An overview of tram tracks related cycling injuries in Ghent, Belgium

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Background: In cities with trams as public transportation, tram tracks are often shared with other road participants like cyclists. Besides the obvious risk of direct collisions, there is also a risk to bicycle wheels getting stuck in tram tracks, causing cyclists to fall.

Objectives: There is a paucity of data on the incidence and severity of tram tracks-related cycling injuries. The aim of this study is to get insight into the incidence, severity and characteristics of tram tracks related cycling injuries, potentially defining significant 'hotspots' in the Ghent city area.

Patients and methods: A one-year, multicenter, prospective, observational study was conducted. All patients presenting to the emergency departments of all 4 Ghent hospitals with tram tracks related cycling injury, were included. Data on patient demographics, circumstances of the accident and type of injury were collected.

Results: 149 patients were included with a median age of 31 years. 42 patients had fractures, 39 patients required wound sutures, 79 and 49 patients suffered from bruising and abrasions respectively. Only 5 patients required admission. No patients died or suffered life-threatening injuries. Women (65.1%) presented more frequently than men (34.9%). Forty-tree percentage of all accidents happened in autumn ($p < 0.001$). However, there is no significant difference in the number of accidents between wet and dry conditions. Mean number of days off work was 2.7 days, significantly increasing to 6.56 days when sustaining a fracture or dislocation ($p = 0.02$).

Conclusions: Tram tracks are potentially dangerous and may lead to clinically important injuries and significant number of days off work.

1. Background

Ghent, Belgium, is a university city with approximately 260.000 inhabitants and about 65.000 students. Each year 1.1 million tourists visit Ghent (1). After the car (39%), the bicycle is the most important transportation method for commuting in the Ghent region (32%)(2). While cycling has been a common means of transportation for decades in Ghent, a further yearly increase of 4 up till 13% in cycling is noted. In a recent evaluation of the 'Ghent Circulation Plan', an increase of up till 50% more cyclists in the city centre was described. Cycling has many advantages, e.g. ecological and health benefits. However, vulnerability in traffic is one of the disadvantages.

In recent years, many efforts were made to prevent injuries amongst cyclists and creating a safer infrastructure. It is proven that purpose-built bicycle facilities reduce crashes and injuries amongst cyclists (3). At the same time, the use of public transportation is being promoted because of its many advantages: excellent passenger safety, environmental benefits and relief of traffic congestion. In

many cities across the world, trams have been added to the streets onto existing road infrastructure, resulting in tram tracks embedded into the public road. However, integrated tram tracks can cause problems for other road participants, including cyclists (4-6). Cyclists and trams have to share the road with pedestrians and cars. Even more challenging for cyclists, is that many of these roads in the ancient city centre are covered with cobblestones. In these tram tracks, bicycle wheels can get stuck easily, causing a cyclist to fall. This mechanism of trauma is a frequent recurring phenomenon and has been accounted for up to 46% of cyclist injuries (5). Despite this high number, only a handful of studies mention this type of accidents. Only one published study in the UK regarding patient characteristics and type of sustained injuries was found (6). A better understanding of the characteristics of the patients, the sustained injuries, and the circumstances of the accident might facilitate targeted interventions to prevent or reduce the incidence of these injuries.

2. Objectives

The aim of this study is to review all patients with tram tracks related cycling injuries and to report the incidence, the type of injuries encountered, the demographics of the patients, the weather conditions and location of the accident.

3. Patients and methods

We conducted a one-year, multicenter, prospective, observational study after approval of the ethics committee in all participating hospitals. The study population consisted of all patients who suffered a tram track related cycling injury in Ghent (Belgium), and were treated in one of the four Ghent emergency departments between January 1, 2018 and December 31, 2018. All hospitals are located in or close to the city centre, and one hospital is a level-1 trauma centre.

