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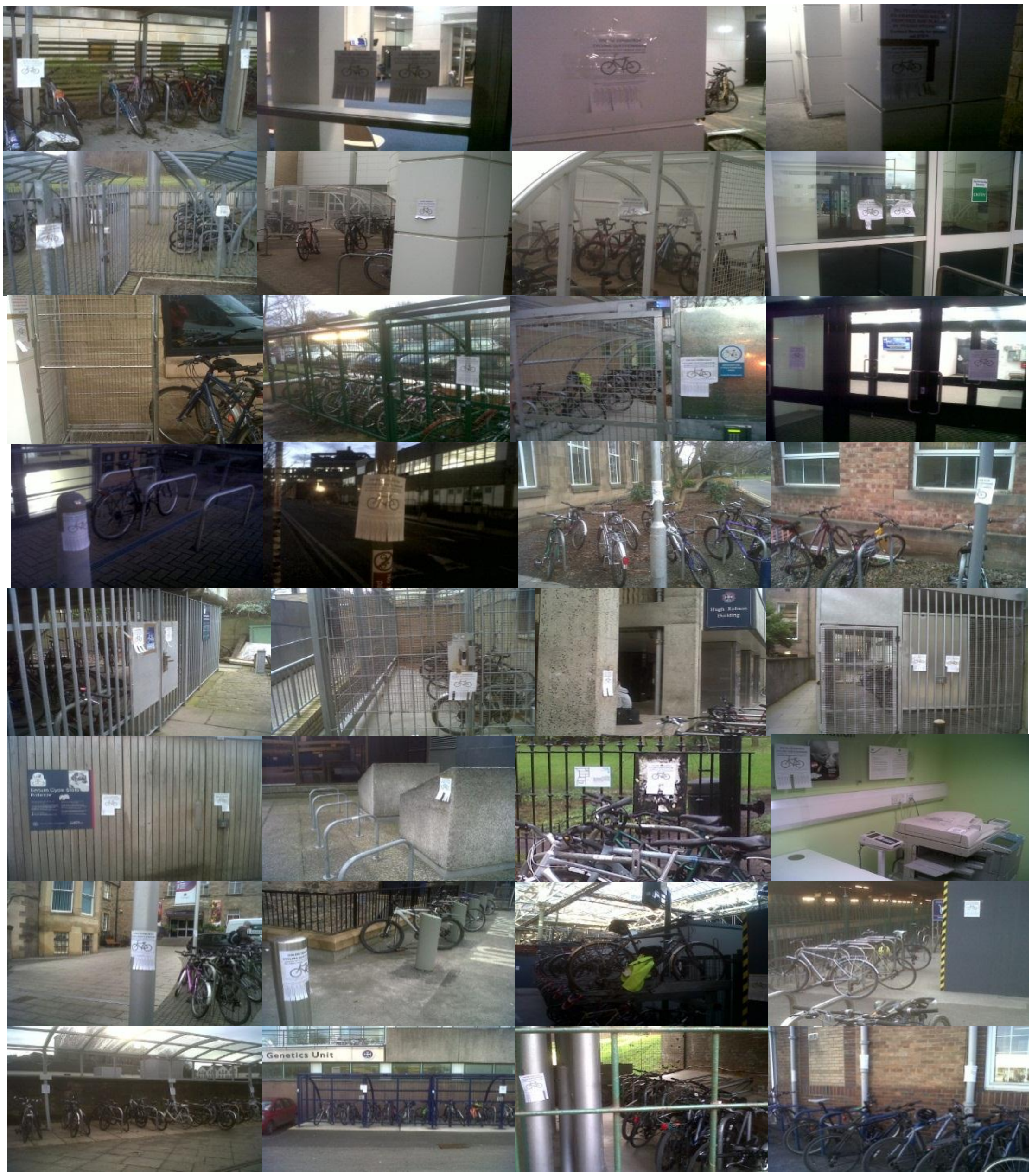
A CROSS-SECTIONAL STUDY OF THE PREVALENCE OF USE OF VISIBILITY AIDS BY EDINBURGH CYCLISTS AND THEIR ASSOCIATION WITH SELF-REPORTED ACCIDENTS / NEAR ACCIDENTS



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ABSTRACT

Background: Recent statistics for the UK, Scotland and Edinburgh have all shown that cycling is becoming an increasingly common activity. This can expected to have important health benefits in the population. However, cycle accidents and casualties, after haven fallen over the past decade, have recently increased. Cycle accidents and injuries and related consensus about cycling safety are likely to be barriers to further population participation in cycling. There is a need to understand the risk factors associated with cycle accidents and injuries so that appropriate preventive action can be taken. There is limited research published on this topic and, in particular, little on the relationship between the use of visibility aids and accidents.

Objectives:

- To conduct a systematic literature review on the prevalence of use of visibility aids; visibility aids as a risk factor for cycle accidents; and the effectiveness of visibility aids in preventing cycle accidents.
- To conduct a survey of a sample of Edinburgh cyclists to gather information on cycle safety behaviour including use of visibility aids and to investigate the association between use of visibility aids and self-reported accidents or near accidents.

Methods: A literature search was performed in: Medline, Embase, Cochrane and CINAHL bibliographic databases; Accident Analysis & Prevention and Injury Prevention journal archives; and Google Scholar to identify relevant articles addressing the above research objectives. An online questionnaire survey of a large sample of Edinburgh cyclists was conducted using “survey monkey” to investigate the prevalence of use of visibility aids and the association with the number of self-reported accidents and near accidents.

Results: The systematic literature review revealed very few relevant publications. There are no trials of visibility aids as an accident prevention measure and only two studies reporting associations between use of visibility aids and accidents. Five hundred forty-two cyclists completed the questionnaire. The use of fluorescent or reflective materials and lights was common and the prevalence of use increased with age with a maximum at age 40-49 years. The frequency of self-reported accidents/ near accidents over the last 3 years was high at

42.7% (95% CI 38.8%-47.1%) and 75.5% (95% CI 71.6%-79.0%) respectively. There was a clear seasonal pattern with January being the peak month for cycle accidents. This was consistent with the top 3 reasons given by cyclists for accidents which were ice, driver pulling out in front of cyclist and potholes in the road. There was no statistically significant association between the use of visibility aids and self-reported accidents (Odds Ratio of overall visibility score for accidents was 1.03 [95% CI 0.72-1.47]). There was an association between listening to music whilst cycling and accidents ($p<0.01$) which was an unexpected finding which will require confirmation in further studies.

Conclusions: Cycle accidents are common amongst Edinburgh cyclists and only 21.1% (95% CI 17.7%-24.8%) of Edinburgh cyclists consider cycling to be safe. There is a high prevalence of use of visibility aids in this study population but no evidence of any association with self-reported accidents. The finding of an association between listening to music and self-reported accidents is a new finding which requires replication in further studies. The findings of this study will be widely disseminated to cycling organizations in Edinburgh and have been submitted to a national conference in the hope that these data will help inform cycle safety strategies.

ACKNOWLEDGEMENTS

I declare that this is my own work; I conducted the literature review; designed the questionnaire survey and carried out the data cleaning and analysis and wrote the report.. I would like to acknowledge the help of the following people and thank them for their assistance and advice:

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INTRODUCTION

Rise in popularity of cycling:

Nationally representative figures describing the number of people who cycle are difficult to ascertain. However, available data from The National Travel Survey (2010) reported that among 19,000 individuals in the UK, 70% of respondents commute by car, 10% walk, 7% by bus, 5% by rail and 3% by bicycle. There is also evidence in Scotland that cycling is becoming a more common activity. Transport Scotland (2010) found that in 2009-2010 cycling accounted for 35miles of total distance travelled per year per person, an increase from 25miles in 2006-2009. Data collected yearly by the Lothian cycle action group Spokes (2011) of rush-hour traffic on two busy Edinburgh roads has also shown an increase in the percentage of cyclists among all road users. In 2011 they observed 12% and 15% more bicycles on Lothian Road and Forrest Road compare to 2010 and 2009 respectively. In addition to this rise, in 2011 they observed the lowest ever number of cars.

There has been no research performed on the reasons for these increases in the uptake of cycling in the UK. However, in Edinburgh, this may be explained by an increasing awareness of the health benefits of exercise coupled to the increasing number of on-road and off-road bike facilities, the consultation with Edinburgh residents in designing ‘quality bike corridors’ and the wide-area 20mph zones implemented as well as the increasing inconvenience of city parking.

Burden of bicycle accidents:

As a result of the increased uptake of cycling in the UK and Edinburgh specifically, road accidents and injuries have also been increasing and so safety is becoming more of a public health issue. The Department for Transport (2010) showed a decrease of 31% in 2008 from the 1994-98 average in the number of killed or seriously injured road casualties in the UK. However, follow up research by the Department for Transport (2011) showed that in the UK between 2010 and 2011, the number of bicycle casualties had increased by 4% and the number of cyclists killed or seriously injured had increased by 8%. These figures highlight the fact that 150 cyclists were killed and 2,500 were killed or seriously injured on UK roads every year, with a quarter of these deaths occurring in cyclists under the age of 20. This contrasts markedly with continuing reductions in pedestrian, motor cycle and car user casualties by 2%, 2% and 7% respectively over the same period.

Valuable data resources used to estimate road casualty statistics include police road accident data (Stats 19) and hospital admission data (in Scotland - Scottish Morbidity Records [SMR] and in England and Wales – Hospital Episode Statistics [HES]). There is evidence that Stats 19 data under-report the number of casualties for all road users, but particularly for cyclists. The most recent publically available data which illustrates this effect are from the Scottish Government (2006) which shows that the number of adults killed or seriously injured in 2005/2006 in Scotland was 420 measured by hospital admission figures compared to 132 measured by Stats 19 data. The Stats 19 data, therefore, only reported 32% of the total casualties reported by hospital admission data. This relationship has been shown to have remained at roughly 30% under-reporting over the period 1997-2006, fluctuating between 27% and 33% each year. In addition, only 16% of child casualties were accounted for by Stats 19 data in 2005/2006.

The Scottish Action Plan (2010) states that approximately half of journeys less than two miles are made by cars. The Scottish Government aims to increase from 1% to 10%, the number of all journeys in Scotland made by bicycles with the aim of reducing the rate of cyclist and motor vehicle collisions. Given the importance of the rising popularity of cycling and the level of cycling accidents in Scotland it is important to understand what factors are involved in injuries and to direct further research to identify effective prevention strategies.

Characteristics of cycle accident collisions:

An analysis of fatal bicycle accidents in New York City from 1996 to 2005 by Nicaj et al (2009) found that: 88% of accidents occurred at intersections; the fatality rate was higher in men than women; head injuries accounted for 77% of deaths (with a corresponding helmet use of 3%); and 91% of fatal accidents involved motorist and bicycle factors, including inattention. In addition, large vehicles were involved in 30% of collisions but made up only 5-17% of road vehicles. Despite this useful information it is difficult to draw any conclusions from these data regarding the generalizability to UK accidents, as there are many differences in road traffic laws and behaviours between these two locations. However, McCarthy & Gilbert (1996) described similar characteristics for bicycle accidents occurring in London from 1985 to 1992. They found that 70% of bicycle collisions involved men and the number of vehicles involved in bicyclist collisions were: cars (53), heavy goods vehicles (40), light goods vehicles (5), buses (5) and motorcycles (5). Among fatal accidents the most common manoeuvres were vehicles turning left and 14 of 15 of these accidents involved heavy goods vehicles (HGV's). They estimated that HGV's in relation to the amount of traffic they contribute, are likely to cause 30 times as many accidents than cars. Once again, head injuries were recorded as the commonest cause of death. These data are not very recent and so it would be important to know if these characteristics hold true at the present time. Morgan et al (2010) analysed trends in the deaths of cyclists from 1992 to 2006. They found again that freight vehicles were involved in 43% of accidents, of which 53% were making left turns. These studies highlight the serious danger that large vehicles and articulated lorries pose to cyclists, and their overrepresentation in accident figures relative to their number. On the road, it is thought that this vehicle type is commonly involved due to driver blind spots when turning at intersections, causing them to be unaware of approaching cyclists. Increased awareness of this problem has led to driver education schemes for Lothian buses and Asda freight drivers in Edinburgh.

Davidson (2005) evaluated the outcome of bicycle injuries at an emergency department in Cambridge. He found that 65.5% of those injured were men and that 64% of injuries were of the upper limb, 24% of the lower limb, 23% of the head and 22% were facial. A low frequency of use of bicycle helmets of 20.8% again reported, implicating the need to increase the use of bicycle helmets. Once again, the generalizability of these results was limited by the sampling of only one emergency department. However, this is supported by Noakes (1995) in an analysis of fatal bicycle accidents who estimated that up to 85% of cycling fatalities caused by head injuries could be prevented by appropriate wearing of cycle helmets. Although this is accepted as a common problem, Rivara (1997) has argued that encouraging helmet use alone will not reduce the number of serious bicycling injuries. This suggests the need for additional interventions to prevent bicyclist accidents with motor vehicles. Rogers et al (1995) in an analysis of cyclist fatality patterns in Washington, USA found a higher fatality risk for males, those over the age of 44 and for those riding in the dark. As they found that riding in the dark was a risk factor for fatality, it can be hypothesised that interventions to increase bicyclist visibility may have an important effect on reducing fatalites. However, the effects of conspicuity aids on bicycle accidents is unknown (Kwan & Mapstone, 2004).

Visibility of cyclists as road users:

Research by Kwan & Mapstone (2006) and Rumar (1990) implicated late detection by other road users as an important driver error responsible for bicycle accidents. This is supported by a study by Hoque (1990) which found that 90% of collisions in Victoria (Australia) in which cyclists were fatally injured were caused by rear impact, suggesting the drivers are unaware of the cyclist prior to the accident. Inexpensive visibility aids are readily available. Fluorescent materials can be used in a variety of ways: worn as high visibility vests, as armbands, attached to the bicycle or luggage on a pannier frame. Kwan & Mapstone (2004) also showed that the use of 'Biomotion' aids including pedal reflectors, spoke reflectors and reflective cycle bands increase visibility range by highlighting the movements of the cyclist.

Knowledge Gaps:

From the literature, there has been some limited discussion on the use of visibility aids as an important factor in relation to bicycle and motorcycle accidents. However, there is no review of information on:

- The prevalence of use of visibility aids;
- The assessment of visibility aids as a risk factors for cycle accidents; and
- The effectiveness of visibility aids in preventing cycle accidents.

Overall Aim:

The overall aim of this project was to summarise the available published data on the frequency of use by cyclists of visibility aids, their association with incidence of accidents, and their effectiveness in preventing cycle accidents; and to conduct a survey of Edinburgh cyclists to measure the frequency of use of visibility aids and their association with self-reported accidents.

Study Hypothesis: The use of visibility aids by Edinburgh cyclists is associated with a lower rate of self-reported road accidents and/ or near accidents.

Therefore the objectives of the study were as follows:

Primary Objectives:

1. To conduct a systematic literature review of published and unpublished literature in English on the prevalence of use of visibility aids; the assessment of visibility aids as a risk factor for cycle accidents; and the effectiveness of visibility aids in preventing cycle accidents.
2. To conduct a survey of a sample of Edinburgh cyclists to assess the relationship between use of visibility aids and self-reported accidents or near accidents.

In achieving these objectives the project will also gather information on other aspects of cycle safety and cyclist behaviour and describe cyclist perceptions of hazards on Edinburgh roads. It is proposed that the study data are used to inform relevant cycling, road safety and public health bodies in Edinburgh and Scotland.

LITERATURE REVIEW

The aim of this study was to answer the research question of whether the use of visibility aids by cyclists is related to the number of self-reported accidents and near accidents. A literature search was performed in: Medline, Embase, Cochrane and CINAHL bibliographic databases; Accident Analysis & Prevention and Injury Prevention journal archives; and Google Scholar. A number of parallel searches were performed within each database and combinations of keywords used in each were individually tailored in order to maximise the number of relevant papers included for analysis. The following list of keywords was selected for the literature search within these databases: bicycling, visibility, light, protective clothing, reflection, conspicuity, prevention, clothing and accident. Three main search strategies were then formulated from this (Table 1) which comprised of 1) bicycling and visibility, 2) bicycling and lights, 3) bicycling and protective clothing or reflection. For the third search strategy the keyword "protective clothing" was included in Medline and Embase database searches whereas in Cochrane and CINAHL databases and Accident Analysis & Prevention and Injury Prevention archive searches the keyword "reflection" was chosen. This was decided based upon the number of results obtained in the searches. Where the number of the results from the search strategies was low, keywords were shortened and truncated by the use of an asterix in order to allow variations of the keyword to be included within the search. Inclusion and exclusion criteria were then applied to the results through reading of relevant abstracts and where necessary, full text articles.

