Cycling in Scotland:
a review of cycling casualties, near misses and under-reporting

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Glossary

Adults: Persons aged 16 years and over.

Active travel: making journeys by a physically active means such as walking, cycling, or scooting.

Bicycle: pedal bike

Bike library: a site where a fleet of bikes are available on a short-term basis to borrow for free.

Children and young people: persons aged from 0-15 years.

Close pass: when another road user passes a cyclist closer than the recommended 1.5 metres.

Cycle hire scheme: schemes where bikes are made available to on a short-term basis for a price. Such schemes are also described as 'bike hire' or 'public bike share' schemes.

Cyclist: an individual riding a bicycle or e-bike.

Cycling/cyclist casualties: individuals injured in road traffic accidents when riding a bicycle.

Cyclist collision: a collision between a cyclist and another road user occurring on a road/footway which may or may not result in an injury.

E-bikes: electrically assisted pedal bikes.

Fatality: as defined for Stats19 recording: a human casualty of a road traffic accident who sustained injuries which caused death less than 30 days after the accident. Confirmed suicides are excluded.

Guidelines for Moderate or Vigorous Physical Activity (MVPA): recommends at least 150 minutes of moderate physical activity or 75 minutes vigorous physical activity, or an equivalent combination of the two, per week.

Health Economic Assessment Tool (HEAT): The World Health Organization's Health Economic Assessment Tool (HEAT) for walking and cycling, allows for the economic assessment of the health impacts of walking and cycling. The tool is based on the best available evidence and transparent assumptions and can be used at national and local level. The tool works by estimating the reduction in mortality that results from specified amounts of these activities, then places a monetary value on the mortality reductions.

Near miss: when a cyclist does not come into direct contact with a vehicle, pedestrian, other cyclist, or stationary object but which is still associated with a risk of injury and reduced safety.

Net zero emissions: Refers to the zero-carbon dioxide emissions which can be achieved by balancing and offsetting carbon emissions.

Road user: anyone who uses the road including drivers and passengers of motorised vehicles, cyclists and passengers of bicycles, and pedestrians.

Road traffic accidents (RTA): An accident occurring on a road/footway in which a vehicle is involved which results in an injury.

Road casualties: Individuals injured in road traffic accidents as pedestrians, cyclists, drivers, or passengers in a vehicle.

Stats19: the system of recording injury road accidents (i.e. an accident involving someone being injured) used by the police in the UK. The information pertaining to such accidents recorded on a Stats19 form is made up of three parts: an accident record, casualty report(s), and vehicle record(s). These data were submitted to Transport Scotland by the police.

Slight injury: As defined for Stats19 recording: an injury incurred in a road traffic accident of a minor character such as a sprain (including neck whiplash injury), bruise or cut which are not judged to be severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical attention.

Serious injury: As defined for Stats19 recording: an injury incurred in a road traffic accident for which a person is detained in hospital as an ‘in-patient’ or any of the following injuries whether or not they are detained in hospital: fractures, concussion, internal injuries, crushing, burns (excluding friction burns), severe cuts, severe general shock requiring medical treatment, and injuries causing death 30 or more days after the accident. An injured casualty is recorded as seriously or slightly injured by the police based on the information available within a short time of the accident. This generally will not reflect the results of the medical examination but may be influenced according to whether the casualty is hospitalised or not.

The Scottish Index of Multiple Deprivation (SIMD): This deprivation index identifies concentrations of multiple deprivation at a small area level across Scotland in a consistent way. The SIMD ranks datazones, which are areas with populations of between 500 and 1,000 household residents of which there are 6,976, from the most deprived (ranked 1) to least deprived (ranked 6,976). The datazones can then be divided into quintile or decile groups using the ranking. SIMD16 is the Scottish Government's fifth edition since 2004.

Zero carbon emissions: Also known as carbon neutral and refers to achieving *a state of* zero carbon dioxide emission typically by balancing carbon emissions with carbon removal or by using renewable energy which does not produce carbon emissions.

Abbreviations

APPCG	All Party Parliamentary Cycling Group
CAFS	Cleaner Air for Scotland
CAPS	Cycling Action Plan for Scotland
CRASH	Collision Reporting and Sharing System
E-bikes	Electronically assisted pedal bikes
GCPH	Glasgow Centre for Population Health
GDP	Gross Domestic Product
HEAT	Health Economic Assessment Tool
HIA	Health Impact Assessment
KSI	Killed or Seriously Injured
km	Kilometres
mph	Miles per hour
NCN	National Cycle Network
NHS	National Health Service
RTA	Road Traffic Accident
SIMD	Scottish Index of Multiple Deprivation
UK	United Kingdom
WHO	World Health Organization

Executive summary

Background: The benefits associated with cycling include improvements to physical and mental health, and a positive impact on the wider economy and environment. Cycling levels in Scotland are increasing yet remain low compared with other European countries. This review combines analysis of reported cycling casualties in Scotland in the 23-year period from 1995-2018 with a literature review of under-reporting of casualties and near misses. Data was derived from the police recorded Stats19 system which records road traffic accidents in which a vehicle was involved and where at least one person was injured.

The key findings include:

- In the whole period examined (1995-2018) reported cycling casualties of all types reduced by more than half, but the rate of serious injuries and fatalities increased by 18% between 2004-2018.
- Most (82%) casualties were male.
- Far fewer children were casualties in 2018 compared with 1995.
- In recent years cycling casualties were highest among young to middle aged adults; in the last five years 65% of all casualties were in the age range 25-54 years.
- The majority (84%) of cycling casualties involved a car and one-in-ten occurrences were hit and run incidents.
- There were small but notable increases in cyclists killed and seriously injured at roundabouts, the pedestrian phase of traffic signal junctions, and where vehicles were turning right.
- Pedestrian casualties arising from a cycling collision were rare (1% of crashes resulting in a pedestrian injury between 2014-18 involved a bike).
- Unlike cycling participation and access to bikes, cycling casualties were not skewed towards wealthier demographics.
- In 2018, 52% of cycling casualties were wearing a helmet; 26% were not; and for 22% of casualties it was not recorded whether or not they were wearing a helmet.
- E-bikes are not currently recorded on Stats19 however there is no evidence of an increased likelihood of an e-bike being involved in a crash compared with a pedal bike.

- It is important to note that studies have shown that reported figures (from Stats19) for slightly and seriously injured cycling casualties are substantially under-estimated, by approximately half. In 1% of reported cycling casualties involving a vehicle there was no collision: this suggests a near miss. However, near misses are considerably under-reported. Thus, police recorded data do not reflect the rate of near misses that cyclists experience on a daily basis.

Near misses occur more frequently than collisions and are significantly associated with an increased perception of risk related to cycling. Therefore, near misses can negatively affect cycling experience more so than collisions. Due to under-reporting and inadequate information on cycling prevalence and distances cycled by different population groups it is difficult to accurately determine the risk associated with cycling in Scotland. Yet there is a high *perception* of risk associated with cycling in Scotland which contributes to low cycling uptake. Meanwhile European cities with high rates of cycling have better safety records for all road users, and the perception of risk is so low that few people wear safety equipment such as helmets.

Discussion: In the UK, men are three times more likely to cycle than women, although there is less of a gender imbalance in the use of cycle hire schemes. Image is a contributory factor to the gender divide in cycling uptake and women express higher concerns about risk compared with men. Cycling is not viewed as socially acceptable among many ethnic communities due to appearance, and associations with cycling and social status. Hostile and dangerous driver behaviour, lack of driver awareness, and stereotypes surrounding people cycling were associated with an increased likelihood of near misses or collisions. Driver error was reported as the primary contributory factor in 63% of cycling-driver collisions between March 2018-April 2019. Negative attitudes and stereotyping of cyclists predict aggressive behaviour towards cyclists.

In Scotland we need to make cycling safe, affordable and accessible for all. This can be achieved by making sure safe cycling infrastructure (including new bike hire schemes) is equally available in deprived and affluent areas, by supporting more bike inclusion schemes (like Bikes for All), and by reducing road speeds particularly in urban settings. An integrated transport system, where a bike can take you from door to door, and a comprehensive cycling network which is separated from motorised traffic, can reduce the risk of injury and improve cycling uptake. Investment in cycling needs to be sensitive to existing inequalities and to avoid exacerbating these further. In the UK cycling uptake is higher among higher income groups. In comparison, people in low-income households in Denmark still make a quarter of daily trips by bike. The wider benefits and relevance of active travel is recognised across a range of policy areas. Increasing levels of active travel can contribute to reducing carbon emissions and air pollution and to improving mental and physical health, and active travel is seen as a key component of more liveable, sustainable towns and cities.

Conclusion: To our knowledge this is the most up to date detailed study of cycling casualties and near misses in Scotland. These findings add to the evidence that motor vehicle speed, infrastructure, cultural norms and individual attitudes are key mechanisms which influence cycling participation and contribute to physical and perceived risks of cycling. Scotland's target of net-zero emissions of all greenhouse gases by 2045[1] demands a shift away from cars to sustainable transport modes including cycling.

Recommendations:

In order to achieve these targets and improve safety for cyclists we recommended the following actions:

1. New and accurate monitoring data of who cycles and how far in order to calculate risk and monitor progress in uptake of everyday cycling.

2. The inclusion of ethnicity and an e-bike identifier on Stats19 to better understand the contextual factors and demographics of cycling casualties.

3. Improvements to police enforcement and investigation of cycling casualties to strengthen cycling safety as a priority.

4. Substantial and sustained Scottish Government investment to increase spending levels in line with high-cycling European countries and enact policies which generate a modal shift from car use to active and sustainable travel.

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[1] Including Glasgow and Edinburgh's net zero emissions target by 2030

5. Substantial and sustained investment in quality cycling infrastructure, protected from motor vehicles, including retrofitting the existing road system to reduce danger where required.