Eligible participants received a questionnaire upon arrival in the emergency department. After signing an informed consent form, patient demographics (age, gender) and information on circumstances (weather conditions, location) were collected, as well as report of helmet use and alcohol use and whether a police report was filed. The second part of the questionnaire was completed by the responsible emergency physician. Type of injury, admission to the hospital and loss of working days, as prescribed by the emergency physician, were recorded. Prescription of subsequent time off work was not registered in this study. To estimate the number of missed cases, we performed a data search in the electronic files in one of the hospitals (Ghent University Hospital) with terms like ‘tram’ and ‘cyclist’. The software packages in the other hospitals did not allow a similar data search.

Statistical analysis was done using Statistical Package for Social Sciences (SPSS) (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY). We performed a descriptive data analysis on patient demographics (age, gender), environmental characteristics (time of the year, weather, location), helmet use, alcohol use, injury type, loss of working days and admission to the hospital. We performed a multiple logistic regression to identify risk factors for sustaining tram tracks related cycling injuries and to identify the impact of certain injuries on number of days off work. Since data was collected over 4 different hospitals, multiple logistic regression included 4 hospitals as a covariate, resulting in a complex model with a risk of overfitting when numbers did not exceed 40 cases in one of the comparison arms. If the number of cases did not exceed 40, a univariate regression was performed. The One Sample Chi^2 test was used to analyze dry versus wet weather conditions and to search for seasonal differences. A binomial test was used to identify a potential gender difference. A p value <0.05 was considered to be statistically significant.

4. Results

Upon presentation to the emergency department, 131 patients were included. We excluded a 10-month old baby who was a passenger in a child bike seat. To make an estimation of the missed cases, a data search in the electronic files in one of the hospitals was performed. Upon reviewing the electronic files, another 31 cases were identified on top of the 14 primarily detected cases. This results in a 68.9% rate of cases that were not included (31.1% pick-up rate) in this hospital. It is not documented whether these patients refused inclusion in this study or were missed. Of these 31 cases, 23 patients were available by phone, which resulted in 19 additional informed consents, totaling 33 patients (73.3% pick-up rate) in this hospital. In total, 149 cyclists who suffered injuries in relation to tram tracks, were included.

Female patients (97, 65.1%) presented with tram tracks related cycling injuries more frequently than male patients (52, 34.9%) (p = 0.001), with no significant difference in encountered type of injury. Median age was 31 years (range 11-74 years) with the most frequent age group being 20-30 years old (31.5%) (also see table 1). Two mechanisms of injury accounted for the vast majority of patients presenting with tram system related cycling injuries. The most frequent mechanism of injury was the bicycle wheel getting caught in the tram track (78 patients, 52.3%), while 63 patients (42.3%) reported to have fallen when trying to cross the rails. Twenty-nine patients (19.5%) reported to have slipped on the tram tracks. Seventy-three (57.5%) accidents occurred in dry weather circumstances and 54 (42.5%) in wet conditions. There was no significant difference in occurrence of accidents in wet conditions compared to dry weather conditions. To the contrary, an almost inverse relationship with more accidents happening in dry compared to wet weather conditions (p = 0.092) is noted. No

Gender	Male	52	34.9%
	Female	97	65.1%
Age	Mean	34.2y	
	Median	31.0y	
	Min – Max age IQR 1-3	11 – 74y 22-45y	
Helmet	Yes	15	11.5%
	No	115	88.5%
Alcohol	Yes	20	15.4%
	No	110	84.6%
Weather type	Sunny	36	28.3%
	Cloudy	37	29.1%
	Rainy	49	38.6%
	Snowy	4	3.1%
	Stormy	1	0.8%
Hospitals	1	33	22.1%
	2	77	51.7%
	3	19	12.8%
	4	20	13.4%
Police report	Yes	7	5.5%
	No	120	94.5%

Table 1. Characteristics of patient demographics, weather characteristics, and reported helmet use and alcohol use.

correlation was found between weather circumstances and rates of fractures, lacerations, bruises or abrasions.

Only 15 patients (11.5%) wore a helmet at the time of the accident. Twenty patients (15.4%) admitted having drunk at least 1 unit of alcohol (ranging 1 – 10 units of alcohol). We could not identify an impact of helmet use or alcohol abuse on injury severity. Only 7 patients out of 127 (5.5%) filed a police report. There was no significant correlation between filing a police report and suffered injuries, hospitalization rates or number of days off work.