The inclusion-exclusion criteria were:

- Articles that were relevant to road lighting conditions or the use of visibility devices
- Articles that looked at these effects on vulnerable road users (pedestrians, motorcyclists, bicyclists).
- Articles from 1975 to present
- Articles in English language
- Articles available in full text

Following application of these inclusion and exclusion criteria, a total of 63 relevant articles were identified from the seven databases. Following the removal of 31 duplications, 32 relevant articles remained for analysis. Full text copies of these articles were obtained and ordered into relevant subject categories which included:

- Frequency of use of Visibility Aids by cyclists
- Visibility aid use as a risk factor for bicycle and motorcycle accidents
- Evidence that use of visibility aids is effective at reducing accidents in cyclists
- Effect of cycle visibility aids on driver behaviour

After reading the full text of the 32 selected articles, 11 were selected for further critical review and analysis since they contained data directly relevant to the research questions. Information was then extracted into summary tables and discussed in the literature review which follows.

Table 1: Literature Search Strategy and Results

	1) Medline	EMBASE	Cochrane	CINAHL	Accident Analysis & Prevention	Injury Prevention	Google Scholar
Searches:	**1)** bicycling, visibility **2)** bicycling, light **3)** bicycling, protective clothing	**1)** bicycling, visibility **2)** bicycling, light **3)** bicycling, protective clothing	**1)** Bicycling , visibility **2)** Bicycling , light **3)** bicycling reflect*	**1)** bicycl*, visibil* **2)** bicycl* , light **3)** bicycl* reflect*	**1)** bicycl*, visibil* **2)** bicycling, light* **3)** bicycl*, reflection	**1)** bicycl*, visibil* **2)** bicycl*, light **3)** bicycl*, reflect*	**1)** bicycling, visibility, conspicuity , prevention , clothing, accident
Total number of Results:	1) 34 2) 88 3) 18	1) 13 2) 73 3) 20	1) 5 2) 31 3) 66	1) 2 2) 31 3) 41	1) 157 2) 60 3) 55	1) 40 2) 145 3) 206	1) 206
Number after Inclusion Criteria Applied:	15	7	1	9	12	6	13
Number of duplicates with Medline	-	6	1	7	4	5	8
Final number after duplicates removed:	15	1	0	2	8	1	5

Visibility aid use as a risk factor for bicycle and motorcycle accidents

The literature review looked broadly at visibility aid use by cyclists and the relationship with accidents. The appropriate study designs to provide information on this subject are cross-sectional surveys, case-control studies and cohort studies. Despite an extensive literature search, only five studies were identified. These are discussed below.

The first of these studies was a web based survey conducted by Thornley et al (2008). Five thousand six-hundred riders who participated in the 2006 Taupo cycle challenge in New Zealand were invited to participate in the study and 2369 riders completed the survey. They asked cyclists about front and back lights, whether they used fluorescent colours and about whether they had an accident in the previous 12 months. They calculated odds ratios associated with a variety of potential risk factors including those noted above. The results with respect to visibility aids are given in the table 2 below. They show a reduced risk associated with wearing fluorescent colour – odds ratio 0.73 (95%CI 0.57-0.93). They concluded that increased use of conspicuity aids might have a large impact on cycle accidents. The strength of this study was the large sample size and the clear risk factor and outcome definitions. However, the main limitations included a low response rate of 44%, the biased study population (only those who took part a 160km cycle challenge which is clearly not representative of the general population), the incomplete consideration of the full range of visibility aids, and for the lack of controlling for possible confounding factors. In conclusion, this study gives some preliminary evidence of an association between conspicuity aids and bicycle accidents in this group of New Zealand cyclists. However, this would need to be replicated in other populations and observational studies give no information about causal relationship or about the effectiveness of conspicuity aid interventions on cycle accidents.

Wells et al (2004) conducted a population-based case control study from 1993 and 1996 in New Zealand to evaluate the risk of accidents and injuries among motorcyclists related to conspicuity. Cases comprised of 463 motorcyclists who were killed, admitted or treated in hospital in ‘Aukland’ region. One thousand two hundred thirty-three controls were recruited for this study from a random sample of 150 roadside locations. Interviews were conducted face to face, by telephone or by next of kin. Questions were asked about conspicuity measures used at the time of accident including headlights, frontal clothing, light or dark motorcycle and helmet and a variety of reflective or fluorescent clothing devices. The results showed that the use of conspicuity aids was associated with a lower accident rate. The odds ratio for the use of fluorescent or reflective clothing varied by time of day with a lower odds ratio at night (OR 0.34, 95% CI 0.16-0.72) than during the day (OR 0.55,0.37-0.82) as would be expected if these aids improve driver perception of cyclists. The strengths of this study include a large sample size (1696 participants), carefully defined cases from a hospital emergency department and closely matched controls and well-designed interviewer administered questionnaire. Limitations included the fact that the survey was conducted among motorcyclists rather than cyclists(who may show different risk associations due to the different speed of travel and types of road used) and the failure to control for possible confounding factors. In addition, this survey was carried out in Aukland New Zealand which may not be widely representative of other urban areas.

Williams and Hoffman (1979) carried out an analysis of 1508 motorcycle accidents based on police data from Victoria Australia in 1974. The investigators made an assessment of the cause of accident through examination of legal documents and other police data. Their main purpose was to assess the role of visibility problems in contributing to these accidents. They estimated that 245 (21%) accidents were due to visibility problems where the driver did not see the motorcyclist. Of these, 158 (64%) occurred during the day with the majority of accidents due to frontal and side-on impact. They concluded that visibility problems are an important cause of motorcycle accidents. The strengths of this study were the large sample size (1508 accidents) and the attempt, through examination of multiple sources of data to directly assess the role of visibility problems in the accidents. The main weaknesses are that this is a study of motorcyclists rather than cyclists, that it is difficult to be certain about the role of visibility as a causative factor in a retrospective study and that there are no specific data on the use of visibility aids. Study conclusions also represent the views of the authors and it is not possible to assess the extent to which their findings are biased by their own views on this issue since the procedures for assigning cause are not described in detail and inter-rarer reliability was not measured.

The following two papers did not directly measure the use of visibility aids but gave information relevant to lighting conditions and visibility. Bil et al (2010) examined critical factors influencing the collision of bicyclist and motor vehicles through analysis of the traffic Police of Czech Republic database from 1995-2007. There was an increased risk of fatality amongst accidents associated with 'bad visibility' during the day (OR 1.4 95%CI 1.08-1.8), and with no street lights at night (OR 2.16 95%CI 1.75-2.67). A strength of this study was that they controlled for other confounding factors through multivariate logistic regression. Limitations of the study were that they only assessed overall visibility as 'good' or 'bad' and therefore it is not possible to assess the role of individual visibility aids. The study therefore only gives indirect evidence on the research question. Hoque et al (1990) carried of an analysis of fatal bicycle accidents in Victoria Australia from 1981 to 1984. They stated that bicycle accidents were over-represented among all accidents (25% of bicycle accidents at night compared to 10% of total bicycle travel at night).They noted that 61% of cyclists involved in fatal accidents did not have any lights on their bicycle and that cyclists were hit in the rear in 80% of night time accidents compared to 10% of day time accidents. The main limitation of this study is that there is no direct measure of visibility aids nor of poor visibility as a factor in the accident. In addition the sample size was limited to the study of only 100 fatal accidents in a single city thus limiting the generalizability of findings.

Conclusions:

The main conclusion of this review was that despite extensive literature searching across several bibliographic databases I was able to discover only 2 studies which directly assessed the role of visibility aids in cycle accidents. Further indirect evidence was obtained on an overall assessment of visibility as a cause of accidents in 3 further cycle and motorcycle studies. As can be seen in the Table 2, the available evidence gives some preliminary support to visibility aids or improved visibility being associated with lower accident rates however these studies are all subject to various methodological problems as discussed above and need to be replicated in large studies which control for confounding factors in several other populations. The results of this literature review provide some general support for the need for a survey such as is conducted in this dissertation.

Table 2: Summary of studies implicating poor visibility as a risk factor for cycle and motorcycle collisions.

Study:	Number of participants:	Conspicuity aid measured:	Outcome measures:	Odds ratio:
Thornley et al, 2012	2469	front light, back light, fluorescent colours worn	Self-reported accident in the past 12 months	Fluorescent Colours: 0.73 (95%CI 0.57-0.93) Front lights in dark: 0.83 (95%CI 0.55-1.27) Rear light in dark: 1.59 (95%CI 1.09-2.32)
Wells et al, 2004	1696	Reflective or fluorescent clothing, headlight operation and colour helmet , clothing and motorcycle	Estimates of relative risk of motorcycle crash related injury	Reflective clothing: 0.63 (95%CI 0.42-0.94) White helmet: 0.76 (95%CI 0.57-0.99) Headlight on during day: 0.73 (95%CI 0.53-1.00
Bil et al, 2010	5428 accidents involving bicycle	Overall assessment of poor visibility as a major cause of accident	Ratio of fatal to non-fatal accident.	Bad daytime visibility: OR 1.4 95%CI 1.08-1.8 No street lights at night: OR 2.16 95%CI 1.75-2.67
Williams et al, 1979	1508 accidents	Overall assessment of poor visibility as major cause of accident	Motorcycle accident registered with Victoria Police.	OR not measured. 245 (21%) of 1508 accidents classified as due to poor visibility.
Hoque et al, 1990	100 fatal accidents	-	Fatal cycle accidents	-

Use of Visibility Aids by cyclists:

It is important to measure the frequency of use of conspicuity devices as part of the study of the relationship between cycle visibility aids and accidents. The appropriate study design to give information on this subject is large cross-sectional surveys of representative population samples. I identified four studies with information about prevalence of use of visibility aids.

Osberg et al (1998) surveyed 5808 cyclists using the same methodology in both Paris and Boston, using a multistage sampling strategy at 17 major street sites in these 2 cities. They found the prevalence of use of front and back lights was 46.8% in France (Paris) and 14.4% in Boston (USA). The strengths of this study were the large sample size and the attempt to sample a representative group of cyclists in these two cities. The major limitation was that they did not measure use of other visibility aids and so the data are restricted only to use of lights.

Amoros et al (2010) survey 900 cyclists in Lyon (France). Their sampling strategy was based on surveying three groups: child cyclists, sports cyclists and commuting cyclists. No details of the sampling method were given. They found that bright coloured clothes were used by 49% of sports cyclists and 9% of commuting cyclists. The strength of this study is that it is one of the very few studies that has measured prevalence of use of coloured clothing. However, the value of the study is greatly limited by the fact that no details of the sampling strategy were given and thus no conclusions about the generalizability of the findings can be made.

Hagel et al (2007) conducted a multistage sample with random selection of study sites in Edmonton, Canada. Cyclist characteristics recorded included clothing colour, use of reflectors and flags as well as the overall impression of visibility of cyclists and pedestrians measured by two trained observers. Data collected from 273 cyclists showed that the colours orange, red, yellow and white accounted for 31.4% of headgear, 34.2% of major trunk colour and 9.2% of major leg colour. The prevalence of use of reflective strips to trunk and legs were 0.7% and 0% respectively, rear reflector use and spoke reflector use were 50.9% and 56% respectively and 29.3% used a front light. The strengths of this study include the robust methodology – random selection of study sites, two independent observers (with reliability data on inter-observer variance) and measurement of use of a wide range of visibility aids. The major limitation is the relatively small sample size which results in imprecise prevalence outcomes.

McGuire & Smith (2000) surveyed 392 cyclists at a single site and single time location in Oxford UK. They found the prevalence of use of high visibility clothing was 9.9% and the use of both front and back lights was 41.6%. The strength of the study was that it is one of the few studies measuring the use of high visibility clothing. The major limitation is the purposive sampling of a single study restricting the generalizability of findings.

Conclusions:

Despite an extensive literature search in several bibliographic databases on the topic of prevalence of use of cycle visibility aids, only four studies were identified. Of these only three measured visibility aids other than front and rear lights. Only one study presented data on the use of reflective materials. The limited data available from these studies suggests that the prevalence of use of visibility aids is very low and substantially less than the use of cycle lights. The results of this review suggest that further surveys such as those presented in this dissertation would significantly add to the literature on this topic.

Table 3: Summary of studies measuring prevalence of use of visibility aids

Study:	**Study population:**	**Sampling Method:**	**N:**	**Type of Visibility Aid:**	**Prevalence of Use:**
Osberg et al, 1998	1) France (Paris) 2) USA (Boston)	Multi-stage sampling at 17 major street sites in 2 cities	5,808	1) Front/back lights 2)Front/back lights	46.8% 14.4%
Amoros, 2010	France (Lyon)	Sample of child cyclists, sports cyclists and commuting cycling- no details sampling given	900	**Sports Cyclists:** -Bright coloured clothes -Front/back lights **Commuting Cyclists:** -Bright coloured clothes -Front/back lights	49% 64% 49% 64%
Hagel et al, 2007	Canada (Edmonton)	Multi-stage sampling with random selection of study sites	273	-Head gear colour(orange/red/ yellow/ white): -Trunk colour(orange/red/ yellow/ white): -Leg colour(orange/red/ yellow/ white): -Front light: -Reflective strips trunk: -Reflective strips legs: -Rear reflector: -Spoke reflector:	31.4% 34.2% 9.2% 29.3% 0.7% 0% 50.9% 56%

McGuire & Smith, 2012	UK (Oxford)	Multistage sample with purposive sample of single urban study site	392	-Front light: -Back light: -Front & Back lights: -High visibility clothing:	48.5% 50.2% 41.6% 9.9%

Evidence that use of visibility aids is effective at reducing accidents in cyclists:

Data on whether the use of visibility aids is a risk factor for accidents does not give information on whether this relationship is causal. Therefore a literature review was carried out to assess whether there was any published evidence from controlled trials that the use of visibility aids reduces cycle accidents. Despite an extensive literature search in several bibliographic databases including the Cochrane database of trials no such controlled trials were identified.

Kwan & Mapstone (2004) published a systematic review of randomised controlled trials of visibility aids by cyclists. They then followed this up by publishing a Cochrane review (Kwan & Mapstone, 2009) which reviewed interventions for increasing cyclist visibility for the prevention of deaths and injuries. This review identified 42 trials assessing the effect of visibility aids on driver responses and showed that these could increase drivers' perception of cyclists. The authors concluded that visibility aids may enable drivers to better detect pedestrians, including at night. However, the authors noted that they could identify no trials of the effect of the use of visibility aids on cycle accidents or other aspects of cycle safety. They suggest that a large cluster randomised controlled trial would be possible but may be challenging to conduct. They proposed that the collection of data on the use of visibility aids amongst cyclists involved in traffic accidents would also be useful until trial data become available. The strength of this review is the robust and detailed methodology used which is a requirement of the Cochrane collaboration guidelines for a Cochrane review. The limitations include the large between study heterogeneity limits the ability to make generalizable conclusions and also the fact that no evidence from trials with accident endpoint are available.

Conclusions:

Despite extensive literature within several bibliographic databases, including the Cochrane database of trials, no trials were identified which assessed the impact of the use of visibility aids on cyclists accidents. Given that any such trial would a major undertaking and require substantial funding, it seems reasonable to conclude that further studies of the relationship of the use of visibility aids and cycle accidents (such as the study described in this dissertation) would be worthwhile to inform the decision as to whether the conduct of a large trial is justified.

METHODS

This section discusses the methodology of the questionnaire design including its evaluation by pre pilot and pilot testing sessions, the sampling strategy for questionnaire distribution, data collection and the analysis of findings.

Questionnaire Design

In relation to the aims of this project, a questionnaire was chosen as the most appropriate method because a valid sample would allow the description of a large population of Edinburgh cyclists. A wide range of standardised information could be collected quickly and cost effectively. Therefore, an initial version of the questionnaire was developed using Microsoft Word tables to address the topics for investigation. This included a section on the personal characteristics to allow description of the sample population. In addition, to determine factors which relate to accidents and injuries amongst the sample population and the prevalence of use of visibility aids, the following sections were included in the survey: bicycle details, safety behaviour, cycling visibility, injuries and history of accidents and near accidents in the past three years. Sections regarding cyclist's attitudes, hazard identification and suggestions to improve Edinburgh road safety were also included. Correspondence was made with Officers from the Lothian Police Road Safety Unit, Spokes and the Bike Station in regards to survey design to ensure that the questionnaire content was relevant to address the research questions.

In the research proposal an attempt was made to estimate study power. This was based on the prevalence of use of visibility aids lying in the range of 20-60%. A sample size of 200 cyclists would allow prevalence in the range of 20-60% to be expressed precisely with a 95% confidence interval of +/- 1%. Furthermore the rate of reported accidents and near accidents in Scottish cyclists in the past 3 years was thought to lie in the range of 10-20%. With an accident/near accident rate of 15%, a study of 200 cyclists would have 84.1% power to show a statistically significant difference at the 5% level between an aid use of 50% versus 25% amongst those who do not/do report accidents. Thus the aim was to recruit at least 200 cyclists to complete the survey.

Pre-Pilot testing

Pre-Pilot 1: On the 7/01/12 an initial pre-pilot session was conducted with five Edinburgh student cyclists to evaluate the questionnaire design. Participants were invited to attend through invitation to a private Facebook event. Each participant was given a paper copy of the questionnaire and instructed to fill it out to the best of their ability. A stopwatch was used to record the time to completion of each participant. This gave an average time of 6 minutes 26 seconds. Following this a 15 minute group discussion session was held to gain feedback on the content and face validity of the questionnaire. To avoid the use of open questions a group brainstorm session helped to define an inclusive and appropriate range of answer choices. Several changes were then made to the layout and structure of the questionnaire. Due to time constraints it was decided that the addition of a bike inspection protocol to the questionnaire distribution, as designed in correspondence with the Bike Station, would not be feasible.