1 Introduction

As a background to the review we describe the health, economic, environmental and community benefits of cycling, summarise current cycling trends in Scotland, highlight factors that influence cycling uptake and set out the relevance of everyday cycling to social, environmental and health policy.

1.1 Benefits of cycling to health

The Chief Medical Officer provides the following recommendations for physical activity across a range of ages[1]: All adults aged 19 years and over (including those aged over 65 years) should aim to be physically active every day. This includes engaging in at least 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity every week, in addition to strength exercises at least twice a week. Children and young people aged 5-18 years are advised to engage in at least 60 minutes of moderate to vigorous physical activity each day in addition to strength building activities three days per week.

Building active travel into everyday life can be an effective way to boost levels of physical activity in a country where only two thirds of adults (66%) meet the moderate or vigorous physical activity (MVPA) guidelines for physical activity, where two thirds of adults are overweight, and 28% are obese[2]. For example, someone who cycles for 30 minutes to and from work each day (i.e. a 15-minute commute) over five days a week would meet the recommended weekly MVPA through commuting. Cycling is starting to be considered as a therapeutic treatment within the NHS with an increasing number of 'cycling-on-prescription' schemes which aim to address physical health, mental health, and weight issues[3,4].

In this context, it is worth highlighting that the health costs of physical inactivity are substantial. Being physically inactive is linked to increased body fat and obesity which contribute to type 2 diabetes, coronary heart disease, and some types of cancer[5]. A recent study found physical inactivity and low physical activity to be among the ten most important risk factors in England[6] and it is estimated that physical inactivity contributes to almost one-in-ten premature deaths from coronary heart disease and one-in-six deaths from any cause worldwide[7].

Notwithstanding the current situation, there are many short journeys that could be undertaken on foot or by bicycle. Over half of all driven journeys in Scotland are less than 5km and 25% are less than 2km therefore swapping short car journeys for cycling is an achievable goal for building the recommended levels of exercise into the day[8]. It is also evidenced that activities which are part of everyday life (such as walking or cycling) are shown to be more sustainable compared with activities which require attendance at specific venues such as gyms or sports clubs[9]. Furthermore, as a low impact and non-weight-bearing activity, cycling is accessible to all but particularly those with joint pain, age-related stiffness, or decreased mobility[10,11] and there are options available for people with physical disabilities[12,13] and families with young children[14,15].

The health benefits of cycling are well documented and cycling undoubtedly has a beneficial role in protecting and improving population health and wellbeing[10,16-18]. Children who walk and cycle regularly are shown to concentrate better in class and achieve higher grades[19] and adults who cycle regularly are reported to have the fitness levels of someone ten years younger[16]. Meanwhile those who commute to work by bicycle have approximately one day fewer sickness-related absence per year compared with those who commute to work by other means[20,21]. Another study noted that interventions to enable commuters to switch from private motor transport to more active modes of travel could contribute to reducing the mean BMI of the population[22].

There is a dose response relationship between frequency of cycling and mortality: the longer a person spends cycling per week, the lower their risk of mortality[18]. It has been shown that people who cycle for approximately 100 minutes per week (less than the recommended rate of physical activity) have a 17% lower risk of mortality compared with those who do not cycle[23]. Researchers in Rotterdam established a 28% lower risk of mortality associated with cycling among those aged over 70 years which emphasised that the benefits of cycling are not tied to age, and participation at any age will reap health benefits[24]. In the UK even mixed mode cycling (i.e. combining cycling with public transport or a vehicle) was associated with a 24% reduced risk of mortality compared with non-active commuting[25,26].

1.2 Benefits of cycling to the economy

In a 2018 scoping study of the economic value of the cycling sector it was estimated that cycling contributed £5.4 billion to the UK economy every year[27] and the estimated contribution to the Scottish economy ranges from £596-£774 million[b,28]. Cycling tourism, meanwhile, including leisure cycling and mountain biking, is a growing sector in Scotland with an estimated total value of £486.4 million in 2015[28].

Modelling using the World Health Organization's Health Economic Assessment Tool (HEAT) and Scottish travel data estimated a £2 billion economic benefit per year, accrued after five years, if 40% of car commuter journeys of less than five miles were swapped to cycle journeys[29]. In Glasgow, the estimated annual health economic benefits from cycling in and out of the city in 2012 was calculated at £4 million[5,29]. Given the 111% increase in cycling trips in and out of Glasgow in the period 2009-2018[30] it is likely that if the health economic benefits of active travel were calculated now the figure would be significantly higher.

In contrast, the annual cost to NHS Scotland from overweight and obesity combined has been estimated to be as much as £600 million and estimates of the total economic costs of obesity to Scotland range from £0.9 billion to £4.6 billion per year[12]. Another study has estimated £94.1 million of direct primary and secondary care NHS costs could be attributable to physical inactivity annually, equating to a mean cost of approximately £18 per Scottish resident per year[31].

In terms of financial benefits to the individual, even considering financial outlays, the overall cost per kilometre travelled when cycling is less than half of that for car journeys[18]. Furthermore, the UK's Cycle to Work scheme[c] introduced in 1999 is reported to have saved UK commuters £37 million per year[32].

It is projected that if UK cycling rates doubled from its current level of 1.5% of all journeys made to 3%, the economy would benefit from an extra £2.09 billion per year; and if UK cycling rates increased to 10% of all journeys, the economic benefit would almost treble to £6.4 billion[18].

1.3 Benefits of cycling to the environment

There is unequivocal evidence that reducing the number of motor vehicles on the road would lead to substantial reductions in carbon emissions, lower pollutant

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[b] These figures consider reduced mortality, reduced congestion and pollution, tourism, and products associated with the cycling industry.

[c] The Cycle to Work scheme enables employees to purchase bicycles and equipment up to the value of £1,000 and pay it off in tax-free monthly instalments via their employer.

exposure to the general population, ease congestion, and reduce noise pollution[8,18,33].

In the UK, greenhouse gas emissions[d] reduced by 43% in the period 1990-2018, but, compared with other sectors, transport emissions show little sign of decreasing[34]. For example, in this period, energy supply emissions reduced by 62% and emissions by business by 31%, but transport emissions reduced by only 3% compared with 1990, as increased road traffic has largely offset improvements in vehicle fuel efficiency. In 2018, transport accounted for 28% of the UK's greenhouse gas emissions, while road transport contributed to 91% of the UK's transport-related greenhouse gas emissions with over half (55%) coming solely from passenger cars; road transport emissions have risen overall by 2% since 1990.

In 2017 the Scottish Government reported that transport (excluding international aviation and shipping) in Scotland accounted for 32% of greenhouse gas emissions. Road transport emissions are the largest source of transport emissions and there was an overall 11% increase in road transport emissions from 1990 to 2017[35].

As cycling is a highly efficient and zero carbon mode of transport it can offer worthwhile environmental savings. Cycling UK highlighted that the cost of investment in behavioural change measures and infrastructure is considered exceptional value for money in terms of CO_2 reduction[36]. It was estimated that if all the commuters in England with a journey of under five miles swapped their car to a bus or a bike their collective CO_2 saving in just one week would be 44,000 tones: the equivalent emissions produced from heating almost 17,000 homes[37]. A 2015 report by the Institute of Transportation and Development Policy concluded that increasing worldwide cycling from the current level of 6% of all urban passenger miles to 11% by 2030 would reduce CO_2 emissions from urban transport by about 7%[36]. A recent survey of users of UK bike share schemes reported that 17% of current bike share commuters had previously travelled by car or taxi and 37% used their car less now, highlighting the potential for bike share schemes to contribute to the reduction of pollution and carbon emissions[38].

[d] Excluding emissions from international aviation and shipping.

1.4 Benefits of cycling to the community

Investment in infrastructure which supports active travel and reduces vehicle traffic has been found to benefit communities and improve the local economy. Cycling can help stimulate economic growth in urban areas, particularly for small independent businesses, by increasing footfall and spending[39]. Walking and cycling can increase social contact among the community, improve social capital, and increase independence and autonomy among vulnerable members of society[5,40].

An evaluation of a bike equity project in Glasgow, Bikes for All (set up to support cheap access to cycling via Glasgow's nextbike cycle hire scheme), found that groups who have been under-represented in cycling benefited from increased social interaction, improved physical and mental wellbeing, and financial savings through cycling[41]. Environments which encourage active travel should be seen to be a core component of physical and social regeneration of communities.

1.5 Cycling trends in Scotland

Findings from the Scottish Household survey published by Transport Scotland showed that in 2018, 1.4% of adults[e] cycled as their main mode of transport and 2.8% commuted to work via bicycle[42]. Even though commuter cycling in Scotland has increased from 1.7% since 1999[42], compared with other European countries, Scottish cycling rates remain considerably low[43,44].

The UK Department for Transport publish estimates of distances cycled on public highways and adjacent paths annually. While there are limitations associated with these data[f], based on this source, cycle traffic in Scotland was estimated to account for 290 million vehicle kilometres cycled in 2018: a rise of 27% since 1993[45].

In 2019 Cycling Scotland reported that across Scotland the top five areas of Scotland where individuals 'regularly or usually' cycled to work were Edinburgh City (11.9%) followed by Highland (11.7%), Moray (9.1%), Dundee City (8.5%) and the Orkney Islands (6.4%)[46]. While Glasgow ranked low (5.4%) for cycling to work, cycling rates in the city have been shown to be increasing[46]. For example, the annual

[e] Aged 16+ years.

[f] Limitations in these estimates, including the significant change in methodology, are discussed later in the report.

Glasgow cordon count indicates that cycling trips in and out of the city of Glasgow increased in the period 2009-18 by 111%[30].

Across the UK there are clear demographic differences between those who cycle and those who do not, and many associated variables which influence cycling participation. These include gender, age, socioeconomic status, and ethnicity.