All patients sustained at least one injury, including fractures (28.2%), lacerations (26.2%), bruises (53%), abrasions (32.9%) and luxations (3.4%). Fifty-four patients (36.2%) suffered multiple injuries. An overview of affected body regions is provided in Figure 1. Most frequently the upper limb was affected, accounting for over 44.5%, with the lower limb accounting for 30% of injuries. Twenty percent of all injuries affected the head. Forty-seven patients (31.6%) sustained a fracture or a dislocation. Over 63% of these are located in the upper limb, whilst only 17% in the lower limb. Radial head fractures are most frequently encountered (9), followed by finger fractures (5), clavicula fractures (4) and wrist fractures (4). Eight percent suffered facial fractures, consisting of nose fractures (2) and orbital fractures (2).

	Yes	No
Fracture	42 (28.2%)	107 (71.8%)
Laceration	39 (26.2%)	110 (73.8%)
Bruises	79 (53%)	70 (47%)
Abrasions	49 (32.9%)	100 (67.1%)
Luxation	5 (3.4%)	144 (96.6%)
Admission to hospital	5 (3.4%)	142 (96.6%)

Table 2. Injuries characteristics.

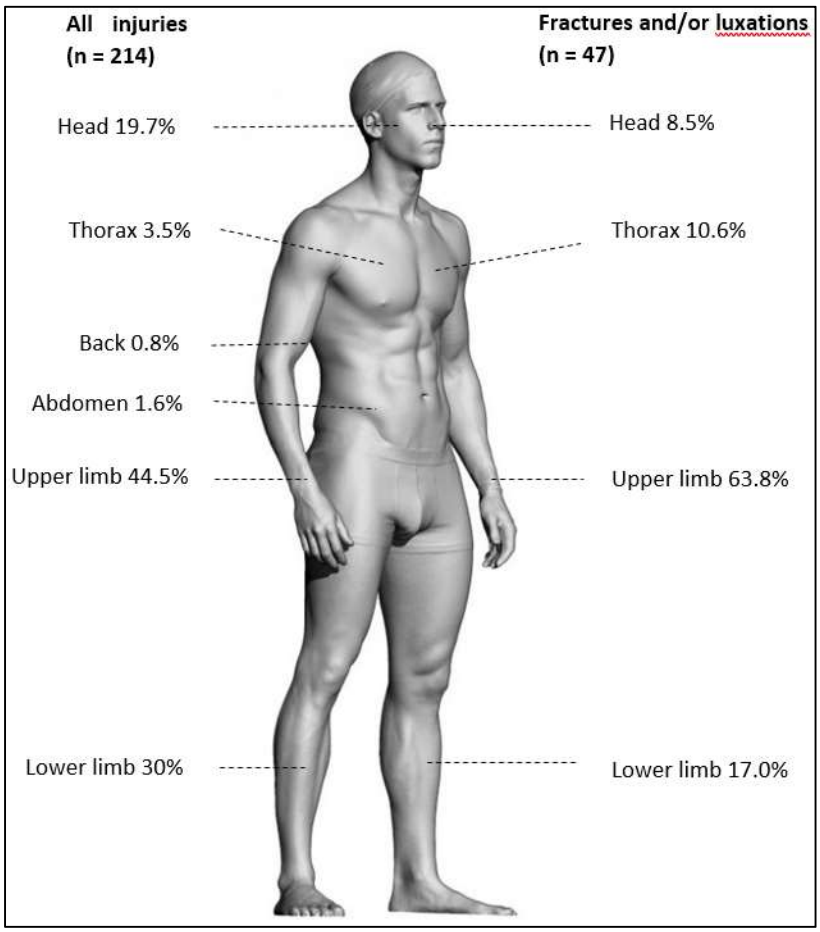

Figure 1. Percentages of injuries per body part.