Pre-Pilot 2: With the permission of the Edinburgh Bike Station a publically conducted pilot test was completed on the 14/01/12 outside the Bike Station. Nine cyclists agreed to participate and were each given a copy of the amended questionnaire. They were asked to individually time themselves and to write this on the questionnaire following completion. This gave an average time to completion of 9 minutes 20 seconds. The increase in time noted following the first pilot session can be explained by the addition of questions and the fact that questionnaire were filled out outside in cold conditions. This time individual feedback was gained on collection of the questionnaire and these suggestions were incorporated into the survey design.

Survey Monkey Questionnaire Design:

Following the relatively low uptake of both an organised event and publically arranged pilot sessions it was decided to design an online version of the questionnaire in an attempt to increase sample size cost effectively. A three month subscription of £24/month as outlined in the project proposal, was taken out for 3 months to allow use of this survey software.

Content and Phrasing: This survey was designed based on the previous questionnaire, the literature review and pilot testing sessions. In addition, the views and opinions of Spokes as well as Edinburgh and Lothian borders police were taken into consideration through previous correspondence. By this stage in the survey development these discussions mainly reinforced the relevance of the existing design. Following this, online questions were designed ensuring that they were phrased appropriately and that instructions were provided if and when required.

Response format: Although pilot sessions highlighted the main response choices they would not be able to account for every possible answer and so an 'other' option was provided. This limited any forced answer selection. In addition, several questions which had multiple answers that could applicable to the respondent were appropriately engineered and clear instructions provided.

Question layout/order: The order of the questionnaire was carefully structured and individual pages were used to separate sections. Skip logic was applied to improve navigation through the survey so that if "no" was answered for having had an accident in the past 3 years, the survey bypassed the accident history section to the near accidents section. If this question was answered "no" this section was redirected to the final submission page. To avoid incomplete questionnaires, the majority of questions were formatted so that they required an answer before continuing.

Pilot Testing:

Prior to publishing the online survey monkey questionnaire, a pilot session was arranged to evaluate online questionnaire navigation and time to completion. On the 24/01/12 a side room of the Greenfield computer suite was used to test the online questionnaire. Cyclists arriving to the building were asked if they would like to be involved in the pilot testing. Each cyclist agreeing to participate was directed to a preloaded copy of the online questionnaire and asked to navigate and complete the survey. Five cyclists in total agreed to participate. Each was individually timed to completion which gave an average time of 7 minutes 20 seconds. This improvement in time from the previous pilot session is explained by the improved layout and the faster navigation through the online survey.

Data Collection:

I sought to plan a sampling strategy to achieve a sample that would widely represent cyclists in Edinburgh. A number of parallel sampling strategies were used in order to sample various sub populations. Four main distribution techniques were used with an individual URL link generated for each to enable the identification of responses by the type of collector. The primary method of data collection was through pull tab poster and advertisement card distribution to secure bicycle stores and bicycle shops respectively. In addition, emails were sent to Edinburgh bicycle clubs for newsletter advertisement and a Facebook event was created.

Pull-tab Posters: Posters with removable URL links to the online survey were designed, published, perforated and distributed throughout Edinburgh. This was done in order to achieve a wide and generalizable sample of Edinburgh cyclists. I was aware that random sampling is the most appropriate methodology, however there is no complete list of all Edinburgh cyclists so it is not possible to draw a random sample of all Edinburgh cyclists. The next best option is a random stratified sample of all parking locations cyclists use. However, there is no publically available list of all these sites and so a systematic sampling strategy was followed.

The University of Edinburgh provides secure bicycle stores at a large number of campus and public buildings throughout the city. These are listed and displayed as maps on the Edinburgh University website and includes several secure stores in the central area as well as King's buildings, the Royal Infirmary of Edinburgh, the Western General Hospital, CSE Pleasance gym and Pollock Halls of Residence. All secure stores at these sites were therefore included in the sample. In addition, an attempt was made to sample from other publically available sites and these locations and from both Waverly and Haymarket train station bicycle racks. Following this, a route was planned for the distribution which is shown by the order of listed sites in Table 4. On the 27/01/12 Pull tab posters were distributed to sites one to four as listed in Table 4. The posters were applied using temporary adhesive glue dots posteriorly and wide selotape anteriorly to make them partially wind and rain resistant. On the 28/01/12 pull tabs were distributed to the remaining sites as shown in Table 1. A selected few sites were monitored regularly to check both the response rate and whether posters remained in place. On the 04/02/12 missing or completed pull tab posters were reapplied in all locations. This was further repeated on the 11/02/12. Finally all posters were taken down following completion of data collection to avoid littering and any continuing responses.

Table 4: Location and number of pull tab posters distributed

Area:	**Number of locations to which pull tabs were distributed:**	**Number of pull tab posters distributed:**	**Total number of pull tabs**
1) Pollock Halls of Residence	1	5	500
2) Royal Infirmary of Edinburgh	4	10	1,000
3) Kings Buildings	10	16	1,600
4) Central Area	11	23	2,300
5) Pleasance CSE gym	4	6	600
6) Waverly Station	2	5	500
7) Haymarket Station	1	5	500
8) Western General Hospital	4	6	600
9) Bike Shop Windows	6	6	600
Total:	**33**	**90**	**8200**

Advertisement Cards: Business card size advertisements containing an online survey URL were designed, published and cut to size for distribution to bicycle shops. This distribution was carried out to increase the coverage of sampling for the general cycling population. No sampling frame was used to decide which Edinburgh bicycle shops to provide advertisement cards for customer distribution. This was decided as by randomly choosing bicycle shops it would not take into account the decision of the shop to participate. Therefore all bicycle shops within Edinburgh central area were approached. Table 2 shows all the shops that agreed to participate and the order in which they were approached. Depending on the size of the store relative to others and the enthusiasm of staff a set number of cards were given to the shop. An email address was also provided so that I could be contacted if they ran out of cards. Although these bicycle shops agreed to distribute the cards, their level of compliance and follow through is unknown.

Table 5: Location and number of advertisement cards distributed

Bicycle Shop:	**Number of Advertisement Cards Distributed:**
1) Bike Station	25
2) Bicycle Repair Man	20
3) Bicycle Works	15
4) Edinburgh Bicycle Cooperative	25
5) Velo Écosse	15
6) Pedals	25
7) MacDonald Bicycles	15
Total:	**140**

Bicycle Club Newsletters: To collect responses from bicycle group and organisation members, emails were sent to the following groups: Edinburgh University cycling club, Edinburgh Napier University cycling club, Ed Falcon's cycle speedway club, Edinburgh road club, Cycling Edinburgh, Christians in Sport and Spokes. From these invitations the following groups advertised the online survey to their mailing list: Edinburgh Napier University cycling club, Cycling Edinburgh and Spokes. All other groups failed to reply although none specifically declined.

Facebook Event: To collect responses from the student population a public event entitled 'Online Edinburgh Cycling Survey (10 minutes to help improve safety)' was created between 25/01/12 and 25/3/12 using Facebook. One hundred sixty-two people known to cycle were invited to the event and encouraged to follow a URL link to access the survey and to 'share' the page with people they knew to cycle. To further increase this reach of this event, six cycling colleagues agreed to advertise this page through their personal Facebook statuses.

EEMeC: In addition to the event discussed above, the survey was advertised to students via the Electronic Edinburgh Medical Curriculum. The convenor of the Medical Students Council agreed to post a short message advertising the URL link to the discussion boards of all years of study.

Table 6: Details of bicycle clubs which advertised the survey through their mailing lists

Cycling Club:	Person Contacted:	Email Address:	Date Distribution:
Edinburgh Napier University Cycling Club	Rhona Stewart	Rhona.nucc@hotmail.co.uk	29/01/12
Cycling Edinburgh	Mike Lewis	mike@cycling-edinburgh.org.uk	06/02/12
Spokes	David du Feu	spokes@spokes.org.uk	17/02/12
EEMec Discussion Board	Michael Poon	M.T.C.poon@sms.ed.ac.uk	29/01/12

Data Analysis:

Coding: The coding of qualitative information was coded manually by grouping responses into common categories and creating tally charts. A condensed numerical excel spread sheet was downloaded from survey monkey. Responses to open answer questions were coded, the data were cleaned and formatted and then imported into the statistical analysis package 'Statistical Package for Social Sciences (SPSS). The numerical values of variables were then renamed to assign meaningful descriptors. Advice was taken from Dr Margaret MacDougall on which statistical approaches were most appropriate to analyse the data (see acknowledgements).

The first stage was a descriptive analysis showing frequency distributions and where relevant, assessing whether they showed a normal distribution. Percentages were expressed with 95% confidence intervals calculated with an online statistics calculator for the main study variables, for example prevalence of use of visibility aids and of self-reported accidents and near accidents. These were based on the standard formula for confidence interval calculation based on a simple random sample. Since this study did not employ a random sample the true confidence intervals are likely to be somewhat larger than those listed in this report. Histograms were prepared and the data were illustrated in a series of figures and tables. Frequency distributions of the key variables were also investigated by age and sex. In describing the main study variables the frequency of use of visibility aids and the frequency of accidents and near accidents 95% confidence intervals were calculated.

The second stage was an inferential analysis to further investigate the descriptive data. Associations between the main study variables (use of visibility aids and self-reported accidents/near accidents) were explored. Since these data were nominal (and therefore non parametric) Chi Squared tests on a series of 2X2 contingency tables were performed. An overall visibility score which summarized overall use by each individual of active and passive visibility aids was constructed. Since these are scale (ratio) data, the association between overall visibility score and accidents/near accidents was investigated using the Mann-Whitney U-Test.

The third stage of the analysis involved further exploring the associations whilst controlling for age and sex. The association between overall visibility score and accidents/ near accidents was investigated whilst controlling for age and in a Mantel-Haenszel Test analysis after the overall visibility score was dichotomised into high and low score categories. In addition, a statistically significant association between listening to music whilst cycling and accidents/near accidents which was noted as an incidental finding was also explored further controlling for age and sex in a Mantel-Haenszel Test analysis. Since no association between the use of visibility aids and self-reported accidents was found it was not thought appropriate to do any further detailed multi-variable analysis (e.g. conditional logistic regression) of this relationship.

These analyses involved a substantial number of statistical tests. It was decided to control for multiple testing by use of the Bonferroni correction. Thus, approximately 32 independent tests of the main study hypothesis were carried out (7 fluorescent/reflective aids and 8 variables describing use of lights for both accidents and near accidents). A statistically significant result was therefore considered to be $p<0.002$ (1/20 X 30). This correction is probably conservative since the use of individual visibility aids are somewhat correlated and not fully independent. The test of the overall visibility score was not included here as this was not independent of the individual visibility aid tests. P values between $p=0.05$ and $p=0.002$ were considered to be of "suggestive significance" requiring further study in the populations.

RESULTS

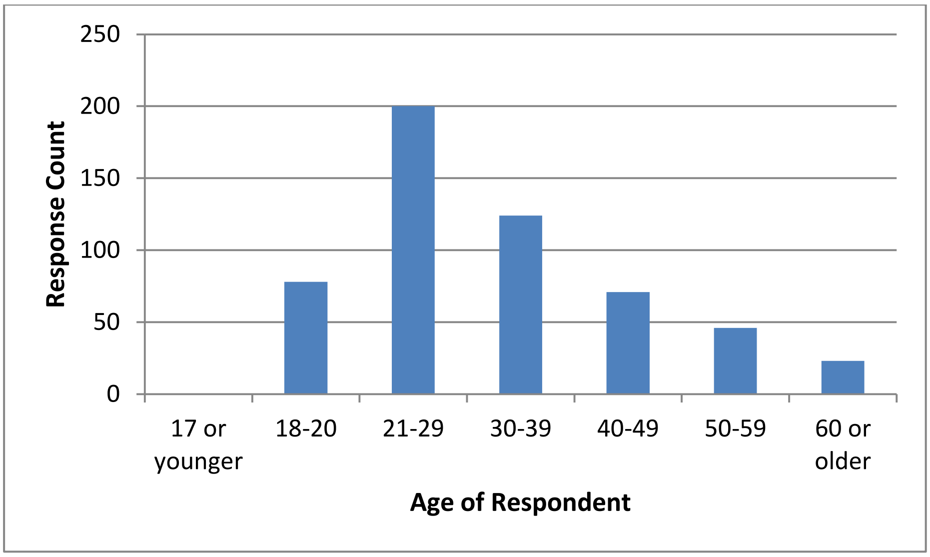
Data Collection

Five hundred forty-two people filled out the online survey monkey questionnaire. From these replies 28 were from the link advertised to spokes membership, 37 were from the link advertised on cards distributed through bike shops, 298 were from the link advertised on pull tab posters and 178 were from the initial web link generated.

Personal Characteristics

Age: The age breakdown of respondents can be seen below in Figure 1.

Figure 1: Age of respondents



Sex: Three hundred forty-two (63.1%) of the replies were from males and 200 (36.9%) were from females.

Occupation: Two hundred twenty-six (42.2%) of the respondents were classed as students, 88 (16.4%) as professional/academic, 57 (10.6%) as technical specialists, 42 (7.8%) as skilled/ semi-skilled, 41 (7.6%) as PhD/ post-doctoral student, 32 (6.0%) as management, 25 (4.7%) as clerical, 16 (3.0%) as retired, 6 (1.1%) as self-employed and 3 (0.6%) as unemployed. Of the University students; 39 (14%) were in their first year of studies, 35 (12.5%) in their second year, 81 (29%) in their third year, 50 (17.9%) in their fourth year, 48 (17.2%) in their fifth year and 26 (9.3%) in their sixth year.

Cycling Behaviours: Three hundred ninety-one people (72.1%) reported cycling daily, 113 (20.8%) cycle weekly, 31 (5.7%) cycle monthly and 7 (1.3%) cycles less often than monthly. The most common purpose for cycling was commuting with 1441 responses (82.7%) followed by Leisure with 120 responses (6.9%), Fitness with 94 responses (5.4%) and Sport with 87 responses (5.0%)**.** One hundred-ten people (20.1%) cycle for a journey of less than 15 minutes, 290 (52.9%) for 15-30 minutes, 72 (13.1%) for 30-45 minutes, 45 (8.2%) for 45-60 minutes and 31 (5.7%) for a journey of greater than 1 hour. Five hundred-two people (92.6%) reported that they cycled in the morning, 338 (62.4%) in the afternoon, 441 (81.4%) in the evening and 167 (30.8%) a night.

Cycling Visibility

High visibility vest/jacket: Two hundred forty-six (45.8%; 95% CI 41.6%-50.0%) said that they regularly wore a high visibility vest/ jacket. The ten most common reasons for not wearing them were: “Unnecessary” - 105 responses (25.7%), “Not bothered” - 70 responses (17.2%), “Fashion” - 66 responses (16.2%), “Money” - 49 responses (12.0%), “Not thought about it” - 41 (10.0%), “Time” - 21 responses (5.1%), “Impractical to wear” - 13 responses (3.2%), “Other high visibility clothing is enough” - 8 (2.0%), “lights are enough” - 7 responses (1.7%), “only wear sometimes” - 6 responses (1.5%).

Reflectors: Three hundred forty-seven (64.6%; 95% CI 60.5%-68.6%) had fitted front reflectors and 397 (73.9%; 95% CI 70.1%-77.5%) had fitted back reflectors.

Lights: Five hundred-eleven (95.2%; 95% CI 93.0%-96.7%) use front lights and 508 (94.6%; 95% CI 92.4%-96.2%) use back lights. Two hundred sixty-two (49.5%; 95% CI 44.9%-53.3%) set front lights to flash and 398 (75.2%; 95% CI 70.7%-78.0%) set back lights to flash. Two hundred sixty-two (50.9%; 95% CI 46.6%-55.2%) use lights in the morning, 67 (13.0%; 95% CI 10.4%-16.2%) in the afternoon, 463 (89.9%; 95% CI 87.0%-92.2%) in the evening and 375 (72.8%; 95% CI 68.8%-76.5%) at night.

Visibility Aids: Two hundred eighty-nine (53.8%; 95% CI 49.6%-58.0%) use pedal reflectors, 227 (42.3%; 95% CI 38.2%-46.5%) use spoke reflectors, 166 (31.0%; 95% CI 27.2%-35.0%) use reflective ankle clips and 45 (8.4%; 95% CI 6.3%-11.0%) use reflective arm bands.

Fluorescent clothing/ accessories: The following materials were listed by respondents: 50 (25.6%) Reflective strips on clothing, 43(22.1%) rucksack cover/bags, 33(16.9%) helmets, 25 (12.8%) reflective strips on bikes, 17 (8.7%) reflective gloves, 11 (5.6%) multiple lights, 8 (4.1%) reflective tape/ stickers and 8 (4.1%) reflective belts.