1.5.1 Gender

The 2018 National Travel Survey by the UK Department for Transport reported that in England men were three times more likely to cycle than women, and men cycled four times as many miles compared with women[47,48]. The 2018 Bike Life report focusing on seven major UK cities highlighted that even though the majority (68%) of women agreed their city would be a better place if more people cycled, 73% of women had never ridden a bicycle[49].

Data from the Scottish Household Survey, Cycling Scotland's (2019) Annual Cycling Monitoring Report highlighted that cycling was also predominantly a male activity within Scotland, with men more likely to cycle for transport, pleasure or fitness compared with women; and awareness and usage of cycle hire schemes was higher among men compared with women[45]. Gender differences in cycling are seen even among children and young people, whereby young boys are more likely to cycle compared with young girls[50,51].

The gender divide in cycling uptake within the UK is clear. Yet evidence from European countries highlights that women cycle just as often as men, and in the case of the Netherlands women cycle more than men[52]. Notably, cycling uptake does not appear to be as gendered in cycle hire schemes although there is variation across different cities. For example, in Glasgow the ratio of male to female registered users of nextbike was approximately 4:6[53] which is line with the gender split reported in the CoMoUK survey of UK bike share schemes although higher than figures from the latest National Travel Survey in England, where only 29% of cycle trips were by women[38]. It appears that lower cycling participation among women in the UK is compounded by many variables rather than simply a reduced desire to cycle.

As highlighted by Cycling UK, some of the barriers that women encounter with cycling are: feeling intimidated by road traffic and sexual harassment; and the perception that cycling does not align with their age, lack of fitness, and appearance[54]. In a 2011 review of transport choices, appearance was also identified as a contributory factor in low rates of cycling among women in the UK. This review suggested that women experience embarrassment or self-consciousness about helmets or cycling clothing and many found that the practical demands of cycling were not congruent with their feminine identity (i.e. wearing makeup, styling their hair, and cycling with a helmet in the rain)[55]. A body of research in Australia has also indicated that safety concerns significantly contribute to lower rates of women cycling compared with men[56]. Furthermore, the type of journeys can also play a role in whether women chose to cycle. The 2018 English National Travel Survey highlighted that women made more shopping and escort trips compared with men. While such journeys tend to be short and are theoretically possible via bicycle, most cycling infrastructure in the UK is not designed to support cycling with children[47,57].

The gender divide in cycling uptake is a concern particularly given the growing inequalities in physical activity between men and women in the UK. In 2017, the British Heart Foundation highlighted that across the UK there were fewer women meeting the recommended physical activity levels for a healthy lifestyle compared with men[58] and the Scottish Health Survey (2018) indicated that 70% of men met the recommended MVPA guidelines compared with 62% of women[2].

1.5.2 Age

For many people in the UK learning how to ride a bike is a childhood milestone but research indicates that cycling to school rates among children and young people are relatively low. The 2018 Scottish Hands Up Survey of travel choices to school reports that active travel to school (walking, cycling, and scooting) has remained the most frequently reported mode of travel to school across Scotland. Cycling to school, while still low, has increased from 2.8% in 2008 to the highest recorded level of 3.8% in 2018[59].

Cycling Scotland's (2019) Annual Cycling Monitoring Report highlighted that participation in cycling in 2017 was highest among the 35-44 years age group (18%) followed by 25-34 years (16%), 45-59 years (15%), 16-24 years (13%), 60-74 years (8%); and cycling participation was lowest (1%) in the 75+ years age group[46]. Meanwhile in the Netherlands it is notable that cycling rates peaked in the 65-70 years age group, although rates did decline after age 80 years[60].

Research suggests that older adults who do cycle regularly were also reportedly physically active during their younger years and therefore it is a natural progression for them to cycle in old age[61]. Findings from the Netherlands suggest that an embedded culture whereby cycling is the norm may also play a role in cycling rates among older adults. While research from Canada and the UK have identified safety concerns, including inadequate infrastructure for their needs and capabilities, are a deterrent to older adults' participation in cycling[61,62].

1.5.3 Socioeconomic status

In the UK there are clear links between socioeconomic status and cycling uptake.

Cycling rates continue to remain higher among the higher income groups compared with lower income groups[63]. Similar findings were also identified in Glasgow whereby those living in the least deprived communities were nearly three times more likely to commute by bicycle to work or study compared with those living in the most deprived communities[64].

The 2017 Transport and Travel in Scotland report demonstrated that cycling and access to a bicycle was also associated with household income. This report found that 60% of households with an income of £40,000 or more per year had access to one or more bikes while only 16% of households with an income of up to £10,000 had access to a bike[65]. In the UK it is important to recognise that low income households are typically living within socially deprived, obesogenic environments which often discourage active travel and where cycling is not perceived as the social norm[66]. Studies have shown that individuals' perceptions of what attributes are required to "be a cyclist" coupled with a non-cycling environment, can create additional barriers for under-represented groups[67].

Meanwhile in countries with high cycling rates there is less of a socioeconomic divide and cycling is perceived as a normal form of transport across the income groups[67]. For example, in Denmark, it is reported that households with an income of less than $13,004 per year still make one quarter of their daily trips by bicycle[67].

1.5.4 Ethnicity

The links between ethnicity and cycling uptake are less well documented than age, gender, and socioeconomic status. Yet there are distinct barriers to cycling experienced by members of ethnic communities which are perhaps not shared by other under-represented groups.

Accessibility has been raised as a barrier experienced by Black and minority ethnic (BME) communities. This has been found particularly among BME women who due to cultural reasons are unable to access cycling due to the “inappropriate clothing” required[66] or because it is not seen as socially acceptable within the community[55]. Religious commitments and home and family responsibilities were also cited as leaving little time for leisure or sporting activities[55].

How cycling is perceived among members of BME communities is key to understanding low cycling uptake. A 2011 study of how ethnic identities can shape transport choices reported cycling was considered a playful childhood activity rather than a mode of transport; and wealth, image, and status was a social barrier to cycling[55]. In addition, a 2011 research summary on barriers to cycling among ethnic minority groups highlighted that many young Asians are expected to reflect the wealth and status of their parents, and cycling, which is associated with poverty and low social status, does not achieve this. Therefore, there is a greater emphasis on car ownership which is seen as prestigious[66]. For many women within the BME community cycling was viewed as inherently inappropriate, and policy interventions and practical solutions would not change this perception[55].

Yet these findings are not replicated across the UK. Almost half of all participants in Glasgow’s bike equity scheme, Bikes for All, were a member of a BME community. Therefore, it may be possible to address some of these barriers through taking a personalised social inclusion approach[41].

1.6 Factors which influence cycling uptake

It is evident that the factors which influence uptake of cycling in the UK are multi-faceted and nuanced. There is increasing evidence to suggest that perceptions surrounding the purpose of cycling, image, and safety play an important role in participation in cycling.

1.6.1 Identity, culture, and attitudes

There is a persistent perception, found particularly among those who do not cycle, that cycling is an activity for sporty people and if an individual does not identify as ‘sporty’ they are less likely to choose cycling as a means of transport[18]. These findings echo those from Transport for London's 2014 attitudes survey which indicated that a key motivator for cycling in the city was a desire to get fit and active, and not as a means of travelling[68].

These findings are in contrast with the perception of cycling among those who live in countries with high cycling uptake whereby cycling is viewed as part of everyday life *first* and with benefits to health and fitness[52]. It is notable that in a UK study of bike share scheme users, health benefits – although mentioned – were not the most common reasons for cycling. Instead respondents cited convenience (61%), saving time (56%) and enjoyment and fresh air (49%). These findings suggest that people using cycle hire schemes for commuting have a more functional outlook on cycling[38].

There appears to be a conflict between individuals' identity and their perception of cycling, which is a contributory factor to cycling uptake. For example, if an individual does not identify as a cyclist (including what they perceive a cyclist to be) then they are less likely to cycle. This relationship is also mediated by context and whether cycling is an accepted social norm. A study on attitudes and behaviours towards cycling in Scotland with over 1,000 participants demonstrated that the majority agreed that Scotland would be a better place if more people cycled. However most declared that cycling was not something they came across in their daily life. In fact, almost two thirds (60%) knew very few people who cycled regularly[69]. This suggests that exposure to cycling could be influenced by descriptive norms (i.e. having friends or family who cycle or seeing cycling within the wider community). The role of descriptive norms has also been linked to cycling to school among primary school children[70,71].

Social norms surrounding cycling is a thread woven throughout the literature and could explain some of the barriers to cycling uptake. If an individual does not view cycling as a mainstream activity this can serve to reinforce stereotypes surrounding cyclists making it an activity which is unattainable for many[72].Studies have also shown that the perceived attributes needed to be a cyclist and stereotypical images of cyclists are creating additional barriers particularly among under-represented groups[55,67]. A key example of this is the type of cycling and the clothing required to cycle. It has been suggested that cycling for commuting and for sport both present a serious image of a 'cyclist' which has associations with Lycra, and which many people feel alienates them from cycling[72]. Meanwhile women reportedly perceive cycling as incompatible with their feminine identity, largely due to the clothing and equipment they believed is required[55]. Findings like these may serve to reinforce the argument for adopting non-stigmatising language surrounding cycling and move away from the exclusive and potentially problematic identity of the 'cyclist'[73]. While others suggest adopting cycling into everyday life may inherently require individuals to reframe their identity to that of a 'cyclist'[74].

1.6.2 Perceptions of safety and risk

The relationship between safety and risk and cycling uptake has been identified as a contributory factor to low cycling rates within the UK.

Previous research by the GCPH[75] showed an increase in adult cyclist casualties (of all levels of severity) in Scotland over a decade from the mid-2000s onwards. The rise, which was observable from both police (Stats 19) and hospital statistics (SMR01), comprised an increase in both casualty numbers and as a population-based casualty rate. The increase occurred principally in large urban areas and indeed adult cyclist casualties rose over this period in all of Scotland's largest cities. Another finding was that adult cyclist casualty rates were consistently higher for people living in the least deprived areas of Scotland. Analysis of hospital discharge data showed that injuries to the upper body, arm hand and head area were consistently more common than injuries to the legs, ankles and feet.