Only 5 patients (3.4%) needed hospitalization, all requiring orthopedic surgery. No patients suffered neurosurgical or visceral injuries, nor did any patient require monitoring on the intensive care unit; there were no fatalities.

The number of days off work prescribed by the emergency physician were registered. Fifty-seven (47.5%) of all patients were absent from work at least 1 day (range 1-28). Bearing in mind that only the first part of incapacity leave is prescribed in the emergency department, mean number of days off work was 2.7, prescribed in the ED episode. Within the group with days off work, mean number of days is 5.7 (median 4 days). Mean time off work increased to 6.6 days for patients sustaining any fracture or dislocation. Patients with a fracture were prescribed days off work significantly more, compared to patients without a fracture (p=0.02) and are more likely to be absent from work 7 days or more (p<0.001). There was no significant correlation between days off work and gender, helmet use, admission to the hospital or weather type. However, patients with any kind of contusion were more likely to be absent from work at least one day (p<0.001).

Most accidents were registered in autumn (September – November), accounting for 64 (43%) of all cases (p < 0.001). Despite autumn usually being a wet season in Ghent, we did not find a significant difference in the number of accidents between wet and dry conditions. There was no significant seasonal difference in number of days off work.

In our study most accidents occurred on a relatively small part of the tram rail system. Out of 114 registered locations, 84 (73.7%) accidents occurred in the city centre (small box, figure 2).

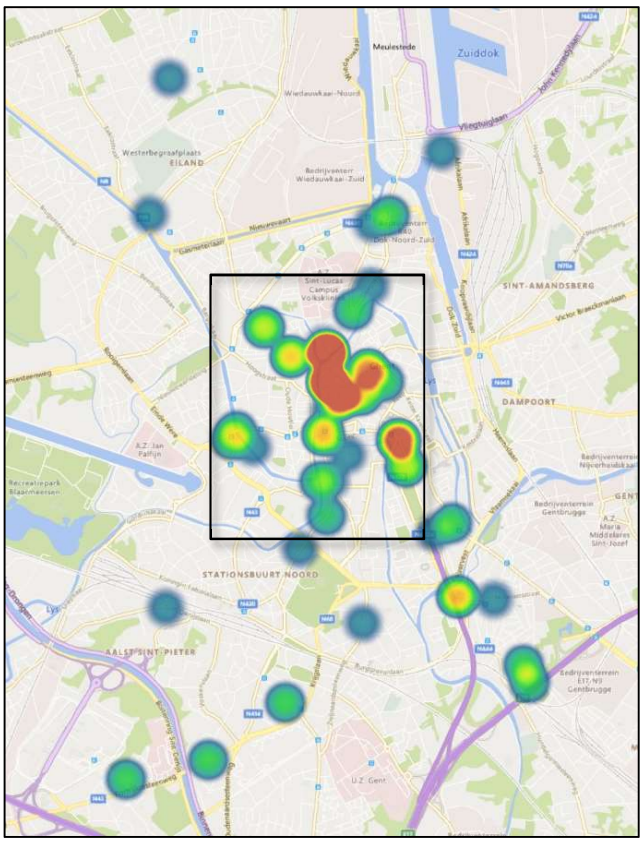

Figure 2. Heat map of Ghent with 114 known accident locations. The small box indicates the city centre with 84 (73.7%) accidents.

5. Discussion

For decades, cycling has been a very popular means of transportation in Belgium, and this is very much the case in Ghent. Despite the obvious health benefits, cycling accidents seem to happen frequently, and official data appear to underestimate true incidence rates. According to police data, only 154 cyclists were involved into an accident in the Ghent city centre in the period April – October 2018 (2). However, an ongoing study registering all types of bicycle accident in all 4 Ghent's emergency departments already registered over 450 patients in the period from June to November 2019 (7). In our study in 2018, 149 cyclists presented to one of four Ghent hospitals with injuries after a fall in tram tracks, while only 7 patients out of 127 (5.5%) filed a police report. Even the 149 registrations might only be the tip of the iceberg. True incidence rates of these accidents might be a multifold because of several reasons. Firstly, the spontaneous pick-up rate was only 31.1% in one of the hospitals; secondly, not every cyclist with tram track related minor injuries will seek medical advice, or might be seen by another type of physician (generalist, orthopaedic surgeon…). This data suggest that this study is not apt for determining true incident rates for tram tracks related cycling injuries, but it does show that tram tracks are a frequent cause of trauma in cyclists. Police report rates appear not to generate reliable numbers and might have an implication on political strategies.