The variation in use of individual aids by age and six is given in detail in the appendix.

Cycling Safety

Bicycle: There were one hundred ninety-eight (33.7%) hybrid bikes reported, 186 (31.6%) road bikes, 154 (26.2%) mountain bikes, 11 (1.9%) touring bikes, 10 (1.7%) cyclocross bikes, 8 (1.4%) folding bikes, 7 (1.2%) city, 5 (0.9%) fixed gear and 9 (1.5%) other.

Maintenance: I their bikes have a problem, 286 people (54.7%) fix it themselves, 152 (29.1%) take it to a bicycle repair shop, 49 (9.4%) fix a small problem themselves but take a big problem to shop, 16(3.1%) take it to a friend, 8(1.5%) do nothing and 12 (2.3%) other. Six people (1.2%) have their bike serviced weekly, 25 (4.9%) monthly, 236 (46.6%) monthly to yearly, 68 (13.4%) less often than yearly, 95 (18.8%) never and 76 (15.0%) as required.

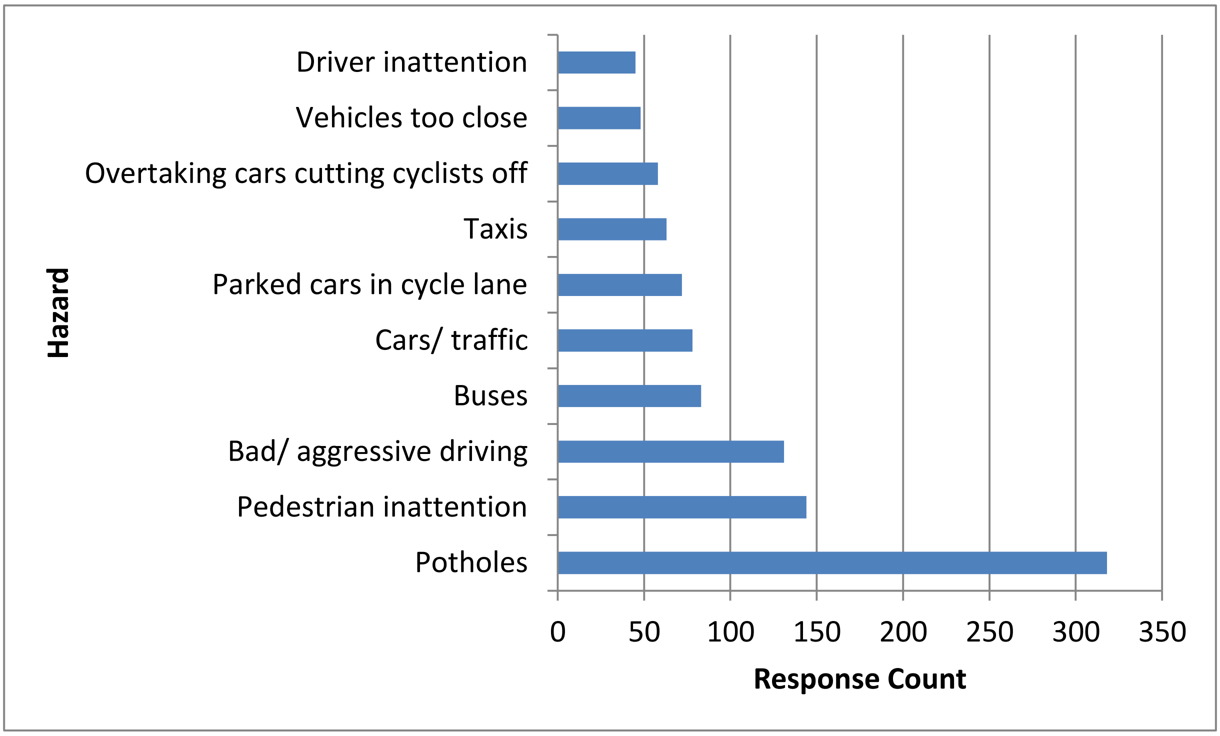
Music: Four hundred-sixteen respondents reported never listening to music, 82 (15.7%) sometimes and 25 (4.8%) always.

Helmet: Three hundred seventy-two (71.1%) always wear a helmet, 81 (15.5%) sometimes and 70 (13.4%) never. The 10 most common reasons for not wearing them were: "unnecessary" - 42 (20.1%), "not bothered" - 26 (12.7%), "evidence helmets not safer" - 24 (11.8%), "fashion" - 21 (10.3%), "not needed for small journey/cycle lanes" - 16 (7.8%), "uncomfortable/restricted vision" - 15 (7.4%), "storage/luggage" - 13 (6.4%), "money" - 13 (6.4%), "only for long journeys/ traffic" - 12 (5.9%), "Time" - 12 (5.9%).

Hazards

Hazards encountered by Edinburgh cyclists were able to be categorised into four main groups. One hundred sixty-six hazards listed involved road design, 384 hazards involved road surface problems, 449 hazards involved other road users and 405 hazards involved dangerous driving behaviours. The 10 most common responses are shown in the Figure 2 below.

Figure 2: Ten most commonly listed hazards



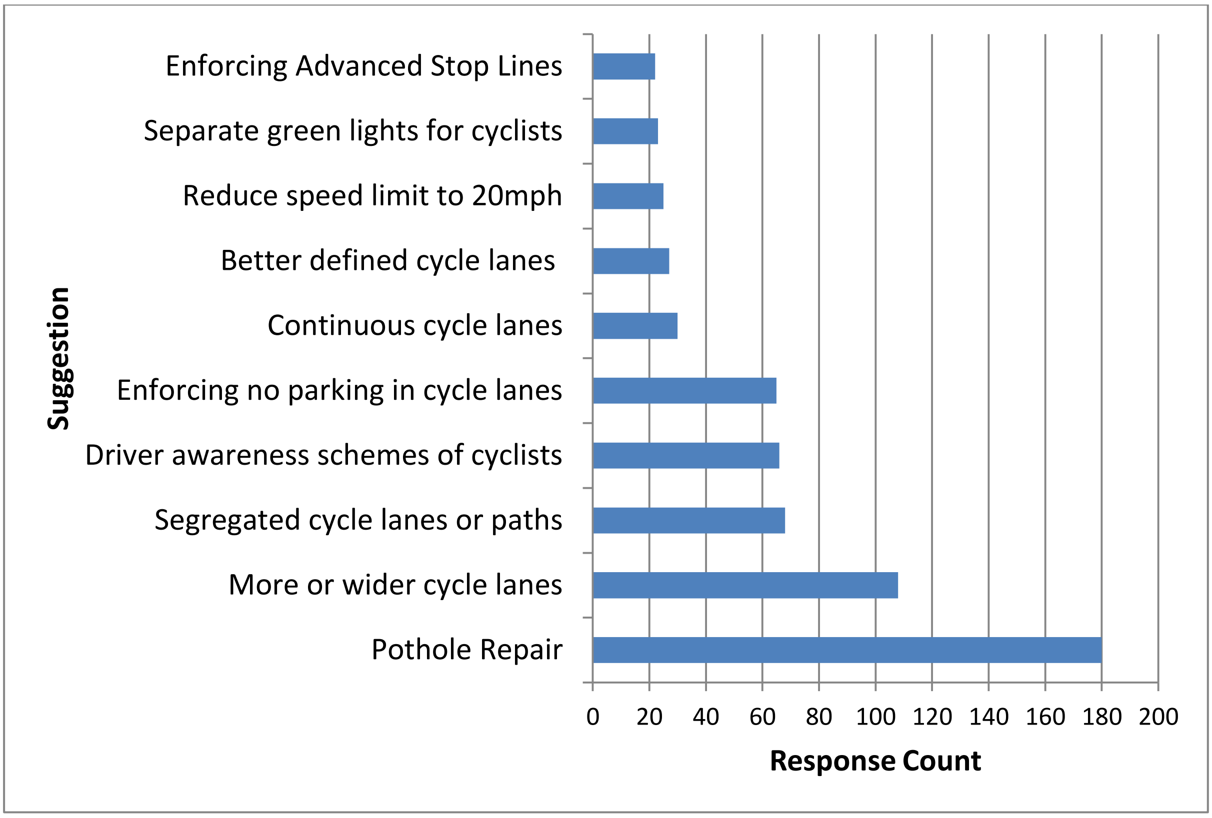
Attitudes

Eighty-two (16.1%) describe cycling in Edinburgh as “unsafe”, 319 (62.8%) as “moderately safe”, 99 (19.5%) as “safe” and 8 (1.6%) as “very safe”. Thirty-two cyclists (16.1%) think that it is “very likely they will have an accident in the next year”, 142 (28.0%) think it is “likely”, 291 (57.3%) think it is “unlikely” and 43 (8.5%) think it is “very unlikely”. Two hundred eighty-seven people (56.6%) thought that there was enough awareness of cyclists from bus drivers, 127 (25.1%) from taxi drivers and 112 (22.1%) from motorists.

Suggestions to improve road safety:

Suggestions made by cyclists in Edinburgh to improve road safety were able to be categorised into three main groups. One hundred fifty-seven suggestions were related to road user education, 542 regarded road engineering and 194 involved enforcement of road laws. The 10 most commonly listed responses are show in the Figure 3 below:

Figure 3: Ten most commonly listed suggestions to improve safety



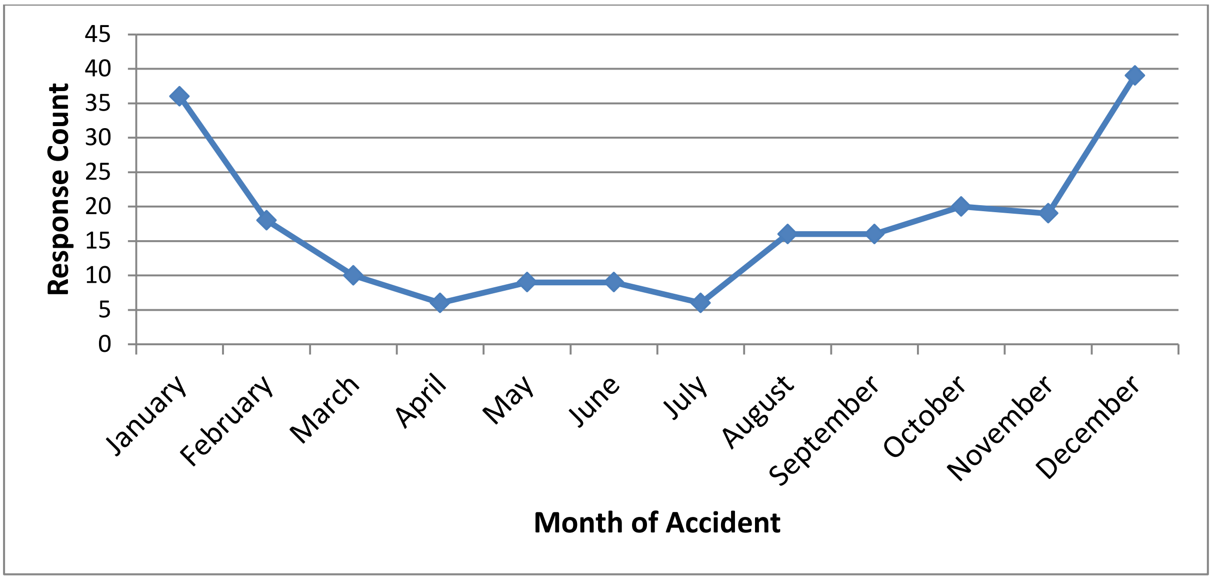
Accidents:

Accident Prevalence: Two hundred-seventeen (42.7%; 95% CI 38.5%-47.1%) of respondents have had an accident cycling in Edinburgh in the last 3 years. An accident was defined as a fall from your bike, a collision or any accident causing injury. Only thirty-five (16.4%) of accidents were reported to the police.

Number of Accidents: Within this time 113 (54.6%) have reported 1 accident, 51 (24.6%) 2 accidents, 24 (11.6%) 3 accidents, 8 (3.9%) 4 accidents, 11 (5.3%) 5 or more accidents.

Month of Accident: This can be seen in Figure 4 on the following page.

Figure 4: Number of cyclists reporting an accident in past 3 years by month



Road User involved: One hundred thirty-eight (53.5%) accidents involved another bicycle, 77 (29.6%) a car, 17 (6.5%) a pedestrian, 8 (3.1%) a taxi, 7 (2.7%) a bus, 6 (2.3%) a van, 3 (1.2%) a lorry, 2 (0.8%) a dog, 1 (0.4%) a motorcyclist.

Time of day: One hundred-three (47.2%) accidents happened in the morning, 57 (26.1%) in the afternoon, 46 (21.1%) in the evening and 12 (5.5%) at night. Forty cyclists (18.6%) thought that they had been seen early enough by the other road user but only 7 (3.2%) thought that wearing a fluorescent jacket or any other visibility aid could have prevented this accident.

Level of Medical Attention:

One hundred forty-one (66.2%) of accidents required no medical attention, 31 (14.6%) went to A & E, 19 (8.9%) self-administered first aid, 13 (6.1%) visited GP/Nurse, 5 (2.3%) were In-patients and 4 (1.9%) required paramedics.

Injuries:

One hundred forty-eight (57.6%) of injuries were minor (abrasions, cuts, sprains, bruises), 43 (16.7%) had none, 14 (5.4%) were head injuries, 13 (5.1%) were fractures, 12 (4.7%) were hand injuries, 12 (4.7%) were leg injuries, 6 (2.3%) were shoulder injuries, 3 (1.2%) were chest/rib injuries, 3 (1.2%) were back injuries, 2 (0.8%) were major (abrasions, cuts, sprains, bruises) and 1 (0.4%) was a neck injury. There were 4 shoulder dislocations, 2 lost teeth, 1 ruptured Achilles tendon, 1 broken collar bone, 1 whiplash and 1 case of broken ribs.

Accident location: The locations of accidents reported by respondents are shown in Figures 5, 6 and 7.

Figure5: Edinburgh bicycle accident map (zoomed out)

Figure 6: Edinburgh bicycle accident map (zoom 1)

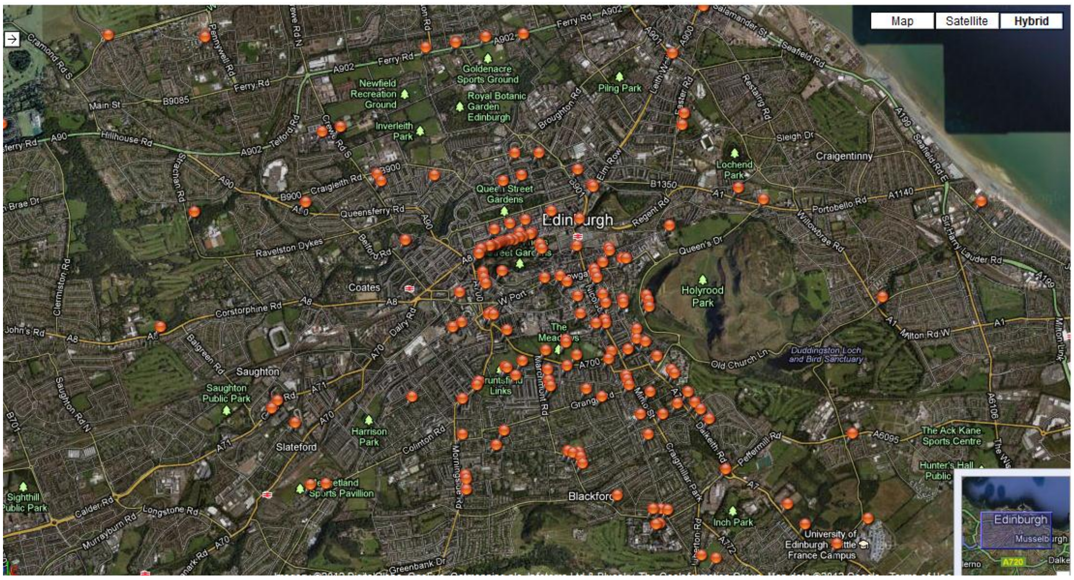
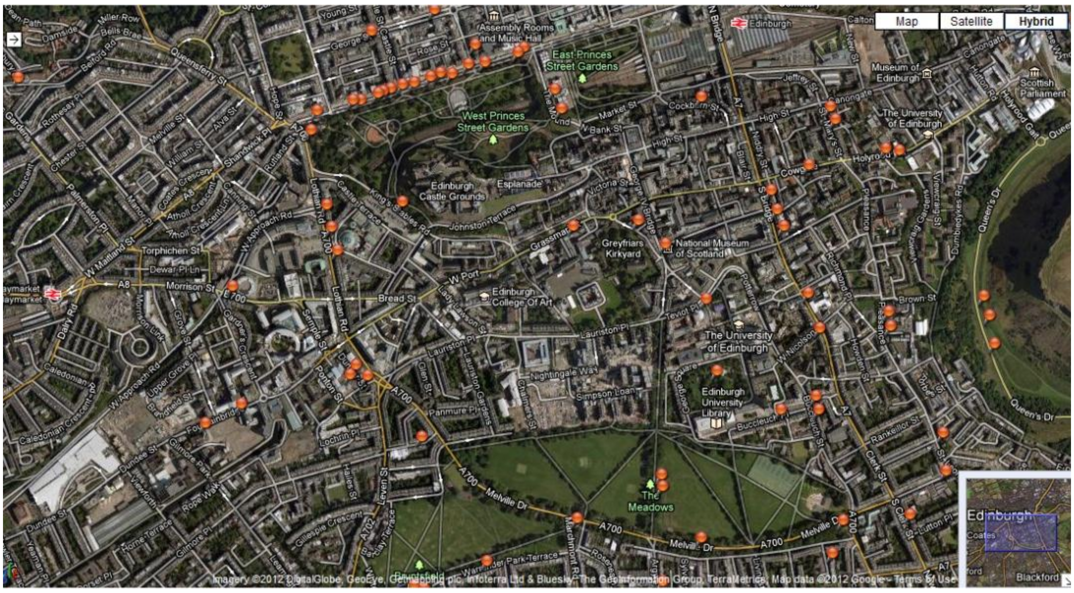