While cycling is generally perceived by many as a healthy transport option there remains an embedded perception that cycling in the UK is unsafe[76]. In a recent survey of 1,049 people living in Scotland, Cycling Scotland agreed that the environment and individual health would improve if more people cycled however concerns surrounding safety contributed to a reluctance to choose cycling over car driving[77]. This sense of traffic danger was found to be a key deterrent to cycling, particularly among under-represented groups and new cyclists[18,52]. For example, there is a large body of research which concludes that perceptions of safety and risk significantly contribute to lower rates of cycling among women[78-80]. Women are less likely to cycle on roads, and when segregated cycle paths are not available, they are likely to cycle less overall[76,80,81].

In addition, a UK-based study exploring cyclists' experiences of non-injury incidents such as near misses highlighted that a high number of 'very scary' incidents per day when cycling was linked to damaging new cyclists' experiences of cycling and negatively impacting their confidence to cycle in the future[82]. Even among those who did cycle, two thirds (66%) reported they too were concerned about their safety on Britain's roads[83].

Concerns surrounding cycling and safety are linked to motor vehicle traffic and the behaviour of drivers, and/or connected to infrastructure. This was evidenced in the *State of Cycling* report by British Cycling which demonstrated that 71% of cyclists believed that drivers were hostile towards people on bikes[83]. Drivers deliberately driving too close to cyclists has frequently been reported as a common form of harassment among cyclists[84,85].

Cycling Scotland's survey of attitudes and behaviours towards cycling identified that dedicated cycle lanes, traffic free routes, and a feeling of safety on the roads scored highly as key facilitators to encourage more people to cycle[69]. Cyclists using a new segregated cycle path in the west of Glasgow consistently commented on the safety aspect of the new infrastructure; some were willing to undertake a longer journey to take advantage of the route and others reported feeling more confident about cycling during peak hours. The raised kerb was seen to be important for creating a feeling of safety[86].Yet others argue that completely separating cycling from the main flow of traffic and removing them from view could be counter-productive in improving cycling uptake and further marginalise cyclists[72]. It is suggested that cycle lanes alongside road traffic or part of the road infrastructure actually contribute to the 'safety in numbers' phenomenon whereby rates of injuries to cyclists decreases as the number of cyclists increases. As this increase in cycling occurs, drivers learn to better accommodate other road users because they encounter them more often, therefore cycling safety increases[72].

Questions remain as to whether the perception that cycling is dangerous is well-founded, what is the likelihood of experiencing an injury while cycling, and what is the relative risk of cycling in the context of the UK.

1.7 New developments in cycling

In recent years there have been several innovative developments to promote cycling in the UK. Examples include e-bikes, cycle hire schemes, adapted bikes, and investment in active travel.

1.7.1 E-bikes

Electrically assisted pedal bikes ('e-bikes') have a battery, which can be charged at a domestic power socket, linked to an electric motor. E-bikes can achieve a speed of 15mph and are permitted on any infrastructure designed for pedal cycling[87]. E-bikes offer users the opportunity to maintain or increase their levels of cycling activity and have the potential to replace some vehicle journeys[87,88] since the average journey covered by e-bikes is one and half times further than pedal bikes[89]. In a 2018 meeting of the All Party Parliamentary Cycling Group (APPCG) which focused on e-bikes, Transport for London suggested that e-bikes could widen access to cycling. Particularly among those who may not have cycled previously or who are deterred from cycling due to distance or perceived lack of physical fitness; including individuals aged over 55 years or with mobility issues, individuals with high travel costs or long commuter journeys, and those with a disability[90].

Given the power assistance given to the user, some have questioned whether e-bikes provide health and fitness benefits. However, there is evidence that while e-cycling is of a lower intensity than conventional cycling it can provide at least moderate intensity physical activity and a level of physical activity which can be higher than achieved while walking. There is also evidence that e-cycling can improve cardiorespiratory fitness in physically inactive individuals[91].

The sale of e-bikes is growing rapidly across Europe. The Netherlands is now one of the biggest markets in Europe where of the 22.8 million bicycles in the Netherlands, approximately 1.8 million are e-bikes[92]. UK bicycle retailer Halfords reported a 220% increase in its sale of e-bikes from 2016 to 2017[90]. Yet in 2018 only 3% (60,000) of all bike sales in the UK were for e-bikes[87]. The UK-based Bicycle Association has criticised the UK government for failing to promote e-bikes with the same vigour as electric cars. They evidenced research from Transport for Quality of Life which argued that incentives for promoting e-bikes were better value, more equitable, and healthier compared with incentives which subsidised the purchase of electric cars[87]. In 2019, however, the Scottish Government announced that £1.14 million of the £80 million active travel budget would be allocated to finance the E-bike Grant Fund[88]. This fund assists local authorities, public sector and community groups, and educational institutions to adopt e-bikes as sustainable alternatives to car journeys.

Barriers to e-bike use include the weight of the bicycle, which is considerably more than a pedal bike; fear of theft; and a concern over battery power to reach a destination[93]. Furthermore, e-bikes are more expensive than pedal bikes in terms of financial outlay and replacement batteries[93], with the average cost of a commuter quality e-bike costing approximately £2,250 in the UK[90]. Due to these financial barriers there are growing calls for the Cycle to Work Scheme value of £1,000 to be raised to make e-bikes more easily accessible[32]. That said, cheaper access to e-bikes is being enabled through cycle hire schemes which increasingly include a proportion of e-bikes in the fleet and avoid the costs of ownership.

1.7.2 Cycle hire schemes

Cycle hire schemes are a service whereby bikes are available to the public to hire on a short-term basis for a fee. Most schemes have docking systems which enable users to borrow a bike from one dock and return it to another dock elsewhere thus facilitating active travel within a town or city.

The first large scale city cycle hire scheme in Scotland was the nextbike scheme introduced to Glasgow in June 2014 prior to the start of the Commonwealth Games hosted in the city[64]. Users register with the service online and can hire and return a bike from stations around the city. During the period 2014-2016 there were approximately 16,000 users registered with nextbike in Glasgow and 191,874 bikes were hired during this time: equating to 262 hires per day over the two-year period[53]. In fact, the increase in cycling activity seen in Glasgow between 2009-2018 was partly attributed to the introduction of the cycle hire scheme[64]. Previous analysis by the GCPH has demonstrated that the cycle hire scheme was used predominantly for commuting within the city and that most users were Glasgow residents, although bikes are also used by tourists[53]. The scheme has been expanded over time and as of 9th October 2019, there were 68 hire stations and 713 bikes (O'Meara, A. Glasgow City Council. Personal communication).

In 2019, nextbike also launched the first school cycle hire scheme in Stirling. By dropping the age at which people can join the scheme from 18 years old to 14 years old, and providing free membership to school pupils for the first 12 months, nextbike facilitates active travel to and from four high schools in the local area[94]. Edinburgh also has a city-wide cycle hire scheme and there are likely to be further schemes introduced in towns and cities across Scotland in the coming years.

E-bike hire schemes are also becoming increasingly available. In 2019 there was the rollout of e-bike hire schemes across Scotland, the largest comprising 120 bikes and 12 hire charging stations launched across three local authorities in the Forth Valley[95]. While a fleet of 63 e-bikes were added to Glasgow's existing nextbike cycle hire scheme in October this year[96].

The 2019 CoMoUK cycle hire user survey[37] highlighted that most respondents using the scheme were aged 25-54 years (78%), over one third (37%) were female, 82% were in employment and 11% were students. Most (63%) respondents reported they cycled more often since joining the scheme and of those using the bikes to commute, 42% reported they were cycling more. This survey also revealed several health benefits: 12% of users had achieved the MVPA guideline of two and a half hours a week by using the cycle hire scheme; 48% used the scheme because of the associated exercise and physical health benefits; and 29% reported that the mental health benefits were a reason for using cycle hire. Other top reasons for using cycle hire included: an easier journey (61%), saving time (56%), fun and fresh air (49%), and environmental reasons (39%)[38].

Cycle hire schemes have been linked with a reduction in bike theft, which has been attributed to the hire bikes being perceived as less desirable compared with privately owned bikes[97]. Therefore, cycle hire schemes could reduce concerns surrounding property loss as a barrier to cycling. That said, there are varied experiences of cycle hire schemes across UK cities with some reporting high levels of vandalism and theft. For example, a 2019 report shows that just 200 of the 500 bikes in the Edinburgh cycle hire scheme, Just Eat Cycles, were available due to vandalism and theft[41,98]. While in Manchester, two years after launching, the company MoBike was reportedly forced to suspend their cycle hire scheme due to vandalism[99] although this used a 'dockless' model. Dockless 'pick up and leave anywhere' schemes involve bikes being typically located, paid for, and unlocked using a smartphone application. These schemes offer cyclists the convenience of not having to worry about finding a docking station at the start or end of their journey. Concerns with this model include clustering of bikes at unsuitable locations and misplacement of bikes[100]. In contrast, Glasgow City Council's nextbike cycle hire scheme (which uses a docking system) has reportedly low levels of theft and 'negligible' levels of vandalism making it one of the more successful schemes in the country[98].

1.7.3 Adaptive and family bikes

Adaptive bikes are those which are modified to suit various learning and physical needs and serve to make cycling accessible to all. Some examples include tricycles, tandems, hand cycles, recumbent cycles, and wheelchair cycles[13]. There are also various options for cycling with children. For example, cargo bikes and trailers are suitable even for young babies and toddlers and can be fitted with an electric assist thus making hills and heavy loads easier to negotiate; and child seats can be fitted to the front and rear of most bicycles[14,15]. Cycling UK advise that by following the rules for solo-cycling, families can cycle safety with children even on quite busy roads[101].

