and accidents. After this study we still think it is difficult to know exactly what rights and obligations the cyclists have. As mentioned in chapter 4.2, cyclists think that clearness and clear interaction between road users positively affects the safety and subjective safety, while poor clearness, lack of road markings and signs, has a negative effect. We think that the opinions of cyclists are important to consider if a larger amount of bicycle journeys is desired, because the perception of safety for cyclists is considered a substantial factor when choosing to use the bicycle or not.

Furthermore, for bicycle accidents it is often difficult to acquire information about the exact behaviour of the involved parts, in order to find out if anyone was breaking the traffic rules. If trying to investigate the breaking of traffic rules it is not only a problem to know who made a mistake, but also that people sometimes think they know the traffic rules for cyclists when they really do not. A common example is traffic accidents reports where the cyclist states that he or she had priority when the car hit them, when further investigations show no indication on that the cyclist should be prioritized by the car.

If traffic rules for cyclists would be clearer and more consistent perhaps the knowledge about them would be higher, which might positively affect the safety and subjective safety for cyclists. One aspect to consider for clarifying of the rules is whether cyclists should have the same conditions always, not depending on the separation level. Alternatively the yielding rules towards motor vehicle traffic should be the same, regardless of the design of the bicycle path or type of intersection.

This study does not show to what extent the cyclists involved in the accidents were taking chances that contributed to the accidents. The reason for that is the variation of details in the accident reports. Mostly, it is only the cyclists themselves that have described the accidents and it might be that some of them did not want to admit that they took a chance that proved to be senseless. Nine accidents were found, where the cause was entirely due to incautiousness, but there might be many more accidents where the real cause was a combination of chancing/acting incautious and other things. Considering cyclists´ tendency to chance at hazardous situations, the concept of green waves might be something to try in Gothenburg in order to decrease the risk for bicycle accidents. A solution like that would perhaps also increase the subjective safety and appeal to cyclists considering their appreciation of “flow”.

10.4 Method

The assumptions or definitions used in this study may differ somewhat from what is usual. One example is the decision to consider the first in a series of events, which causes an accident, as the crucial cause. This approach can mean difficulties, partly because of lack of details about the course of events in the accident reports but also due to the complexity of accident situations, compare with the expression “which came first, the chicken or the egg?” However, as the primary wish is to reduce the total number of accidents and hence also increase subjective safety, rather than reducing the severity of accidents, it is beneficial to know what event probably initiated the accident in order to be able to fix the causing parameter to prevent future accidents.

Another definition that differs from the usual definition is the concept of single accidents. This study does not consider accidents due to a cyclist making an evasive maneuver for another road user as single accidents. Usually a crash has to occur to define other traffic elements as involved. Nevertheless, these evasive accidents would not have happened if there were not for the other traffic element and hence that traffic element is considered as the cause. As mentioned above we consider it better from a preventing point of view to cognize the initiating event. The lower amount of single bicycle accidents in the result of this study compared to other studies highlights the importance of considering the interaction between cyclists and other road users when planning for cyclists.

Moreover, this approach means the share of single bicycle accidents is lower in this study than in other earlier studies. A negative effect of this would possibly be that some readers that are used to the ordinary approach may miss the difference and jump to conclusions; it may create confusion to deviate from practice. Furthermore, the figures for share of single accidents are not comparable, which on the other hand is not an aim of the study. The positive effect is that the relatively lower share of single bicycle accidents rightfully highlights the accidents between cyclists and other road users as a more distinct problem.

Considering accidents in which both cyclists and motor vehicles are involved, it would have been interesting to make notes about the size of intersection, flow and speed of motor vehicle traffic. With this kind of information, and perhaps a longer studied period, it might have been possible to draw some conclusions regarding how these factors could affect accident types. The next step would have also been to reflect over if there are different approved solutions for cyclist´s safety depending on the factors mentioned.