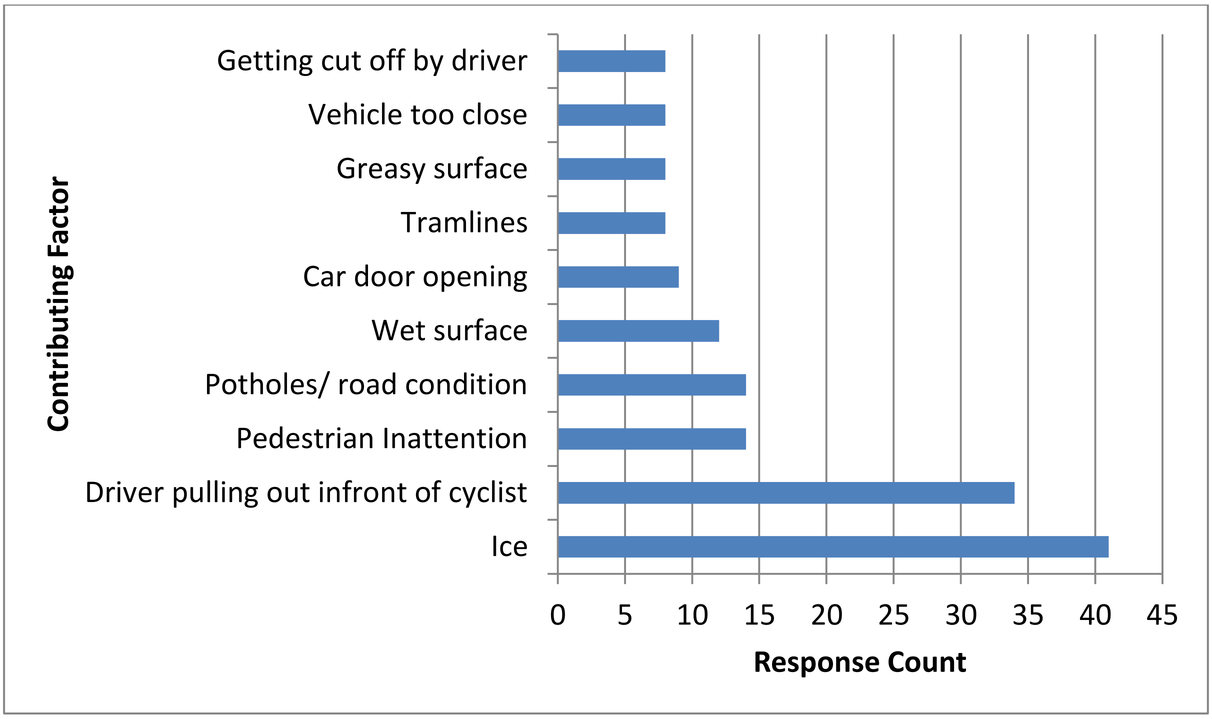
Figure 7: Edinburgh bicycle Accident map (zoom 2)



<u>Accident Contributing Factors:</u>

Factors identified by cyclists as having contributed to causing their accident can be grouped into road surface/ design problems, driver behaviours, cyclist behaviours and behaviour of other road users. These are shown below in Figure 8.

Figure 8: Ten most commonly listed factors contributing to accidents



Near Accidents:

Accident Prevalence: Three hundred eighty-two (75.5%; 95% CI 71.6%-79.0%) of respondents have had a near accident cycling in Edinburgh in the last 3 years. A near accident was defined as a road incident causing concern for safety or risk of injury but not causing an accident. Only 7 (2%) of near accidents were reported to the police.

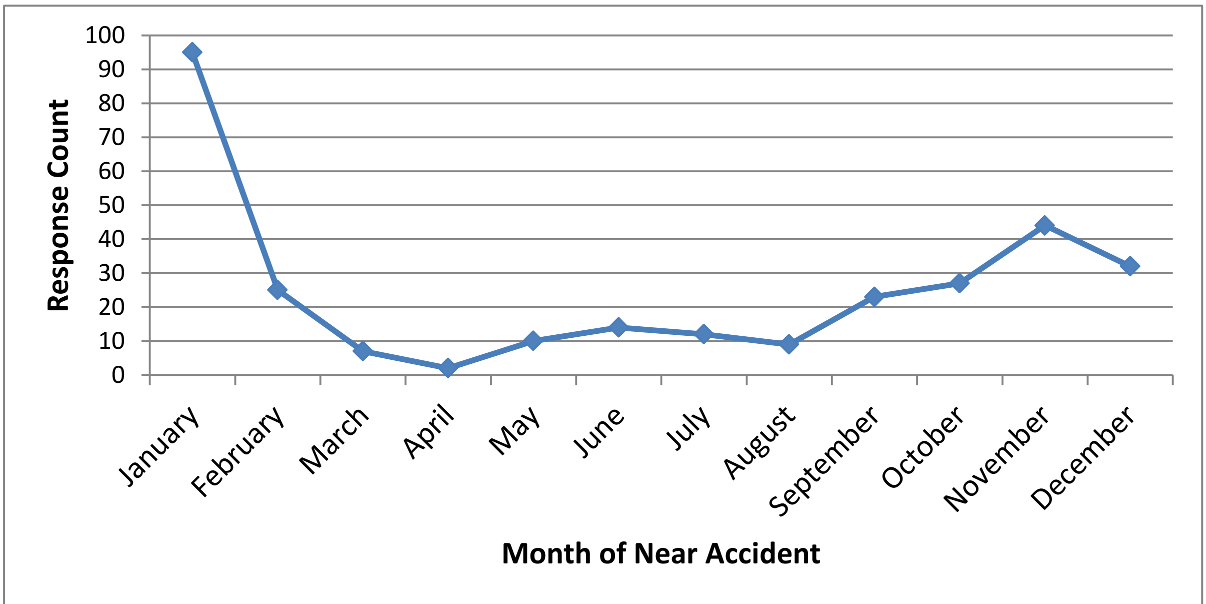
Number of Accidents: Within this 3 year time period sixty-four (23.4%) have reported 1 near accident, 69 (25.2%) 2 near accidents, 41 (15.0%) 3 near accidents, 15 (5.5%) 4 near accidents, 28 (10.2%) 5 near accidents, 17 (6.2%) 6 to 9 near accidents, 20 (7.3%) 10 to 15 near accidents, 5 (1.8%) 16 to 20 near accidents, 15 (5.5%) greater than 20 accidents.

Road User involved: Two hundred forty-five (44.5%) involved a car, 149 (27.1%) another bicycle, 38 (6.9%) a pedestrian, 48 (8.7%) a taxi, 42 (7.6%) a bus, 18 (3.3%) a van, 4 (0.7%) a lorry, 3 (0.5%) a HGV, 2 (0.4%) a dog and 2 (0.2%) a motorcyclist.

Time of day: One hundred twenty-six (35.9%) happened in the morning, 116 (33.0%) in the afternoon, 97 (27.6%) in the evening and 12 (3.4%) at night. One hundred forty-seven cyclists (71.9%) thought that they had been seen early enough by the other road user but only 33 (9.4%) thought that wearing a fluorescent jacket or any other visibility aid could have prevented this accident.

Month of Accident of Near Accident: This can be seen in Figure 9 below.

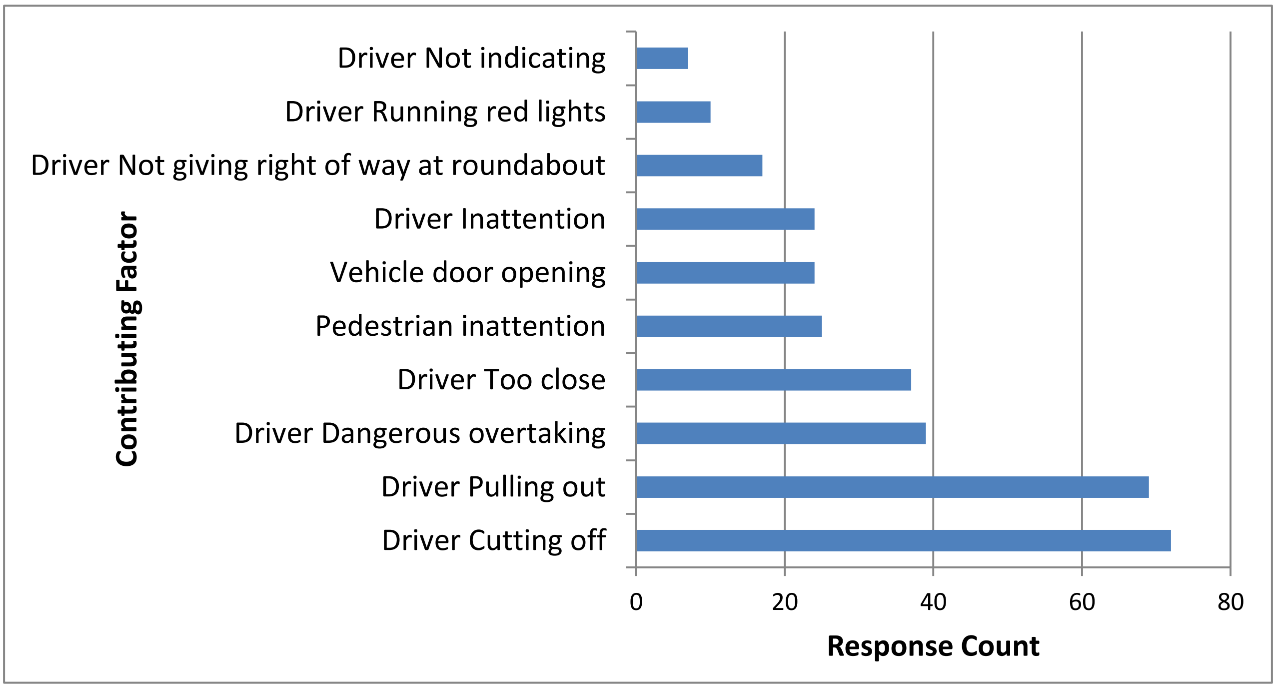
Figure 9: Number of cyclists reporting a near accident in past 3 years by month



Contributing factors for Near Accidents:

Factors identified by cyclists to have contributed to causing their near accident can be grouped into road surface/ design problems, driver behaviours, cyclists own behaviours, other cyclists behaviours and other road users. These are shown below in Figure 10.

Figure 10: Ten most commonly listed factors contributing to near accidents



Inferential Analysis:

Table 7: Associations between the use of Visibility Aids (Fluorescent or Reflective Materials) and Accidents/ Near Accidents (Pearson Chi-Square Test).

Type Visibility Aid:	**Response:**	**Accident**		**Near Accident**	
		Yes	No	Yes	No
1) High Visibility Jacket	1.1) Yes	101 (42.8%)	135 (57.2%)	190 (80.5%)	46 (19.5%)
	1.2) No	116 (42.6%)	156 (57.4%)	192 (71.1%)	78 (28.9%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2 (continuity correction)**: 0.000, p=1.000 (2 sided)* ***OR** (No/Yes):1.006 (95%CI: 0.707, 1.431)*		***X^2 (continuity correction)**: 5.514, p=0.019 (2 sided)* ***OR** (No/Yes):1.678 (95%CI: 1.107, 2.543)*	
2) Front Reflectors	2.1) Yes	129 (39%)	202 (61%)	239 (72.4%)	91 (27.6%)
	2.2) No	88 (75.6%)	89 (50.3%)	143 (81.3%)	33 (18.8%)
STATISTICAL SIGNIFICANCE:		***X^2**(continuity correction):*		***X^2**(continuity correction):*	

(**OR** = Odds Ratio)		*5.011, p=0.025 (2 sided)* ***OR** (No/Yes):0.646 (95%CI: 0.447,0.933)*		*4.367, p=0.037 (2 sided)* ***OR** (No/Yes):0.606 (95%CI: 0.387,0.950)*	
3) Back Reflectors:	3.1) Yes	153 (40.4%)	226 (59.6%)	283 (74.9%)	95 (25.1%)
	3.2) No	64 (49.6%)	65 (50.4%)	99 (77.3%)	29 (22.7%)
STATISTICAL SIGNIFICANCE: (**OR** = Odds Ratio)		***X^2**(continuity correction)**:*** *2.993, p=0.084 (2 sided)* ***OR** (No/Yes):0.688 (95%CI: 0.460,1.027)*		***X^2**(continuity correction)**:*** *0.197, p=0.657 (2 sided)* ***OR** (No/Yes):0.873(95%CI: 0.543, 1.403)*	
4) Pedal Reflectors	4.1) Yes	113 (41.1%)	162 (58.9%)	204 (74.2%)	71 (25.8%)
	4.2) No	104 (44.6%)	129 (55.4%)	178 (77.1%)	53 (22.9%)
STATISTICAL SIGNIFICANCE: (**OR** = Odds Ratio)		***X^2**(continuity correction)**:*** *0.511, p=0.475 (2 sided)* ***OR** (No/Yes):0.865 (95%CI: 0.608, 1.231)*		***X^2**(continuity correction)**:*** *0.416 , p=0.519 (2 sided)* ***OR** (No/Yes):0.856 (95%CI: 0.569, 1.287)*	
5) Spoke Reflectors	5.1) Yes	87 (39.7%)	132 (60.3%)	166 (75.8%)	53 (24.2%)
	5.2) No	130 (45%)	159 (55%)	216 (75.8%)	71 (24.7%)
STATISTICAL SIGNIFICANCE: (**OR** = Odds Ratio)		***X^2**(continuity correction)**:*** *1.200, p=0.273 (2 sided)* ***OR** (No/Yes):0.806 (95%CI: 0.564, 1.151)*		***X^2**(continuity correction)**:*** *0.001, p=0.972 (2 sided)* ***OR** (No/Yes):1.030 (95%CI: 0.684, 1.550)*	
6) Reflective Clips	6.1) Yes	69 (43.1%)	91 (56.9%)	120 (75%)	40 (25%)
	6.2) No	148 (42.7%)	199 (57.3%)	262 975.9%)	83 (24.1%)
STATISTICAL SIGNIFICANCE: (**OR** = Odds Ratio)		***X^2**(continuity correction)**:*** *0.000, p=0.997 (2 sided)* ***OR** (No/Yes):1.020 (95%CI: 0.698, 1.488)*		***X^2**(continuity correction)**:*** *0.014, p=0.906 (2 sided)* ***OR** (No/Yes):0.950 (95%CI: 0.615, 1.468)*	
7) Reflective Bands	7.1) Yes	20 (46.5%)	23 (55.3%)	35 (81.4%)	8 (18.6%)
	7.2) No	197 (42.5%)	267 (57.5%)	347 (75.1%)	115 (24.9%)
STATISTICAL SIGNIFICANCE: (**OR** = Odds Ratio)		***X^2**(continuity correction)**:*** *0.125, p=0.724 (2 sided)* ***OR** (No/Yes):1.179 (95%CI: 0.630, 2.206)*		***X^2**(continuity correction)**:*** *0.537, p=0.464 (2 sided)* ***OR** (No/Yes):1.450 (95%CI: 0.654, 3.216)*	

Table 7 shows no statistically significant differences between the use of any of the visibility aids and accidents/ near accidents. P values less than 0.05 were found for the associations between the use of high visibility jacket and more near accidents (p=0.019), front reflectors and fewer accidents (p=0.025) and fewer near accidents (p=0.037), pedal reflectors with fewer near accidents (p=0.464) are not considered to be statistically significant due to the bonferroni correction (see methods); however may be considered as "suggestive" statistical significance and requiring further study.

Table 8: Associations between the use of Visibility Aids (Lights) and Accidents/ Near Accidents (Pearson Chi-Square Test).