1.8 Funding for active travel in Scotland

The Scottish Government has committed to increasing active travel throughout the country in the Long-Term Active Travel Vision and Cycling Action Plan for Scotland (CAPS)[102]. Furthermore, funding for active travel has increased from £39 million in 2017-2018 to £80 million in 2018-2019 and 2019-2020 which equates to £13.50 per head: twice the amount spent in England[103].

Nonetheless, criticism surrounding the level of funding for active travel remains. The Scottish Government's active travel budget of £80 million equates to only 1.9% of the overall transport budget[104]. Some have called for multi-year funding, rather than annual funding, to allow stakeholders to plan more ambitiously and deliver across towns and cities rather than in more limited phased developments[104]. Many organisations have campaigned for 10% of the transport budget to be allocated to active travel in order to bring Scotland's spending in line with countries with high levels of cycling like the Netherlands and Denmark. For example, capital investment by the Dutch government in road and parking infrastructure for cycling has been "almost €0.5 billion per year over the last decades"[60]. The annual health benefit (related to reduced mortality) resulting from this investment in cycling is an estimated €19 billion, which in turn corresponds to more than 3% of the Dutch gross domestic product[60].

1.9 Policy links for active travel in Scotland

Scotland's poor health position in comparison with the rest of the UK and other Western European countries is well documented and efforts to improve health in Scotland are multi-faceted[105]. There are various interlinked policies[106] which support greater levels of active travel in Scotland, which aim to achieve the Scottish Government's vision that we live long, healthy and active lives regardless of where we come from[107].

In 2014 Transport Scotland published their Long-term Vision for Active Travel which envisaged that by 2030 "Scotland's communities are shaped around people, with walking or cycling being the most popular choice for shorter everyday journeys. This helps people make healthy living choices and assists in delivering places that are happier, more inclusive and equal, and more prosperous"[106].

However, access to cycling has an inequalities dimension which challenges whether this vision is achievable. Bike ownership and cycling is higher in more affluent groups within the population and transport poverty[108,109], including forced car ownership are increasingly recognised issues[109]. Widening access to affordable sustainable transport, such as cycling, is relevant to addressing poverty and is recognised as a key issue by Scotland's Poverty and Inequality Commission[110].

Nevertheless, it is perhaps in relation to environmental policy that the strongest arguments for active travel, including everyday cycling, can be made. The recent review of Scotland's cleaner air policy, CAFS (Cleaner Air for Scotland), pointed to a need for more "focus on inter-related interventions including improved transport infrastructure that encourages higher levels of active travel"[111]. It also stated that the second National Transport Strategy "should lead to a permanent preference for more sustainable transport modes and infrastructure investments" and noted the need for "further and coherent, expanded support for cycle and pedestrian/active modes"[111].

The draft National Transport Strategy for Scotland has a vision of a sustainable, inclusive and accessible transport system that helps deliver a healthier, fairer and more prosperous Scotland. This strategy notes the importance of promoting active travel to not only improve health and address health inequalities, but to contribute to climate action[112,113].

It is evident that to achieve Scotland’s climate change target of net-zero emissions of all greenhouse gases by 2045 and 75% by 2030[112], significant reductions in transport emissions will be required. Achieving this demands fewer motor vehicles on the roads and a modal shift away from cars to sustainable transport modes, including cycling. Scotland’s two largest cities, Glasgow and Edinburgh, have committed to reaching zero-carbon and net-zero emissions, respectively, by 2030[114,115]. Finally, in relation to cyclist casualties, the original Cycling Action Plan for Scotland (CAPS) specifically noted the importance of achieving the Road Safety Framework targets of a 40% decrease in road deaths and a 55% decrease in seriously injured road casualties by 2020[116].

In summary, there is now a multitude of policy in Scotland that should be supportive of investment in cycling to enable the growth of cycling as a normal everyday activity with accompanying health, social and environmental benefits.

2 Aims and methods

This review combines analysis of reported cyclist casualties in Scotland with a literature review of under-reporting of cyclist collisions and near misses. The analysis of reported cyclist casualties summarises trends in reported cyclist casualties and the physical contexts associated with cycling collisions and near misses. The review focuses on cycling rates in Scotland and the factors that influence cycling uptake; and the under-reporting element of cyclist casualties and near misses.

2.1 Datasets

The data used for the analysis were derived from the police recorded Stats19 system which records road traffic accidents (RTAs) occurring on roads, in which a vehicle was involved and where at least one person sustains an injury. Data were obtained on request from Transport Scotland and three sets of data extracts were requested:

1. The primary dataset comprised accident, vehicle, and casualty records relating to reported RTAs occurring in Scotland involving a reported cyclist casualty in the 23-year period from 1995-2018.
2. A second bespoke dataset provided RTA information relating to reported cyclist casualties in the five-year period from 2014-2018 which had been linked to the home postcode of the casualty. This allowed for analyses of the deprivation and urban/rural characteristics of where casualties resided.
3. A third dataset provided details of reported RTAs involving pedestrian casualties for the five-year period from 2014-2018 to analyse the proportion of accidents where a cyclist was involved.

Stats19 covers RTAs involving an injury where the police attended the scene and also self-reported RTAs[g]. While Stats19 is the most comprehensive UK-wide system for recording RTAs involving injury, the system does not record *all* accidents involving injury and is thus known to significantly under-estimate casualties and injuries in Scotland. Nevertheless, Stats19 can provide a useful picture of trends in casualties over time and identify characteristics and circumstances surrounding such incidents.

[g] Where a member of the public reports a road traffic accident at the police station.

Presenting data on cyclist casualties presents some methodological problems. Ideally a denominator would be used to compare casualty rates accounting for exposure to risk. An ideal denominator would be one that takes account of the number of people cycling and the time they spend cycling. Unfortunately, accurate statistics on cycling prevalence which can be used for this purpose do not exist in Scotland or the UK. For this reason, most of the data presented are counts of casualties instead. The limitations of this approach are commented upon in the discussion section of the report.

3 Findings

This section provides the findings from the analyses from Stats19 data and from a literature review. The analysis from Stats19 data is focused on cyclist casualties with injuries categorised as slight, serious, and fatal which have been reported to the police. The literature review focuses on cycling near misses and the under-reporting element of casualties and near misses.

3.1 Overall trends in cyclist casualties

Since 1995 the number of reported cyclist casualties on Scotland's roads has more than halved, reducing from 1,323 casualties (1995) to 638 (2018). Most of this reduction occurred before 2007. However, these overall figures mask a more nuanced picture which emerges if trends by severity of injury are examined. Stats19 records three levels of injury among casualties: slight, serious, and fatal[117]. Further details on the categorisation of injury types can be seen in the Glossary.

Figure 1 illustrates trends in cyclist casualties over the 23-year period from 1995-2018. In this period, slight injuries accounted for 81% of reported cyclist casualties, serious injuries accounted for 18%, and fatalities accounted for 1%. In this timeframe there were reductions in all three injury categories: slight injuries showed the largest reduction (-54%), while serious injuries reduced by a slightly lower amount (-44%). Slight injuries reduced noticeably in two distinct periods between 1995-2007 and from 2014 onwards. Fatal injuries reduced by 45% over the whole period however there were fluctuations in the number of cycling fatalities in some intervening years, notably in 2013 when cycling fatalities rose to a high of 13. As a result of a more modest reduction in serious injuries compared with slight injuries, serious injuries account for a greater proportion of reported cyclist casualties over time: 24% in 2018 compared with 21% in 1995. It is notable that cyclist casualties with serious injuries reduced to a low point in 2005 when 116 seriously injured cyclist casualties were reported. However, from 2005-2018, there has been a steady increase in seriously injured cycling casualties, equating to a 34% rise in this period; in 2018, 156 seriously injured cyclist casualties were reported.

Figure 1: Cyclist casualties by severity, 1995-2018, Scotland.