Figure 2. Cycling can be challenging in Ghent with many tram tracks crossings (A) and even cobblestones (B) *Published with permission of (A) Bas Bogaerts, 'De Morgen' and (B) Bert Staes, 'Het Nieuwsblad'.*

These tram tracks related cycling accidents appeared to be more common in females (65.1%, $p<0.001$), with the majority occurring in individuals aged 20-30 years (31.5%). Results on gender preponderance in cycling accidents have been contradicting, with many theories around these differences (8, 9). With a mean age of 34.2years, accidents seem to happen in a rather young population compared to the mean age of Ghent inhabitants (39.4 years) (10). Possible explanations for this young population might be an overestimation of Ghent's population true mean age because many of Ghent's students are not

official inhabitants, as well as older people might be less likely to ride a bicycle. Teschke et al., in a smaller study of 87 patients, reported a similar age and gender distribution (11), while Maempel et al. found it to be more frequent in males (6).

There is no tradition of wearing helmets in Belgium, shown by only 15 (11.5%) patients wearing a helmet in this cohort. There was no significant difference in encountered injuries, hospitalization rates or number of incapacity days when wearing a helmet, albeit no neurotrauma was reported in this cohort. However, the lack of people suffering more serious trauma and the limited number of people wearing a helmet in this study might be insufficient to demonstrate such a difference. Twenty (15.4%) patients admitted having drunk at least 1 unit of alcohol (ranging 1 – 10 units of alcohol), though this did not have an impact on fracture rates or number of days off work in this cohort.

All presenting patients sustained at least one injury. Most patients suffered bruises (53%), abrasions (32.9%) and lacerations (26.2%), but 31.6% of all patients sustained a fracture or a dislocation. The majority of fractures and dislocations sustained by cyclists were of the upper limb (63.8%). This is in keeping with multiple previous reports (5, 6). Radial head fractures are most frequently encountered (9), followed by finger fractures (5), clavicula fractures (4) and wrist fractures (4). Twenty-four patients (19.7%) suffered a head injury, 4 of whom suffered facial fractures, consisting of nose fractures (2) and orbita fractures (2). Two studies reported head injury rates of 4 up till 32.4% (5, 6). Of 47 patients with upper limb fractures or dislocations in our study, 5 were hospitalized for orthopedic surgery. The other patients were discharged home after presentation to the emergency department.

The number of days off work prescribed by the emergency physician were registered. Locally, it is common practice for emergency physicians to prescribe a maximum of 5-7 days, while the remainder of days, if necessary, will be prescribed by the orthopedist in fracture clinics or by the general practitioner. Fifty-seven (47.5%) patients were absent from work at least 1 day. For the whole group, the mean number of days off work was 2.7 days. Within the group with days off work, mean number is 5.7 days (median 4 days). Time off work increased to 6.6 days for patients sustaining any fracture or dislocation as a result to their accident. Patients with a fracture are significantly more frequently prescribed days off work then patients without a fracture (p=0.02) and are more likely to be absent from work 7 days or more ($p<0.001$). This number will be an underestimation of the real number of days off work since we have no data on total work incapacity days. Furthermore, in a few patients, a substantial time off work was registered. One case was prescribed 7 months of medical leave due to a shoulder fracture. These injuries result in costs, not only to the public health system, but also have a significant potential for economic impact to patient and employer (12). Time off work was not affected by gender, helmet use, weather or age.