Type Visibility Aid:	**Response:**	**Accident**		**Near Accident**	
		Yes	No	Yes	No
1)Front Lights	1.1) Yes	212 (43.6%)	274 (56.4%)	370 (76.3%)	115 (23.7%)
	1.2) No	5 (22.7%)	17 (77.3%)	12 (57.1%)	9 (42.9%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction)**:** 2.950, p=0.086 (2 sided) **OR** (No/Yes):2.631 (95%CI: 0.955, 7.245*		***X^2**(continuity correction)**:** 3.020, p=0.082 (2 sided) **OR** (No/Yes):2.413 (95%CI: 0.992, 5.872)*	
2)Back Lights	2.1) Yes	211 (43.6%)	273 (56.4%)	369 (76.4%)	114 (23.6%)
	2.2) No	6 (25%)	18 (75%)	13 (56.5%)	10 (43.5%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction)**:** 2.516, p=0.113(2 sided) **OR** (No/Yes):2.319 (95%CI: 0.905, 5.943)*		***X^2**(continuity correction)**:** 3.675, p=0.055(2 sided) **OR** (No/Yes):2.490 (95%CI: 1.063,5.830)*	
3) Front Lights Flashing	3.1) Yes	117 (46.8%)	133 (53.2%)	202 (81.1%)	47 (18.9%)
	3.2) No	97 (38.6%)	154 (61.4%)	174 (69.6%)	76 (30.4%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction)**:** 3.079, p=0.079(2 sided) **OR** (No/Yes):1.397 (95%CI: 0.979, 1.993)*		***X^2**(continuity correction)**:** 8.311, p=0.004(2 sided) **OR** (No/Yes):1.877 995%CI: 1.238, 2.847)*	
4) Back Lights Flashing	4.1) Yes	176 (46.3%)	204 (53.7%)	297 (78.4%)	82 (21.6%)
	4.2) No	39 (32.2%)	82 (67.8%)	80 (66.7%)	40 (33.3%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction)**:** 6.868, p=0.009 (2 sided) **OR** (No/Yes):1.814 (95%CI: 1.178, 2.792)*		***X^2**(continuity correction)**:** 6.133, p=0.013 (2 sided) **OR** (No/Yes):1.811 (95%CI:1.153, 2.844)*	
5) Lights On in Morning	5.1) Yes	117 (45.5%)	140 (54.5%)	208 (80.9%)	49 (19.1%)
	5.2) No	100 (39.8%)	151 (60.2%)	174 (69.9%)	75 (30.1%)

STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction): 1.453, p=0.228 (2 sided)* ***OR**(No/Yes):1.262 (95%CI: 0.887, 1.795)*		***X^2**(continuity correction): 7.767, p=0.005 (2 sided)* ***OR** (No/Yes):1.830 (95%CI: 1.211, 2.764)*	
6) Lights on in Afternoon	6.1) Yes	26 (39.4%)	40 (60.6%)	48 (72.7%)	18 (27.3%)
	6.2) No	191 (43.2%)	251 (56.8%)	334 (75.9%)	106 (24.1%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction): 0.204, p=0.652 (2 sided)* ***OR** (No/Yes):0.854 (95%CI: 0.504, 1.449)*		***X^2**(continuity correction): 0.116, p=0.684 (2 sided)* ***OR** (No/Yes):0.846 (95%CI: 0.472, 1.518)*	
7) Lights on in Evening	7.1) Yes	197 (44.8%)	243 (55.2%)	332 (75.5%)	108 (24.5%)
	7.2) No	20 (29.4%)	48 (70.6%)	50 (75.8%)	16 (24.2%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction): 5.069, p=0.024 (2 sided)* ***OR** (No/Yes):1.946 (95%CI: 1.118, 3.387)*		***X^2**(continuity correction): 0.000, p=1.000 (2 sided)* ***OR** (No/Yes):0.984 (95%CI: 0.538, 1.798)*	
8) Lights on at Night	8.1) Yes	156 (43.7%)	201 (56.3%)	275 (77.2%)	81 (22.8%)
	8.2) No	61 (40.4%)	90 (59.6%)	107 71.3%)	43 (28.7%)
STATISTICAL SIGNIFICANCE: *(**OR** = Odds Ratio)*		***X^2**(continuity correction): 0.347, p=0.556 (2 sided)* ***OR** (No/Yes):1.145 (95%CI: 0.778, 1.685)*		***X^2**(continuity correction): 1.688, p=0.194 (2 sided)* ***OR** (No/Yes):1.364 (95%CI: 0.886, 2.102)*	

Table 8 shows no statistically significant differences between the use of any of the lighting circumstances and accidents/ near accidents. The p values less than 0.05 for the associations between the use of front light flashing and more accidents (p=0.004), back light flash and more accidents (p=0.009) and more near accidents (p=0.013), lights in the morning and more near accidents (p=0.05) and lights in the evening and more accidents (p=0.024) are not considered to be statistically significant due to the bonferroni correction to account for multiple testing (see methods); however may be considered as “suggestive” statistical significance and requiring further study.

The analysis of overall visibility score (ranging from 0-19) was assessed in two ways. Firstly the number of accidents/ near accidents between a high score and a low score were compared by means of a Pearson Chi-Squared Test then the distribution of exact scores between those reporting or not reporting accidents/ near accidents were compared by a Mann-Whitney U test.

Table 9: Associations between the use of Visibility Aids (Overall Score) and Accidents/ Near Accidents (Pearson Chi-Square Test).

Type Visibility Aid:	**Response:**	**Accident**		**Near Accident**	
		Yes	No	Yes	No
1) Visibility Score	1.1) High	120 (43.3%)	157 (56.7%)	217 (78.3%)	60 (21.7%)
	1.2) Low	97 (42.5%)	131 (57.5%)	163 (72.1%)	63 (27.9%)
STATISTICAL SIGNIFICANCE *(**OR** = Odds Ratio)*		***X^2****(continuity correction):* *0.007, p=0.932 (2 sided)* ***OR*** *(No/Yes):1.032 (95%CI: 0.724, 1.471)*		***X^2****(continuity correction):* *2.277, p=0.131 (2 sided)* ***OR*** *(No/Yes): 1.398 (95%CI: 0.930, 2.102)*	

Table 9 shows no statistically significant differences for the relationship between a high or low visibility score and accidents/ near accidents. Note that in Table 9 although there is no statistically significant association with overall visibility score and accidents, the 95% CI of the OR are consistent with having a score for use of visibility aids being association with a 28% lower rate of accident and a 7% lower rate of near accidents.

Table 10: Associations between the use of Visibility Aids (Overall Score) and Accidents (Mann-Whitney U Test).

Statistic:	**Value:**
Visibility Score (Accident No)	Mean Rank Sum=251.31
Visibility Score (Accident Yes)	Mean Rank Sum=258.77
Mann-Whitney U	30646.000
Statistical significance	P=0.568

Table 10 shows no statistically significant difference of the relationship between the range of overall visibility scores and accidents

Table 11: Associations between the use of Visibility Aids (Overall Score) and Near Accidents (Mann-Whitney U Test).

Statistic:	**Value:**
Visibility Score (Near Accident No)	Mean Rank Sum=232.15
Visibility Score (Near Accident Yes)	Mean Rank Sum=260.43
Mann-Whitney U	21036.000
Statistical significance	P=0.059

Table 11 shows no statistically significant difference of the relationship between the range of overall visibility scores and near accidents

TABLE 12: Associations between Personal Characteristics and the use of Visibility Aids (Pearson Chi-Square Test).

Personal Characteristic:	**Response:**	**Accident**		**Near Accident**	
		Yes	No	Yes	No
1) Age	1.1) 18 to 20	24 (33.8%)	47 (66.2%)	39 (55.7%)	31 (44.3%)
	1.2) 21-29	76 (40.9%)	110 (59.1%)	138 (74.6%)	47 (25.4%)
	1.3) 30-39	59 (50%)	59 (50%)	99 (83.9%)	19 (16.1%)
	1.4) 40-49	34 (50.7%)	33 (49.3%)	58 (86.6%)	9 (13.4%)
	1.5) 50-59	15 (33.3%)	30 (66.7%)	33 (73.3%)	12 (26.7%)
	1.6) 60 or Older	9 (42.9%)	12 (57.1%)	15 (71.4%)	6 (28.6%)
STATISTICAL SIGNIFICANCE		***X^2:*** *8.510, p=0.130*		***X^2:*** *24.131, p=0.000*	
2) Sex	2.1) Male	151 (47%)	170 (53%)	261 (81.6%)	59 (18.4%)
	2.2 Female	66 (35.3%)	121 (64.7%)	121 (65.1%)	65 (34.9%)
STATISTICAL SIGNIFICANCE		***X^2:*** *6.663, p=0.010* ***OR*** *(M/F): 0.614 (95%CI: 0.424,0.890)*		***X^2:*** *17.328, p=0.000* ***OR*** *(M/F): 0.421 (95%CI: 0.278,0.636)*	
3) How regularly Cycle	3.1) Daily	180 (48.5%)	191 (51.5%)	286 (77.3%)	84 (22.7%)
	3.2) Weekly	33 (31.7%)	71 (68.3%)	75 (72.8%)	28 (27.2%)
	3.3) Monthly	3 (11.5%)	23 (88.5%)	16 (61.5%)	10 (38.5%)
	3.4) Less Often Monthly	1 (14.3%)	6 (85.7%)	5 (71.4%)	2 (28.6%)
STATISTICAL SIGNIFICANCE		***X^2:*** *22.873, p=0.000*		***X^2:*** *3.849, p=0.278*	
4) Journey time <15 Minutes	*<15 Minutes*	*31 (32.3%)*	*65 (67.7%)*	71 (74%)	25 (26%)
	15-30 Minutes	*110 (41.4%)*	*156 (58.6%)*	195 (73.6%)	70 (26.4%)
	Journey time 30-45 Minutes	*34 (52.3%)*	*31 (47.7%)*	48 (73.8%)	17 (26.2%)
	Journey time 45-60 Minutes	*22 (55%)*	*18 (45%)*	30 (76.9%)	9 (23.1%)
STATISTICAL SIGNIFICANCE		***X^2:*** *9.352, p=0.025*		***X^2:*** *0.198, p=0.978*	

Table 12 shows: an increase in the frequency of accidents between age categories from 18 to 50 and a decrease older than 50; a higher accident and near accident frequency for men; an increase in accident and near accident frequency with increasing cycling frequency; and an increase in accident and near accident frequency with increasing journey time. The level of statistical significance for these findings is given in the Table

TABLE 13: Associations between Safety Behaviours and the use of Visibility Aids (Pearson Chi-Square Test).

Safety Behaviour:	*Response:*	Accident		Near Accident	
		Yes	*No*	Yes	No
1) Type of Bike	*Road bike only*	*67 (46.2%)*	*78 (53.8%)*	11 (71.1%)	33 (22.9%)
	Mountain bike only	*35 (31.8%)*	*75 (68.2%)*	73 (67%)	36 (33%)
	Hybrid only	*75 (44.1%)*	*95 (55.9%)*	124 (72.9%)	46 (27.1%)
	Combination or Other	*40 (48.2%)*	*43 (51.8%)*	74 (89.2%)	9 (10.8%)
STATISTICAL SIGNIFICANCE		***X^2:*** *7.215, p=0.065*		***X^2:*** *13.448, p=0.004*	
2) Helmet	*2.1)Yes (always/sometimes)*	*188 (42.7%)*	*252 (57.3%)*	333 (75.9%)	106 (24.1%)
	2.2) No	*29 (42.6%)*	*39 (57.4%)*	49 (73.1%)	18 (26.9%)
STATISTICAL SIGNIFICANCE		***X^2:*** *0.000, p=0.990* ***OR****(always,sometimes/Never): 0.997 (95%CI: 0.595,1.670)*		***X^2:*** *0.232, p=0.630* ***OR****(always,sometimes/Never): 0.867 (95%CI: 0.484,1.552)*	
3) Music	*3.1) Yes (always/sometimes)*	*56 (53.8%)*	*48 (46.2%)*	75 (72.8%)	28 (27.2%)
	3.2) No	*161 (39.9%)*	*243 (60.1%)*	307 (76.2%)	96 (23.8%)
STATISTICAL SIGNIFICANCE		***X^2:*** *6.620, p=0.010* ***OR****(always,sometimes/Never): 0.568 (95%CI: 0.368,0.876)*		***X^2:*** *0.502, p=0.479* ***OR****(always,sometimes/ Never): 1.194 (95%CI: 0.731,1.950)*	

Table 13 shows: no difference in accident or near accident frequency for road or hybrid bike users but a lower accident and near accident frequency for mountain bike users; no difference in accident or near accident frequency for wearing or not wearing a helmet; and an increase in accident (p=0.01) and near accident (p=0.479) frequency for listening to music. The level of statistical significance for these findings is given in the Table.

Table 14: Association between the use of Visibility Aids (Overall Score) and Accidents, controlling for Age (Mantel-Haenszel Test).

Statistic:	**Value:**
Breslow-Day Test of Homogeneity:	X^2=1.135, df=5, p=0.951
Mantel-Haenszel Test of Conditional Independence :	X^2=0.011, df=1, p=0.917
Common Odds Ratio:	0.964 (95%CI:0.670, 1.387)

There is no statistically significant evidence to reject the null hypothesis of homogeneity across different age groups (p=0.951). There is no evidence of an association between use of visibility aids and self-reported accidents after controlling for age (p=0.917) with an odds ratio of accidents associated with use of visibility aids of 0.964.

Table 15: Association between the use of Visibility Aids (Overall Score) and Accidents, controlling for Sex (Mantel-Haenszel Test).

Statistic:	**Value:**
Breslow-Day Test of Homogeneity:	X^2=6.728, df=1, p=0.009
Mantel-Haenszel Test of Conditional Independence :	X^2=0.227, df=1, p=0.634
Common Odds Ratio:	1.110 (95%CI:0.774, 1.591)

There evidence to reject the null hypothesis of homogeneity across different gender groups (p=0.009), with accident rates higher in males than females in all visibility aid categories. There is no evidence of an association between use of visibility aids and self-reported accidents after controlling for gender (p=0.634) with an odds ratio of accidents associated with use of visibility aids of 1.110 (although, from the 95% CI a 23% lower rate of accidents associated with overall use of visibility aids cannot be rejected.

Table 16: Association between listening to music while cycling and Accidents, controlling for Age (Mantel-Haenszel Test).

Statistic:	**Value:**
Breslow-Day Test of Homogeneity:	X^2=0.587, df=4, p=0.964
Mantel-Haenszel Test of Conditional Independence :	X^2=8.032, df=1, p=0.005
Common Odds Ratio:	1.97 (95%CI:1.25, 3.096)

There is no evidence to reject the null hypothesis of homogeneity across different age groups (p=0.964). There is evidence of an association between listening to music and self-reported accidents after controlling for age (p=0.005) with an odds ratio of accidents associated with listening to music of 1.97.

Table 17: Association between listening to music while cycling and Accidents, controlling for Sex (Mantel-Haenszel Test).

Statistic:	**Value:**
Breslow-Day Test of Homogeneity:	X^2=1.170, df=1, p=0.279
Mantel-Haenszel Test of Conditional Independence :	X^2=4.877, df=1, p=0.027
Common Odds Ratio:	1.67 (95%CI:1.08, 2.58)

There is no evidence to reject the null hypothesis of homogeneity across different gender groups (p=0.279). There is evidence of an association between listening to music and self-reported accidents after controlling for gender (p=0.027) with an odds ratio of accidents associated with listening to music of 1.67.

DISCUSSION:

General findings:

Frequency of visibility aid use: In the Highway Code rule 60 states that you must have white front and red rear lights lit when cycling at night. Bicycles are also required to be fitted with a red rear reflector and amber pedal reflectors. The self-reported use of front and back light by respondents was 95.2% (95% CI 93.0%-96.7%) and 94.6% (95% CI 92.4%-96.2%) respectively which is much higher than the use of front lights 48.5% and back lights 50.2% as reported in the literature by McGuire & Smith (2012). Back lights were set to flashing by 75.2% (95% CI 70.7%-78.0%) compared to 49.5% (95%CI 44.9%-53.3%) for front lights flashing which may represent the attitude that accidents are more likely to happen from behind. 73.9% (95% CI 70.1%-77.5%) used back reflectors and 53.8% (95% CI 49.6%-58.0%) used pedal reflectors. This frequency of use of rear reflectors is however greater than that reported by Hagel et al (2007) of 50.9%. Compliance was therefore high for the use of lights but many Edinburgh cyclists are cycling illegally without the required fitting of reflectors.

Accident Characteristics: The rates of self-reported accidents (42.7%; 95% CI 38.5%-47.1%) and near accidents (75.5%; 95% CI 71.6%-79.0%) were high which is reflected by only 21% (95% CI; 17.7%-24.8%) of respondents describing cycling in Edinburgh as “safe” or “very safe”. In addition 34.3% (95% CI 30.3%-38.5%) of cyclists thought that it was “likely” or “very likely” they would have an accident in the next year. A striking seasonality of these accidents/ near accidents was apparent in December and January amongst Edinburgh cyclists. The number of cyclists reporting accidents (near accidents) in a 3 month period in winter (December-February) was 3.0 (4.3) times greater than in a 3 month period in summer (June-August). Thus 46% (58%) of all reported accidents (near accidents) for which month of year was given by the respondent occurred in the 3 month period from November to February. This is in contrast to the results of an analysis of hospital admissions in England between 1992 and 2004 by Gill et al (2009) who found fewer accidents presenting in winter months (27% lower in December). It was, however, concluded that more of these injuries occurring in winter months were fatal. Therefore, it seems that this is an important issue that merits more attention in cycle safety education.