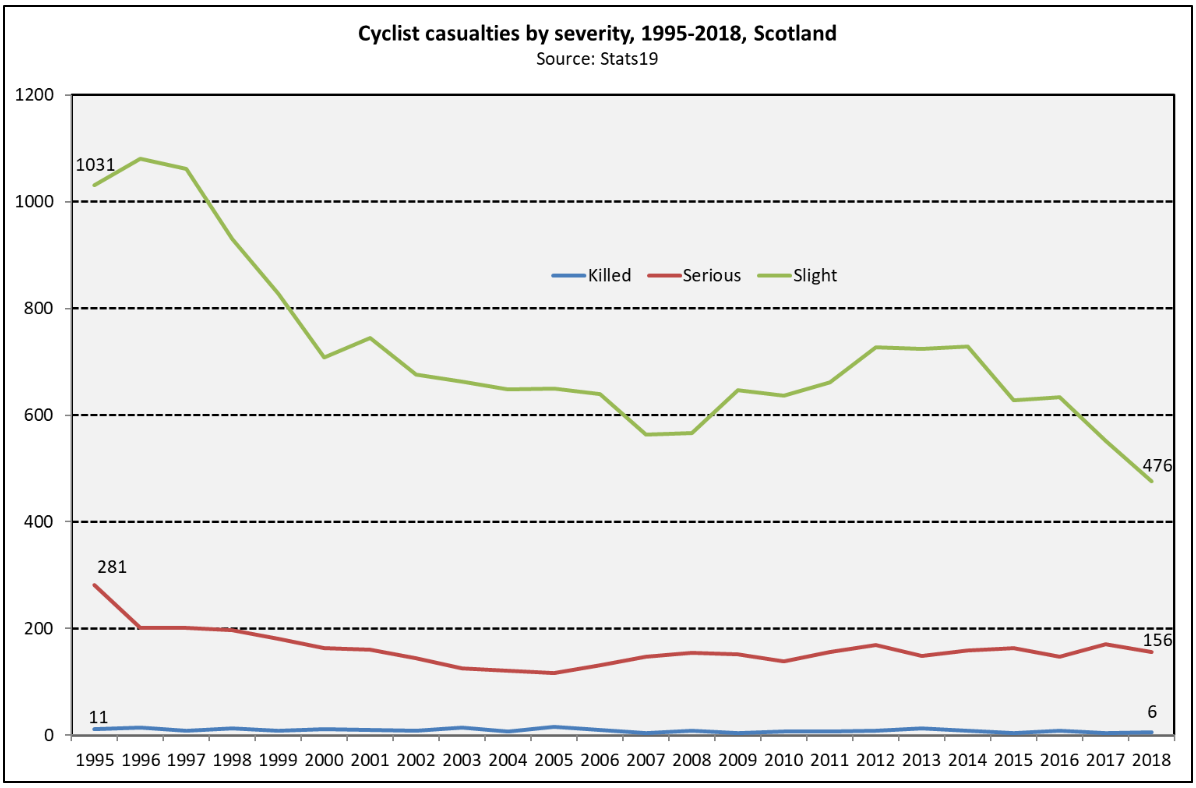
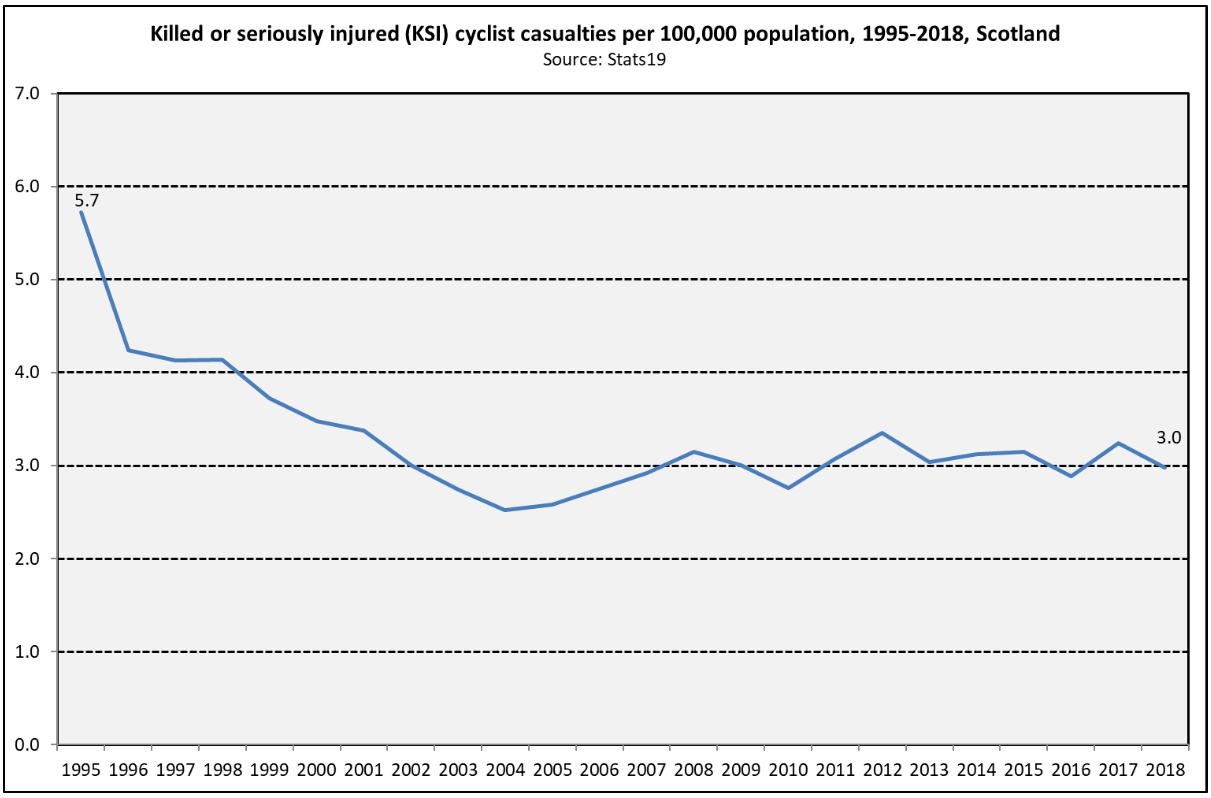


Figure 2 illustrates the rate of cyclist casualties who were killed or seriously injured per 100,000 population in Scotland in the same period. After a reduction in the early part of the period from 1995-2004, the rate of cyclist casualties killed or seriously injured in Scotland increased over the following 14 years; by 18% in the period 2004-2018.

Figure 2: Killed or seriously injured (KSI) cyclist casualties per 100,000 population, 1995-2018, Scotland.



In summary, most of the reductions in cyclist casualties in Scotland have been driven by reductions in slight injuries over the period from 1995-2018 and the reductions in killed and serious injuries that occurred in the earlier period from 1995-2004.

3.2 Analysis of vehicle manoeuvres and junction types associated with incidents in which a cyclist was killed or seriously injured (KSIs)

Given the significance of the upward trend in killed and seriously injured cyclists, further analysis was carried out on vehicle manoeuvres and junctions associated with incidents where a cyclist was killed or seriously injured.

In accidents involving a KSI cyclist casualty, ***turning right*** has become a slightly more commonly recorded manoeuvre on Stats19 – occurring on average in 30 such incidents annually in the period from 2014-18 compared with an average of 25 annually in the period from 1995-99. Additionally, as a proportion of all motor vehicle manoeuvres, turning right has increased from 13% in 1995-99 to 20% in 2014-18. For reference, ***going ahead*** is still the most commonly described manoeuvre in such incidents, but accounts for only 31% of all vehicle manoeuvres in 2014-18 compared with 54% in 1995-1999.

The number of accidents involving a killed or seriously injured cyclist at ***T-junctions or staggered junctions*** has reduced from 92 on average per year in the period 1995-1999 to 54 per year in the period 2014-2018; a reduction of 41%. As a proportion of all collisions involving KSI cyclist casualties, accidents at T-junctions have reduced from 44% to 34%.

Over the same period the number of such accidents at ***roundabouts*** has increased from 13 annually (1995-99) to 20 annually (2014-18), representing an increase of 53%. As a proportion of all collisions involving KSI cyclist casualties, accidents at roundabouts have increased from 6% to 12%.

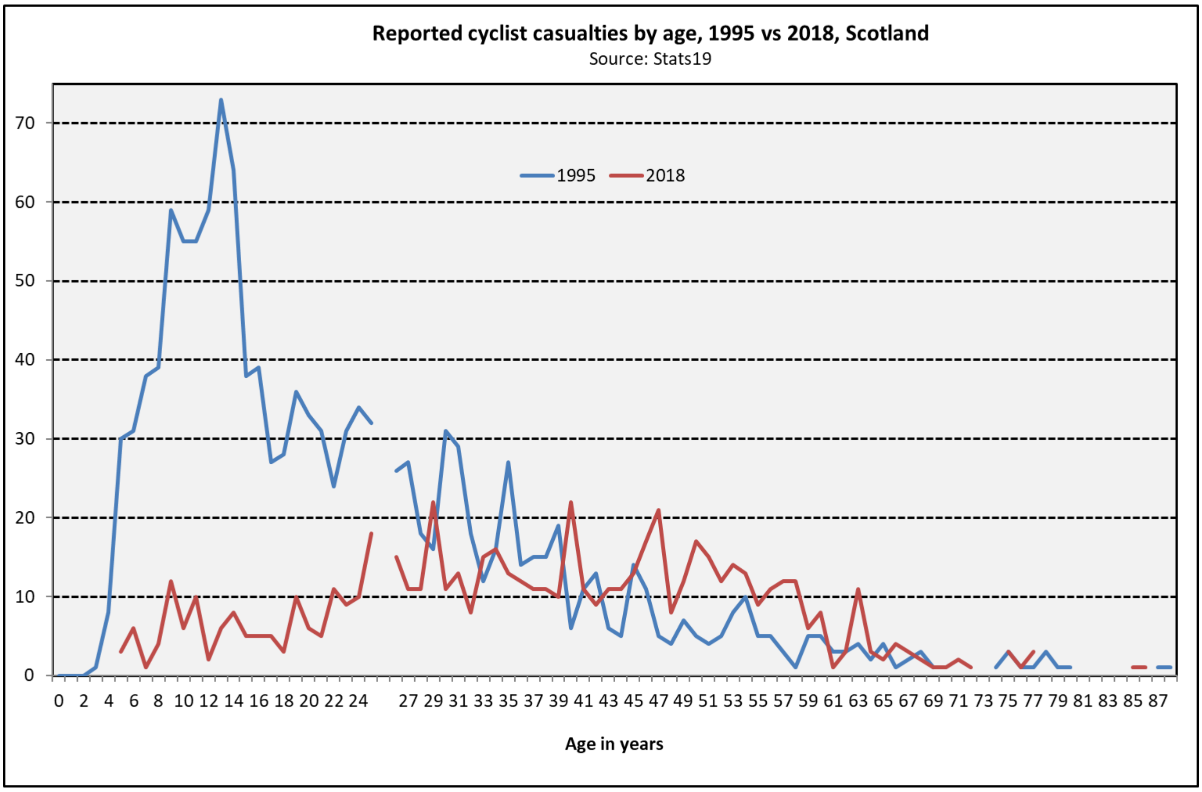
The number of accidents at the ***pedestrian phase at traffic signal junction*** has increased from eight on average per year in the period 1995-1999 to 18 per year in the period 2014-2018; an increase of 110%. As a proportion of all collisions involving KSI cyclist casualties, accidents at the pedestrian phase at traffic signal junctions have increased from 4% to 11%. Nevertheless, most accidents involving a killed or seriously injured cyclist still occur away from physical crossings (81% in 2014-2018).

While the trends described could represent genuine changes in the circumstances pertaining to incidents with KSI cyclist casualties, it is also possible that some of the observed changes are related to more detailed and accurate recording of the circumstances pertaining to road traffic accidents.