10.5 Sources of error

Regarding single accidents with unknown cause, there might be some inaccuracies. Despite the fact that they are categorized as single accidents, there is a chance that some of these accidents involve other traffic elements. They are assumed to be single accidents because if there were other involved traffic elements that should be noted in the reports. However, considering that the reports for this category generally are insufficiently filled in, hence the “unknown cause”, there might be mistakes also regarding the filling in of the involved traffic elements boxes. So even though it is likely that “fell” as the accident description can be concluded as it was a single bicycle accident, the risk for missing traffic elements is probably larger for this category than for other categories. This might be a source of error which is unnecessary since it would be relatively easily solved by ensuring a better knowledge of how to fill in reports.

Regarding the description of locations for accidents, with separation form, type of intersection and crossings design, there have been continuous discussions during the study. The method for descriptions is not so useful for all of the different accident categories and would perhaps have been chosen differently if the way of presenting the results were known beforehand. However, the detailed description method with several additional attributes regarding crossings etc. to choose from made it possible to group separation form, attributes etc. differently depending on what accident category it concerned when putting together the figures for the results. This makes the description method useful for different accident categories but may cause some

confusion for the reader due to the somewhat incoherent relation between different chapters.

There are examples of accidents, for which deeper studies show that the accident would not have happened if not either of the involved parts broke the rules, e.g. it was not possible for a cyclist and a car driver to get green traffic light simultaneously. However, due to the lack of details in some traffic accident reports it is not always possible to know which of the traffic elements that made a mistake and hence not possible to make any suggestions to what can be arranged differently to prevent the accident.

11 Conclusion

More than anything, this study shows that the real or first cause for each accident is difficult to investigate from the reports in STRADA and the quality of the reports cause problems. Additionally, the aggregation of causes in terms of how detailed each category should be, influences the result. Each accident is complicated and unique; categorizing it with others to acquire some kind of result is a tricky process to do properly, considering the problems to know the first cause.

With the time and method of this project, maybe deeper studies of fewer accidents, or a more shallow study would have been easier to perform since this "in between" study gave a lot of information about each accident but not enough time to investigate them.

Since accidents with motor vehicles and road related accidents are the most common, measures to increase safety should be focusing on those categories. There is a major difference regarding the both categories; for motor vehicle accidents it is almost always more difficult to know a certain cause for the accidents than it is for road related accidents. Hence it is also more complicated to try and figure out what measures can be made to prevent accidents. Above all, there is a need to increase the status of bicycle traffic, by making the same rules apply at all time and construct a uniform network of bicycle roads. That means the bicycle road cannot just all of a sudden disappear due to lack of space or road works. For example at roads works there could be a sign telling the cyclists to walk with their bicycle. The same would never be possible for motor vehicles, making the cyclists less prioritized.

The different designs of crossings should mean different things legally as well to decrease confusion. Since they look different, people may think they mean different things. For example, cyclists think they have priority at elevated crossings. Even though effort is put on making bicycle crossings better, still so many accidents take place there which is not acceptable since unprotected road users like cyclists are extra vulnerable in conflicts with motor vehicles.

Regarding the road related accidents, slipperiness is the most common cause which also probably is one of the causes which is easiest to do something about, at least in the aspect of knowledge about how to solve the problem. However, there might be practical and economical aspects that set limitation to the measure for preventing slipperiness related bicycle accidents.

Furthermore, if you want to increase the share of journeys made by bicycle we believe that it is important to listen to the cyclists' opinions of safety. Even though actual safety and subjective safety is not always the same, we have been able to see similarities between cyclists´ opinions and the results of our study, many parameters are the same. However, one thing to have in mind is that a too high subjective safety perhaps can affect the safety negatively if cyclists start taking greater risks because they feel safe.

To conclude, this study might not have given the answer that we expected, in terms of a clear result of which parameters are the most important for causing bicycle accidents. Instead, it resulted in many different aspects to consider regarding STRADA, traffic rules for cyclists and design of bicycle paths.

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