Although there has been a major focus from the council and government on getting more cycle lanes in cities, the most commonly provided suggestion by Edinburgh cyclists for improving safety was to repair potholes.

Hazards: There a substantial level consensus on a few of the hazards identified by cyclists and the most commonly implicated hazard, ice, is consistent with the strong seasonality in winter months. This information is not commonly acknowledged and it therefore needs to be reinforced that greater care needs to be taken when cycling in winter and consideration given to avoiding cycling in icy conditions. Some cycle organisations are ambivalent about overall impact on public health associated with cycling helmets (Spokes – personal communication. However, these findings also reinforce the role of helmets in to limiting the seriousness of injury due to cyclists having accidents in icy conditions.

Other Safety behaviours: Although only 4.8% (95% CI 3.3%-7.0%) reported always listening to music whilst cycling and 15.7% (95% CI 12.8%-19.0%) reported sometimes listening to music whilst cycling, survey data suggest it is associated with an increase in the rate of self-reported accidents. It is not sure however, if this is a causal relationship or whether it is confounded by other factors and behaviours. Since this was not a research question specified at the start of the study this result should be considered as hypothesis-generating and requires replication in further studies.

Factors Associated with Accidents:

There was an increase in the number of accidents from age categories between 18 years and 50 years followed by a decrease after the age of 50 years. This is similar to Rogers et al (1995) who reported an increased risk of fatality associated with cyclists older than 44 years. There was also a greater number of accidents and near accidents for men than for women. This finding is supported by Nicaj et al (2009), McCarthy & Gilbert (1996), Davidson (2005) and Rogers et al (1995) who reported accident rates between 65% and 70% for men. There was also a stepwise increase in the number of accidents and near accidents with increasing cycling frequency and journey time. A lower accident and near accident rate was noted for mountain bike users. It is possible that that the larger tyres and improved suspension deal better with potholes (noted as a common hazard). An increased accident and near accident rate was associated to cycling whilst listening to music which remained even after controlling for age and sex. This finding has not been previously reported and merits further study.

<u>Findings related to research hypothesis:</u>

The study hypothesis was that the use of visibility aids by Edinburgh cyclists is associated with a lower rate of self-reported road accidents and/ or near accidents. The study found no evidence of an association between use of visibility aids and self-reported accidents. This did not change after controlling for the effects of age and sex in a Mantel-Haenszel analysis. However, the 95% CI of the odds ratio suggest that an association with a 28% lower ratio of accidents/ 7% lower rate of near accidents cannot be excluded by these data. It is possible that the sampling of the study population led to findings that are not generalizable to other settings or that the method of the survey, which required recall of behaviour led to inaccuracies in self-reporting. It is recommended that further surveys are conducted. However, this study does not give support to investing in controlled trials of visibility aids as an accident prevention measure. The literature review, discussions with police safety officers during the pilot phase and the results on causes of accidents proposed by cyclists in this survey suggest a number of other important causes of cycle accidents. This includes driver inattention at T-intersection junctions as well as blindspots for heavy goods vehicles (HGV). Summala et al (1996) analysed drivers scanning behaviours at T-intersction and found that drivers developed visual scanning strategies where attention was narrowed to detect only major hazards. This type of accident has been described in the literature as 'looked but failed to see'. Werneke (2012) conducted a driving simulator study where he found that the least complicated T-junctions were associated more accidents. He interpreted this to be the result of inadequate attention allocation. Koustanai (2008) described that this accident can occur as a result of the driver not seeing the danger (perceptual stage) or seeing the danger but not recalling this information (processing stage). Other important hazards as identified in this questionnaire involve road conditions such as ice and potholes. It is therefore recommended that future surveys of cycle accidents and safety seek to measure these variables in more detail.

Strengths and Limitations:

Literature review: Strengths of the literature review conducted included that it was performed in six relevant databases within which a number of parallel search strategies were individually tailored and keywords truncated where appropriate to maximise the number of relevant results found. A large number of relevant articles were found duplicated between the databases and search strategies highlighting that the most relevant articles were extracted. However, the search was limited by the fact that articles were excluded which were not available in English, were published prior to 1995 or were not available in full text copies. I was also not able to get a second independent parallel reviewer to identify that all of the relevant literature and data had been extracted correctly. This would have improved the reliability of the findings.

Survey: In the design of the questionnaire input and feedback was taken from Lothian cycle action group 'Spokes', the Lothian Police Edinburgh Road Safety Unit and the Bike Station. This correspondence with experts on cycling safety ensured that the content was highly relevant to address aspects of visibility. Two pre-pilot testing sessions and one pilot testing session of the questionnaire made sure that it was comprehensive and reliable. In addition, a multi-site sampling strategy allowed different sub population in Edinburgh to be accounted in the survey. The questionnaire design and distribution methodology resulted in good participation to reach a large sample of 542 which compares to those of studies mentioned in the literature review. However, there were several limitations including the effect of participation bias in favour of safety-conscious cyclists or keen cyclists that are more likely to have taken part and who may have different behaviours. This may have potentially therefore over-represented the frequency of use of protective equipment. In addition, the sampling strategy was not completely random and so participation rate could not be measured. The survey was conducted at one particular point in the year and could be biased due to seasonal variation of participation or response. However, questions were focused on the regular safety behaviours of individuals and accidents were reported over a three year period. It could not be confirmed that all statements were truthful as it would not have been possible to trace or access medical or police data regarding accidents due to ethical reasons and the fact that all responses were kept anonymous. Regarding the main hypothesis of this study it is important to note that measuring the association between visibility aids and accidents does not give information about whether the relationship is causal as a controlled trial of a visibility aids intervention would be required. However, the aim of this project was to gather information to evaluate whether such a trial would be justified. These data are likely to be specific to Edinburgh and may not be generalizable to other Scottish cities or rural areas. In addition, no data were collected for individuals under the age of 18 and so the data are not applicable to child cyclists.

Data and Analysis: A limitation in the data of responses is that many of the items were self-reported and therefore liable to subject bias. In addition, questions regarding accidents could relate to a time from the previous three years and so memory recall could affect the accuracy of reporting. In assessing the relationship between the use of visibility aids by cyclists and the occurrence of accidents direct information on whether the visibility aids were worn at the time of accident was not requested, so the data only act as a proxy measure. It was not possible to get a second independent researcher to check the coding of responses which would have been beneficial to improve the reliability of the results. Another weakness was that due to the nature of the questionnaire data, non-parametric tests had to be performed which is a less powerful analysis. There was also incomplete responses for some figures, with 34 (6.3%) individuals having missing data for the occurrence of an accident and 36 (6.6%) having missing data for the occurrence of a near accident. Missing data for the use of visibility aids ranges from five respondents (0.9%) to eight (1.5%) in these questions. Attempts were made to reduce this effect by requiring respondents to answer certain questions and by providing pre-determined options to select from, where appropriate. An advantage of the survey design was that it was flexible allowing respondents to provide free text responses if options did not apply for questions which were later recoded. This allowed respondents to express their true opinions. Clear definitions of accidents and near accidents were stated in the questions which allowed accidents classification to be standardised across responses. In addition, the primary research question was able to be analysed and to control for confounding factors.

Dissemination of survey results to groups interested in cycle safety

In the design of the questionnaire used in this project email correspondence was made with Spokes and the Bike Station as well as a meeting held with three Lothian Police Road Safety Unit Officers. Feedback was obtained on the questionnaire content prior to distribution to ensure that it was relevant to the address all aspects of road safety relating to visibility. Efforts are planned to share study data with other researchers in this area and members of the public. Therefore, data will distributed to Lothian Police, Spokes and the Bike Station. In addition, to further disseminate the results of this project a meeting was arranged with an Orthopaedic surgeon and chairman of the Cyclists' Touring Club for Scotland, where discussions have been held regarding the publication of the results of this project in a relevant sports medicine or injury prevention journal. A road show of the 'Drive Safe, Cycle Safe' campaign was launched on the 3rd April 2012 by Streets Ahead, a collaboration in Edinburgh of the Council, Police, Fire Service and NHS Lothian. Interest was shown in the project results following attendance at this meeting and so data will also be made available to help with their campaign. In addition, I have submitted an abstract to the third International Conference on Sport and Society to be held in Cambridge between the 23rd and 25th of July (further details can be accessed at http://sportandsociety.com/conference-2012/). These attempts have been made to distribute the results of this project so that study information can be useful to those involved in improving cycle safety.

Future research

An extensive review of the literature has uncovered the fact that there are very few studies looking at risk factors associated with cycle accidents. From these studies, most include cycle helmets but other safety equipment such as the use of visibility aids is rarely evaluated. There is therefore a need for further studies to examine the factors associated with cycle accidents. The most appropriate study designs to do this are either large representative cross-sectional surveys or case-control studies of cyclists who have had accidents compared to those who have not. Miller et al (2010) has published a protocol for a large case control study to investigate the relationship between conspicuity aid use and risk of cycling injuries. Their sample size calculations suggest that the sample size should be 218 for cases and four times greater than this for controls in order to detect an odds ratio of

0.63 with 80% power. Confounding factors (age, gender, deprivation score, sensation seeking psychometric scale as a proxy measure of risky road behaviour, daily cycle route length and amount of cycling experience) will be included into a conditional logistic regression analysis. Response bias will also be assessed by comparing responders to non-responders between cases and controls, comparing them in terms of age, gender and deprivation score. Many of the variables will be assessed directly by interviewers and the reliability of measurements evaluated by calculation of kappa statistics. From the protocol published for this study, it looks like it may provide promising information on the relationship between the use of visibility aids and the occurrence of accidents.

CONCLUSIONS:

Cycle accidents are common amongst Edinburgh cyclists and show striking seasonality with increased accidents in winter and related to icy conditions. Only 21% of Edinburgh cyclists consider cycling to be safe. There is a high prevalence of use of visibility aids in this study population but no evidence of any association with self-reported accidents. Although the 95% CI do not exclude an association with a slightly reduced rate of accidents or near accidents. The finding of an association between listening to music and self-reported accidents is a new finding which requires replication in further studies. The findings of this study will be widely disseminated to cycling organizations in Edinburgh and have been submitted at a national conference in the hope that these data will help inform cycle safety strategies.

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[Accessed 27 January 2012]

APPENDICES:

Appendix 1: Survey Monkey Questionnaire

Edinburgh Cycling Safety Questionnaire

Personal Characteristics

Instructions: please note that for questions with circles beside answers, only one option may be selected but for those with boxes beside answers, multiple options may be selected as required. Thank you for participating in this Questionnaire.

Which category below includes your age?

- 17 or younger
- 18-20
- 21-29
- 30-39
- 40-49
- 50-59
- 60 or older

Sex

- Male
- Female

What is your current occupation?

Year of University study if applicable?

- 1
- 2
- 3
- 4
- 5
- 6

How regularly do you cycle?

- Daily
- Weekly
- Monthly
- Other (please specify)

What purpose do you use your bicycle for?

- Leisure
- Commuting
- Sport
- Health and Fitness
- Other (please specify)

Edinburgh Cycling Safety Questionnaire

What is your regular journey time in minutes?

- <15
- 15-30
- 30-45
- 45-60
- Other (please specify)

What times of day do you regularly cycle at?
(please select as many of the following that apply)

- Morning
- Afternoon
- Evening
- Night

Cycling Visibility

Do you regularly wear a high visibility vest/jacket?

- Yes
- No

If no, why not?
(please select as many of the following that apply)

- Money
- Time
- Fashion
- Unnecessary
- Not thought about it
- Not bothered
- Other (please specify)

Do you have fitted reflectors?

	Yes	No
Front?		
Back?		

Do you use lights?

	Yes	No
Front?		
Back?		

Edinburgh Cycling Safety Questionnaire

Do you set your lights to flashing?

	Yes	No
Front?	○	○
Back?	○	○

Which times of day do you use lights?
(please select as many of the following that apply)

- ☐ Morning
- ☐ Afternoon
- ☐ Evening
- ☐ Night

Do you have any of the following?

	Yes	No
Pedal Reflectors	○	○
Spoke Reflectors	○	○
Reflective ankle clips	○	○
Reflective arm bands	○	○

Please list any other reflective or fluorescent clothing/accessories that you use:

Cycling Safety

What type of bicycle do you have?

- ○ Road
- ○ Mountain
- ○ Hybrid
- ○ Other (please specify)

If your bike has a problem which of the following do you do?

- ○ Fix it yourself
- ○ Take it to a bicycle repair shop
- ○ Do nothing
- ○ Other (please specify)

How often do you have your bicycle serviced?

Edinburgh Cycling Safety Questionnaire

Do you listen to music when cycling?

- Always
- Sometimes
- Never

Do you wear a helmet?

- Always
- Sometimes
- Never

If no, why not?
(please select as many of the following that apply)

- Money
- Time
- Fashion
- Unnecessary
- Not thought about it
- Not bothered
- Other (please specify)

List 3 Hazards that you have encountered cycling on Edinburgh Roads:

1)
2)
3)

Attitudes

How would you describe cycling in Edinburgh?

- Unsafe
- Moderately safe
- Safe
- Very safe

What would you say the likelihood of you having an accident in the next year is?

- Very likely
- Likely
- Unlikely
- Very unlikely

Edinburgh Cycling Safety Questionnaire

Do you feel there is enough awareness of cyclists from:

	Yes	No
Motorists?	○	○
Bus drivers?	○	○
Taxi drivers?	○	○

Describe 2 suggestions to improve road safety for Edinburgh cyclists:

ACCIDENTS

Have you had an ACCIDENT cycling in Edinburgh in the last 3 years?
(ACCIDENT defined as a fall from your bike, a collision or any incident causing injury)

○ Yes

○ No

How many ACCIDENTS have you had?

In your most recent ACCIDENT :

Briefly what happened?

Which of the following was involved?
(please select as many of the following that apply)

☐ Bicycle ☐ Car ☐ Pedestrian ☐ Bus ☐ Taxi

☐ Other (please specify)

What time of day did it occur?

○ Morning ○ Afternoon ○ Evening ○ Night

Edinburgh Cycling Safety Questionnaire

Do you think that you had been seen early enough by the other road user?

- ○ Yes
- ○ No
- ○ Not applicable

Do you think that wearing a fluorescent jacket or any other visibility aid could have avoided this ACCIDENT?

- ○ Yes
- ○ No
- ○ Not applicable

What month of the year was it?

Where did it happen?

Was this ACCIDENT reported to the Police?

- ○ Yes
- ○ No

What level of Medical attention did you require?

- ○ None ○ GP/nurse ○ A&E ○ In-patient
- ○ Other (please specify)

Which of the following injuries did you have?
(please select as many of the following that apply)

- ☐ Minor (abraisions, cuts, sprains)
- ☐ Fracture
- ☐ Head injury
- ☐ Hand injury
- ☐ Leg injury
- ☐ Other (please specify)

Additional details if neccessary:

Edinburgh Cycling Safety Questionnaire

NEAR ACCIDENTS

Have you had any NEAR ACCIDENTS in the past 3 years?
(NEAR ACCIDENT defined as road incidents causing concern for safety of risk of injury but not causing an accident)

- ○ Yes
- ○ No

How many NEAR ACCIDENTS have you had?

In your most recent NEAR ACCIDENT :

Briefly what happened?

Which of the following was involved?
(please select as many of the following that apply)

- ☐ Bicycle
- ☐ Car
- ☐ Pedestrian
- ☐ Bus
- ☐ Taxi
- ☐ Other (please specify)

What time of day did it occur?

- ○ Morning
- ○ Afternoon
- ○ Evening
- ○ Night

Do you think that you had been seen early enough by the other road user?

- ○ Yes
- ○ No
- ○ Not applicable

Edinburgh Cycling Safety Questionnaire

Do you think that wearing a fluorescent jacket or any other visibility aid could have avoided this NEAR ACCIDENT?

- Yes
- No
- Not applicable

What month of the year was it?

Where did it happen?

Was this NEAR ACCIDENT reported to the police?

- Yes
- No

Which level of Medical attention did you require?

- None
- GP/nurse
- A&E
- In-patient
- Other (please specify)

Which of the follwoing injuries did you have?
(please select as many of the following that apply)

- Minor (abraisions, cuts, sprains)
- Fracture
- Head Injury
- Hand Injury
- Leg Injury
- Other (please specify)

Additional details if neccessary:

Appendix 2: Survey Pull Tab Poster

ONLINE EDINBURGH CYCLING QUESTIONNAIRE

(10 MINUTES TO HELP IMPROVE SAFETY!)

https://www.surveymonkey.com/s/edinburghbikesafety

If you have ever cycled in Edinburgh, I would greatly appreciate 10 minutes of your time to fill in an online Questionnaire for my Sports Science Dissertation and help improve cycling safety in Edinburgh.

Please tear off a copy of the Questionnaire URL below to complete in your own time. Thank you for your participation!