3.2.1 Age of casualties

Figure 3 illustrates the age profile of cyclist casualties at two time points: 1995 and 2018. In 1995 the peak ages for cyclist casualties were the teenage years while in 2018 there was a broader elevated peak in casualties between the 20-60-year age group.

Figure 3: Cyclist casualties by age, 1995 versus 2018, Scotland.



Further analysis of casualty trends by age group reveals contrasting trends for different age groups. In the period 1995-2018 cyclist casualties reduced among the younger age groups: 88% among the 0-15 years age group and 77% among the 16-24 years age group. As a result, child casualties accounted for only 10% of cyclist casualties in 2018 compared with 42% in 1995. Among young adults, cyclist casualties accounted for 10% of all casualties in 2018 compared with 21% in 1995.

In the subsequent age groups (25-34 years and 35-44 years) the reduction in cyclist casualties was more modest, with a notable rise in casualties from 2008 to 2013-14 before casualties within these age groups decreased again.

Figure 4 illustrates that in older age groups the trend patterns were markedly different. In the age groups 45-54 years and 56-64 years, cyclist casualties increased from the mid-2000s. The overall rise in cyclist casualties between 1995-2018 was 95% in the 45-54 years age groups, and 111% in the 55-64 years age group. Consequently, these age groups now represent a greater proportion of cyclist casualties with 45-54-year olds representing 22% of casualties in 2018 (compared with 6% in 1995) and 55-64-year olds representing 12% of casualties in 2018 (compared with 3% in 1995). In the oldest age group studied, 65+ years, there was a 16% increase in cyclist casualties over the period 1995-2018 but the numbers of casualties in this age group were low and fluctuated from year to year.

Figure 4: Cyclist casualties by age group, 1995-2018, Scotland.

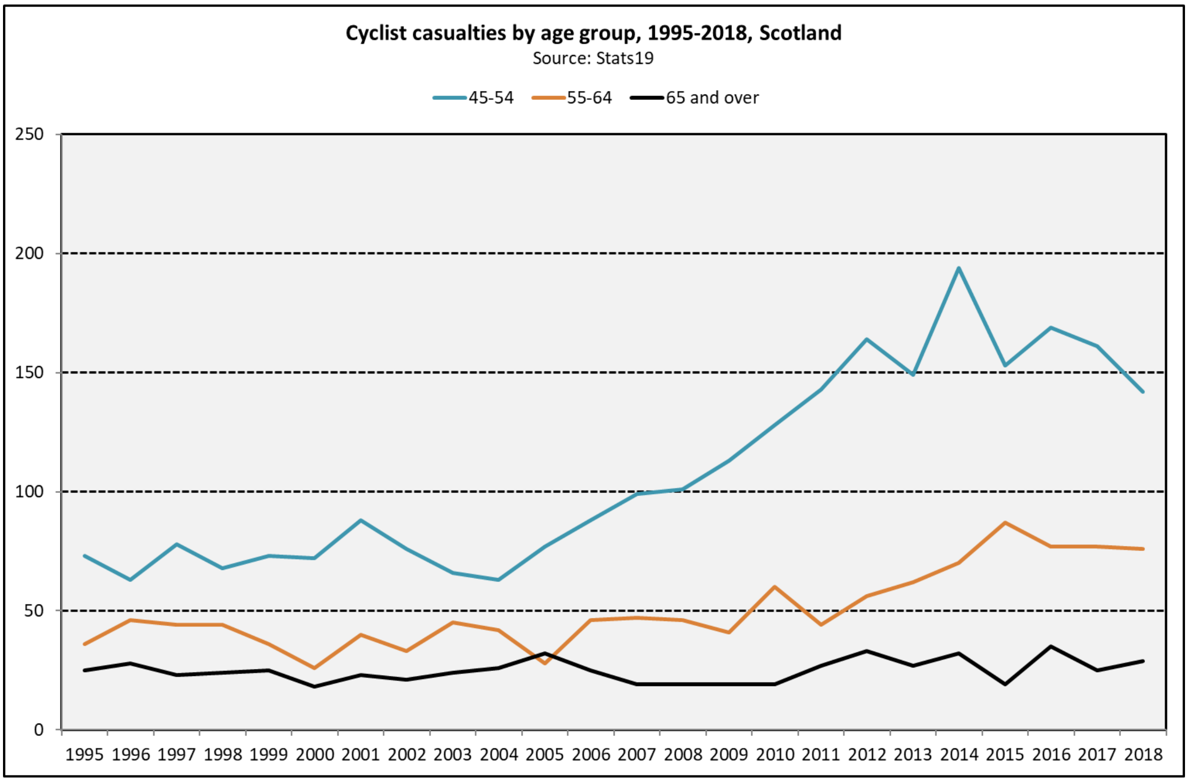
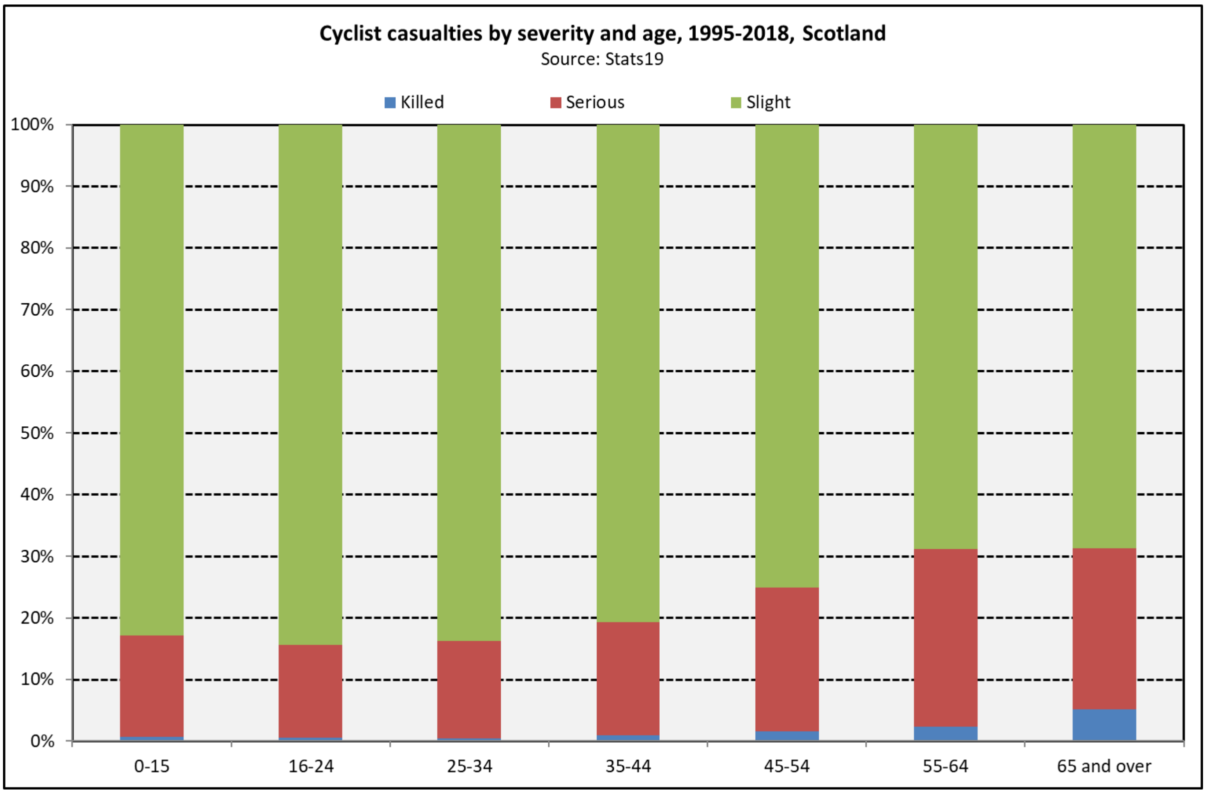


Figure 5 compares the age of casualty with severity of injury. This shows an increasing proportion of killed or seriously injured casualties with age, which is particularly apparent among casualties aged 45+ years.

Figure 5: Cyclist casualties by severity and age, 1995-2018, Scotland.



3.2.2 Gender of casualties

The proportion of male and female cyclist casualties did not change greatly over the period 1995-2018. Overall, 82% of cyclist casualties were male and 18% were female.