Most accidents appeared to happen in autumn (September – November), accounting for 64 (43%) of all cases ($p < 0.001$). Despite autumn usually being a wet season in Ghent, we did not find a significant difference in the number of accidents in wet or dry conditions. On the contrary, we see almost an inverse relationship with more accidents happening in dry compared to wet weather conditions ($p = 0.092$). A few reasons for this finding are possible. Firstly, there might be more cyclists in dry weather conditions. The absolute number of accidents in dry weather conditions could be higher compared to wet weather conditions. However, with possibly less cyclists on rainy days, there might be a relatively higher number of accidents in these weather conditions. Secondly, cyclists who defy bad weather conditions, might be more skilled cyclists who are less likely to get stuck in tram rails.

A possible explanation for this seasonal peak might be that many new students with little knowledge on local traffic infrastructure start in September. Besides, these students often don't have a local general practitioner and might visit the emergency departments instead, making up for more inclusions in our study at the start of the academic year.

Studies conducted in Amsterdam have shown that identifying accident "hotspots" and separating trams from other vehicles and bicycles in these areas, may lead to a significant reduction in accidents (13). We identified a few of these "hotspots" in Ghent (figure 2), mainly located in the city centre. Awareness of the potential danger of these on-road tram tracks is essential for policy makers. I.C. Cameron et al. found the number of tram tracks related cycling injuries in Sheffield fell sharply after a period of local media attention to this particular problem (5). K. Teschke et al. found route design measures, including dedicated rail ways and cycle tracks (physically separated bike lanes), to be the best strategy to prevent the majority of track-involved injuries (11, 14). If this cannot be realized, another possible intervention might be the placement of rubber linings within the tram gutter, making it difficult for bicycle wheels to get trapped in them. However, these rubber linings are still in testing phase and show disappointing results with important concerns for public safety (pedestrians tripping over these linings, derailing of trams, wearing of the rubber linings) and feasibility in turns or tram track switches (15).

Our data suggests tram tracks related injuries occur most frequently in the city centre in young adults, and most frequently in autumn. To achieve the highest reduction in tram tracks related cycling accidents, policy makers should focus on route infrastructure (dedicated tram tracks) on one hand, and on awareness strategies with the focus on young adults on the other hand.

6. Strenghts

This study is unique for the city of Ghent, with only a few more similar studies available worldwide. By including patients from all the hospitals in Ghent, we covered an entire city and tram tracks system. We could identify the most frequent occurring injuries and the impact of tram tracks related cycling injuries on number of days off work. Furthermore, we managed to identify hotspots in Ghent, making a targeted approach possible.

7. Limitations

Despite having included 149 patients in this study, this figure is an underestimation of the real incidence rates of tram tracks related cycling injuries. The real incidence might be a multifold. A database search in one of the hospitals showed an inclusion rate of only 31.1%. A similar search was not possible in the other hospitals. Since there was no follow-up contact with the patients, this observational study is limited to the data available at the time of the accident. In Belgium, it is common practice for emergency physicians to prescribe a testimony for a maximum of 5-7 days, with the remainder of days prescribed by their general practitioner or orthopedist. Real total days off work due to this type of accidents might be significantly higher. This study didn't register the purpose of the cycling trip (commuting, school, leisure), nor the type of bicycle (city bike, racing bike, mountain bike, electric bike…). The data collected in this study might be typical for a university city with a relatively young population, and might not be extrapolatable to other cities.

8. Conclusions

Our data suggests tram tracks related injuries occur most frequently in young female adults, and most frequently in autumn despite not being related to weather circumstances. The most frequent injuries are bruises and abrasions, with the upper limb followed by the lower limb being most often affected in these falls. Up to 31.6% of patients suffered fractures or dislocations, with the most frequent fracture being a radial head fracture. About 48% of our patients was absent from work at least 1 day with a median of 4 days. Time off work increased to 6.6 days for patients sustaining a fracture or dislocation. We managed to identify a few 'hotspots' in the city centre of Ghent where infrastructural measures could lead to the highest reduction in tram tracks related cycling injuries. Awareness raising by policy makers should focus on young adults, especially near the start of the academic year.

9. Conflicts of interest

No conflicts of interest have been reported.

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