EDINBURGH CYCLING SURVEY: https://www.surveymonkey.com/s/edinburghbikesafety

EDINBURGH CYCLING SURVEY: https://www.surveymonkey.com/s/edinburghbikesafety

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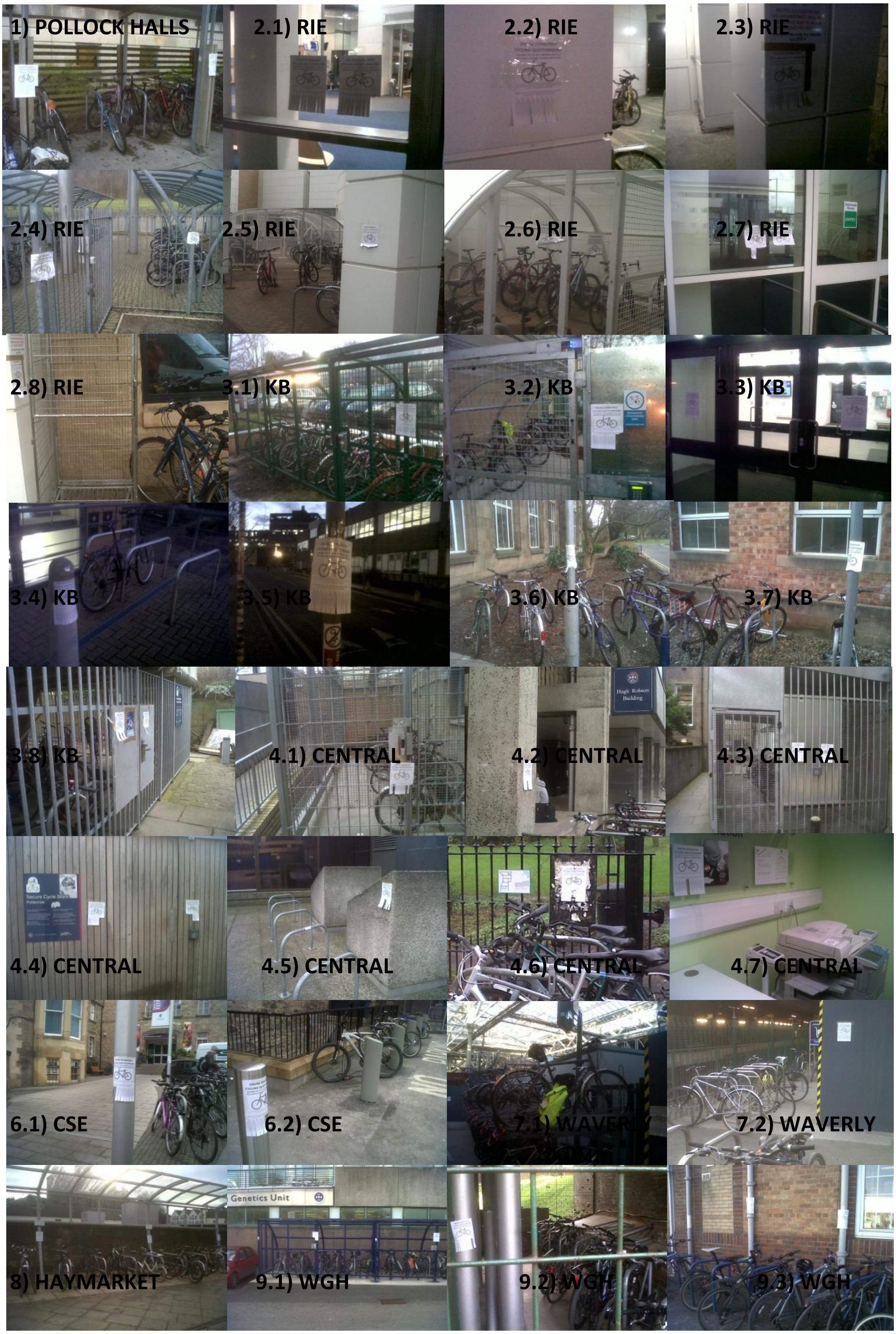
EDINBURGH CYCLING SURVEY: https://www.surveymonkey.com/s/edinburghbikesafety

Appendix 3: Pull Tab Poster Locations



Appendix 4: Advertisement cards distributed to bicycle shops

ONLINE EDINBURGH CYCLING QUESTIONNAIRE: (10 minutes to help improve safety) **Please fill out at:**	**ONLINE EDINBURGH CYCLING QUESTIONNAIRE:** (10 minutes to help improve safety) **Please fill out at:**
https://www.surveymonkey.com/s/edinburghcyclingsafety	**https://www.surveymonkey.com/s/edinburghcyclingsafety**
ONLINE EDINBURGH CYCLING QUESTIONNAIRE: (10 minutes to help improve safety) **Please fill out at:**	**ONLINE EDINBURGH CYCLING QUESTIONNAIRE:** (10 minutes to help improve safety) **Please fill out at:**
https://www.surveymonkey.com/s/edinburghcyclingsafety	**https://www.surveymonkey.com/s/edinburghcyclingsafety**
ONLINE EDINBURGH CYCLING QUESTIONNAIRE: (10 minutes to help improve safety) **Please fill out at:**	**ONLINE EDINBURGH CYCLING QUESTIONNAIRE:** (10 minutes to help improve safety) **Please fill out at:**
https://www.surveymonkey.com/s/edinburghcyclingsafety	**https://www.surveymonkey.com/s/edinburghcyclingsafety**
ONLINE EDINBURGH CYCLING QUESTIONNAIRE: (10 minutes to help improve safety) **Please fill out at:**	**ONLINE EDINBURGH CYCLING QUESTIONNAIRE:** (10 minutes to help improve safety) **Please fill out at:**
https://www.surveymonkey.com/s/edinburghcyclingsafety	**https://www.surveymonkey.com/s/edinburghcyclingsafety**

Appendix 5: Associations between Age of respondent and the use of Visibility Aids (Pearson Chi-Square Test).

Type Visibility Aid:	**Response:**	**Age**					
		18-20	21-29	30-39	40-49	50-59	60-69
1) High Visibility Jacket	1.1) Yes	20 (26%)	73 (37.1%)	71 (57.3%)	41 (57.7%)	28 (60.9%)	9 (40.9%)
	1.2) No	57 (74%)	124 (62.9%)	53 (42.7%)	30 (42.3%)	18 (39.1%)	13 (59.1%)
STATISTICAL SIGNIFICANCE:		***X^2: 34.673, p=0.000***					
2) Front Reflectors	2.1) Yes	48 (62.3%)	128 (65%)	84 (67.7%)	47 (66.2%)	27 (58.7%)	13 (59.1%)
	2.2)No	29 (37.7%)	69 (35%)	40 (32.3%)	24 (33.8%)	19 (41.3%)	9 (40.9%)
STATISTICAL SIGNIFICANCE:		***X^2: 1.792, p=0.877***					
3) Back Reflectors	3.1) Yes	54 (70.1%)	141 (71.6%)	89 (71.8%)	57 (80.3%)	35 (76.1%)	21 (95.5%)
	3.2) No	23 (29.9%)	56 (28.4%)	35 (28.2%)	14 (19.7)	11 (23.9%)	1 (4.5%)
STATISTICAL SIGNIFICANCE:		***X^2: 8.329, p=0.139***					
4) Front Lights	4.1) Yes	68 (88.3%)	183 (92.9%)	124 (100%)	70 (98.6%)	44 (95.7%)	22 (100%)
	4.2) No	9 (11.7%)	14 (7.1%)	0 (0%)	1 (1.4%)	2 (4.3%)	0 (0%)
STATISTICAL SIGNIFICANCE:		***X^2: 19.297, p=0.002***					
5) Back Lights	5.1) Yes	63 (81.8%)	186 (94.4%)	124 (100%)	70 (98.6%)	44 (95.7%)	21 (95.5%)
	5.2) No	14 (18.2%)	11 (5.6%)	0 (0%)	1 (1.4%)	2 (4.3%)	1 (4.5%)
STATISTICAL SIGNIFICANCE:		***X^2: 34.060, p=0.000***					
6) Front lights flashing	5.1) Yes	30 (39%)	88 (45.8%)	75 (60.5%)	39 (55.7%)	20 (44.4%)	10 (47.6%)
	5.2) No	47 (61%)	104 (54.2%)	49 (39.5%)	31 (44.3%)	25 (55.6%)	11 (52.4%)
STATISTICAL SIGNIFICANCE:		***X^2: 12.009, p=0.035***					
7)Back lights flashing	5.3) Yes	48 (62.3%)	148 (76.3%)	102 (84.3%)	58 (81.7%)	28 (62.2%)	14 (63.3%)
	5.4) No	28 (36.8%)	46 (23.7%)	19 (15.7%)	13 (18.3%)	17 (37.8%)	8 (36.4%)
STATISTICAL SIGNIFICANCE:		***X^2: 18.665, p=0.002***					
8) Lights On in Morning	5.1) Yes	21 (26.9%)	78 (39%)	81 (65.3%)	53 (74.6%)	27 (58.7%)	2 (8.7%)
	5.2) No	57 (73.1%)	122 (61%)	43 (34.7%)	18 (25.4%)	19 (41.3%)	21 (91.3%)
STATISTICAL SIGNIFICANCE:		***X^2: 71.762, p=0.000***					
9) Lights on in Afternoon	6.1) Yes	8 (10.3%)	21 (10.5%)	21 (16.9%)	6 (8.5%)	7 (15.2%)	4 (17.4%)
	6.2) No	70 (89.7%)	179 (89.5%)	103 (83.1%)	65 (91.5%)	39 (84.8%)	19 (82.6%)

STATISTICAL SIGNIFICANCE:		***X^2: 5.239, p=0.387***					
10) Lights on in Evening	7.1) Yes	58 (74.4%)	173 (86.5%)	113 (91.1%)	65 (91.5%)	38 (82.6%)	16 (69.6%)
	7.2) No	20 (25.6%)	27 (13.5%)	11 (8.9%)	6 (8.5%)	38 (82.6%)	16 (69.6%)
STATISTICAL SIGNIFICANCE:		***X^2: 18.175, p=0.003***					
11) Lights on at Night	8.1) Yes	50 (64.1%)	149 (74.5%)	85 (68.5%)	48 (67.8%)	28 (60.9%)	15 (65.2%)
	8.2) No	28 (35.9%)	51 (25.5%)	39 (31.5%)	23 (32.4%)	18 (39.1%)	8 (34.8%)
STATISTICAL SIGNIFICANCE:		***X^2: 5.364, p=0.373***					
12) Pedal Reflectors	9.1) Yes	38 (49.4%)	96 (48.7%)	77 (62.1%)	38 (53.5%)	25 (54.3%)	15 (68.2%)
	9.2) No	39 (50.6%)	101 (51.3%)	47 (39.7%)	33 (46.5%)	21 (45.7%)	7 (31.8%)
STATISTICAL SIGNIFICANCE:		***X^2: 7.923, p=0.161***					
13) Spoke Reflectors	10.1) Yes	33 (42.9%)	88 (44.7%)	51 (41.1%)	28 (39.4%)	18 (39.1%)	9 (40.9%)
	10.2) No	44 (57.1%)	109 (55.3%)	73 (58.9%)	43 (60.6%)	28 (60.9%)	13 (59.1%)
STATISTICAL SIGNIFICANCE:		***X^2: 0.978, p=0.964***					
14) Reflective Clips	11.1) Yes	14 (18.2%)	47 (24%)	48 (38.7%)	29 (40.8%)	17 (37%)	11 (50%)
	11.2) No	63 (81.8%)	149 (76%)	76 (61.3%)	42 (59.2%)	29 (63%)	11 (50%)
STATISTICAL SIGNIFICANCE:		***X^2: 21.581, p=0.001***					
15) Reflective Bands	12.1) Yes	7 (9.1%)	9 (4.6%)	16 (12.9%)	8 (11.3%)	2 (4.3%)	3 (13.6%)
	12.2) No	70 (90.9%)	187 (95.4%)	108 (87.1%)	63 (88.7%)	44 (95.7%)	19 (86.4%)
STATISTICAL SIGNIFICANCE:		***X^2: 9.539, p=0.089***					
16) Visibility Score	13.1) High	32 (42.1%)	88 (44.4%)	78 (62.9%)	49 (69%)	18 (39.1%)	10 (43.5%)
	10.2) Low	44 (57.9%)	110 (55.6%)	46 (37.1%)	22 (31%)	18 (39.1%)	10 (43.5%)
STATISTICAL SIGNIFICANCE:		***X^2: 22.860, p=0.000***					

This table shows the variation in the frequency of use of different visibility aids by age.

Appendix 6: Full list of hazards

Hazard:	Number of Responses:
Potholes	318
Pedestrian inattention	144
Bad/ aggressive driving	131
Buses	83
Cars/ traffic	78
Parked cars in cycle lane	72
Taxis	63
Overtaking cars cutting cyclists off	58
Vehicles too close	48
Driver inattention	45
Other cyclists	42
Doors opening parked vehicles	30
Ice/ untreated roads	30
Lorries	29
Poor cycle lane design	26
Tram lines	25
Lack of cycle lanes	18
Roadworks	16
Driver encroaching advance stop box	15
Roundabouts	14
Cars pulling out in front of cyclist	14
Shared bus and cycle lane	12
Drain covers/ raised grids	11
Cobbles	10
Dogs	10
Glass	9
Poor junction design	8
Narrow cycle lane	8
Badly lit areas	8
Cars making right turns at 4 way junction	7
Greasy surfaces	5
Temporary Traffic lights	5
Pinch points	5
Poor cycle lane maintenance	4
Speed bumps	2
Gravel	1

Appendix 7: Full List of Suggestions

Suggestion:	Number of Responses:
Pothole Repair	180
More or wider cycle lanes	108
Segregated cycle lanes or paths	68
Driver awareness schemes of cyclists	66
Enforcing no parking in cycle lanes	65
Continuous cycle lanes	30
Better defined cycle lanes e.g. coloured	27
Reduce speed limit to 20mph	25
Give cyclists greater priority at crossing/ separate green lights for cyclists	23
Enforcing ASL's	22
Education to bus and taxi drivers of awareness of cyclists	20
Enforce – make available free lights	19
Cyclist safety classes	18
Promotion of spacing	17
Enforce – make available free reflectors and visibility aids	17
Better maintenance of cycle lanes	16
Increase penalties for drivers in accidents with bicycles (default position driver liable as Dutch	14
Practical cycling as part of the driving test	14
Enforce helmets	14
Actions to change attitudes of motorists	11
Cycle lanes separated by raised barrier	11
Better off road cycle network	11
More signs to draw attention to cyclists	8
Improve maintenance of road edges	7
Better cycle lanes around junctions and roundabouts	7
Actions to increase awareness of ASLs	6
Better lighting of cycle ways	6
Enforce laws on red lights	6
More cycle boxes	5
Better road planning for cyclists	5
Decrease parking in the city centre	5
Gritting cycle paths in winter	5
Police cycle patrols	5
Remove bad cycle lanes	4
Better lighting at main junctions	4
Built cycle under and overpasses	3
Improve road signs about cyclists	3
Cyclist awareness campaign of vehicle blind spots	3
Council bike maintenance classes	2
Print city wide cycle safety leaflet (with safe cycle route maps and hazards)	2

Remove railings at junctions	2
Stop pinch points and bus stops sticking out into the road	2
Have cycle adverts on buses	1
Lower kerbs	1
Video cameras in taxis	1
Allow cyclists to report dangerous motorists	1
Increase driving test to 5 yearly	1
Don’t allow taxis to open doors on roadside	1

Appendix 8: Full list of accident contributing factors

Accident Contributing Factor:	**Number of Responses:**
Ice	41
Driver pulling out infront of cyclist	34
Pedestrian Inattention	14
Potholes/ road condition	14
Wet surface	12
Car door opening	9
Tramlines	8
Greasy surface	8
Vehicle too close	8
Getting cut off by driver	8
Cycling downhill	8
Cyclist loss of control	8
Driver suddenly stopping	6
Driver inattention	6
Roundabout	6
Cycling too fast	6
Driver turning without indicating	5
Turning at junction	5
Driver turning without indicating	5
Cobbles	4
Wind	4
Chain snapped/ came off	4
Dangerous overtaking	4
Wind	4
Badly lit areas:	3
U turn	3
Brakes bad condition/ failed	3
Other cyclist	3
Driver indicating incorrectly	2
Cyclist Intoxicated	2
Cyclist Inattention	2
Dangerous overtaking by cyclist	2
Dog	2
Drain	1
Low kerb	1
Speed bump	1
Debris	1
Driver changing lane	1
Driver texting	1
Dangerous overtaking	1
Intoxicated	1
Driving into cyclist from behind	1
Front on collision into cyclist	1
Traffic	1
Blind corner	1
Filtering traffic	1
Cycling too close to a vehicle	1

Braking too late	1
Confusion in traffic	1
Problem with gears	1
Bike clips	1
Puncture whilst cycling	1
Improper use of brakes	1
Pedestrian entering taxi from roadside	1
Bus	1
Motorcyclist	1

Appendix 9: List of all 32 articles obtained from literature review

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