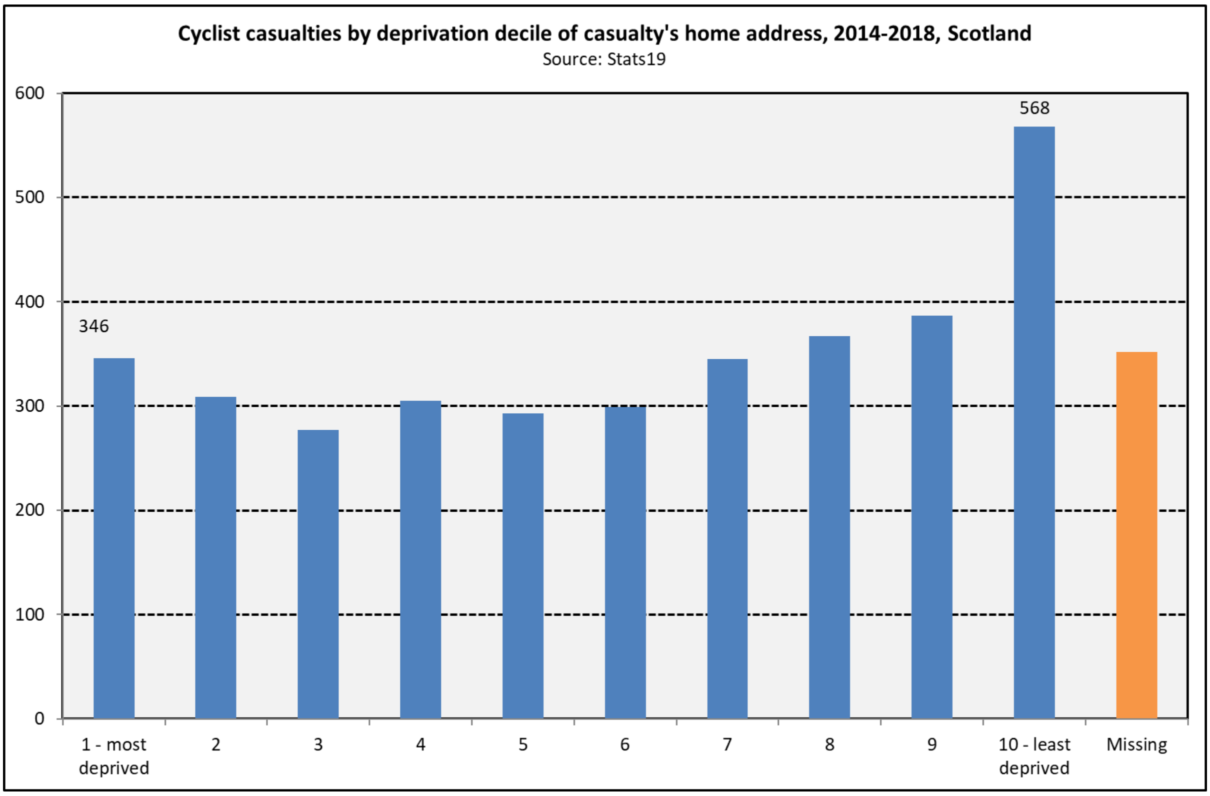
3.2.3 Deprivation of casualties

The Scottish Index of Multiple Deprivation (SIMD) was used to categorise the deprivation characteristics of cyclist casualties in the five-year period 2014-2018. The SIMD categorisation uses the casualty's home address, not the location of the accident, to determine the casualty's SIMD decile. Nine percent of casualty records from Stats19 could not be assigned a deprivation score, because the address data were incomplete[h]; the missing data are excluded from the following analyses.

[h] Some of the address data from Stats19 were incomplete due to home postcode of the casualty being missing, inaccurate, or incorrectly formatted.

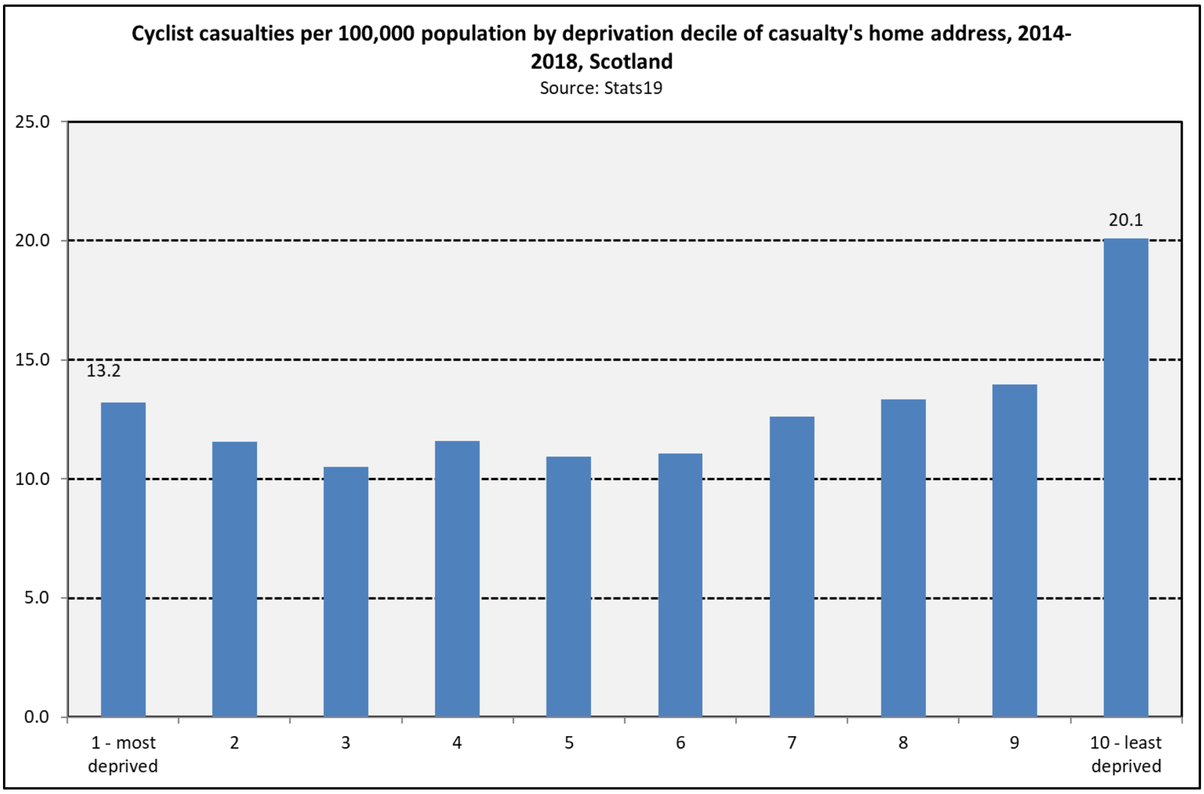
Figure 6 illustrates that in Scotland there was a relatively even distribution of cyclist casualties across most deprivation deciles, but with a clear peak in casualties in the least deprived decile (SIMD 10) and a second smaller peak in the most deprived decile (SIMD 1).

Figure 6: Cyclist casualties by deprivation decile of casualty's home address, 2014-2018, Scotland.



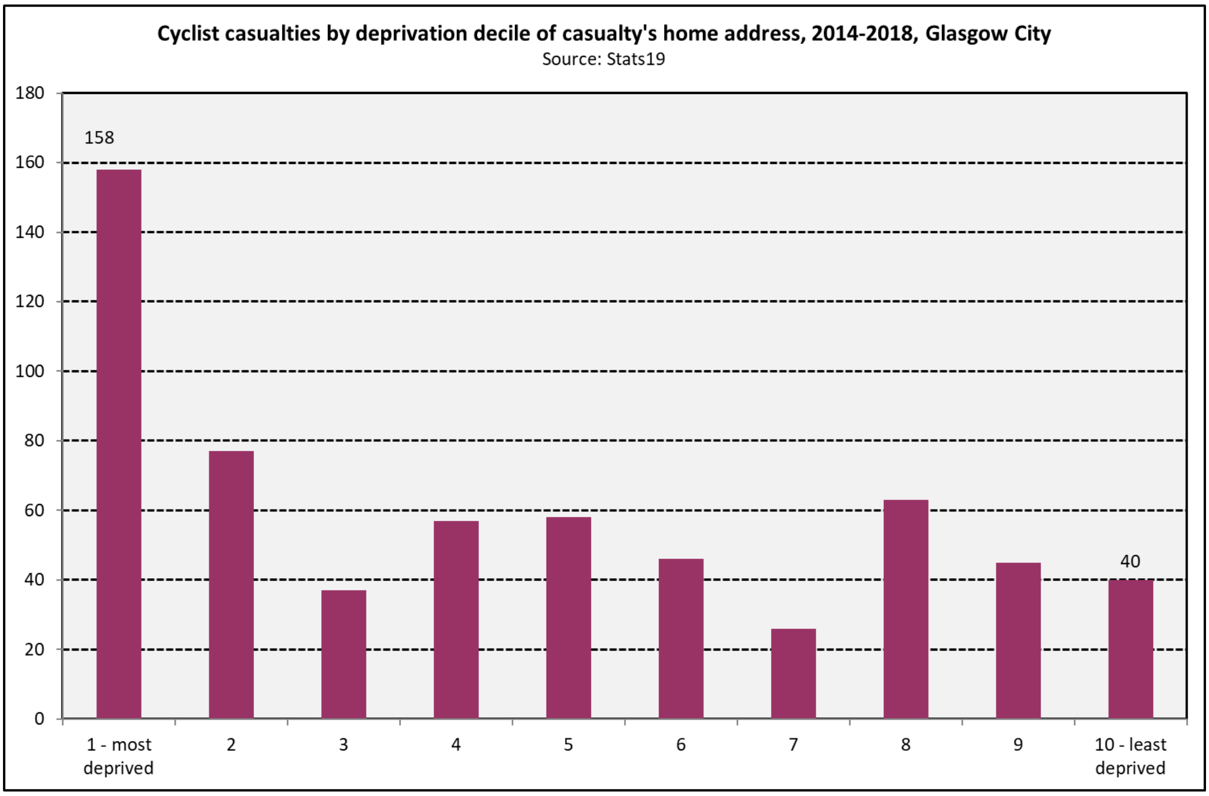
The casualty rate within each SIMD decile was then calculated as a rate per 100,000 of the population. Figure 7 illustrates that the highest casualty rate of 20.1 per 100,000 is in the least deprived decile (SIMD 10) and this rate is 40-90% *higher* than that observed in other deciles.

Figure 7: Cyclist casualties per 100,000 population by deprivation decile of casualty's home address, 2014-2018, Scotland.



Across Scotland's local authority areas, cyclist casualties were highest within Glasgow and Edinburgh. Figure 8 highlights that in Glasgow, the distribution of casualties was highest in the most deprived areas, but this is largely explained by the fact that one third of Glasgow's population live in the most deprived decile.

Figure 8: Cyclist casualties by deprivation decile of casualty's home address, 2014-2018, Glasgow City.



Presenting cyclist casualties in Glasgow as a casualty rate per 100,000 population showed that the highest rate of cyclist casualties was among those living in the least deprived decile (Figure 9).

Figure 9: Annual cyclist casualties per 100,000 population by deprivation decile of casualty's home address, 2014-2018, Glasgow.

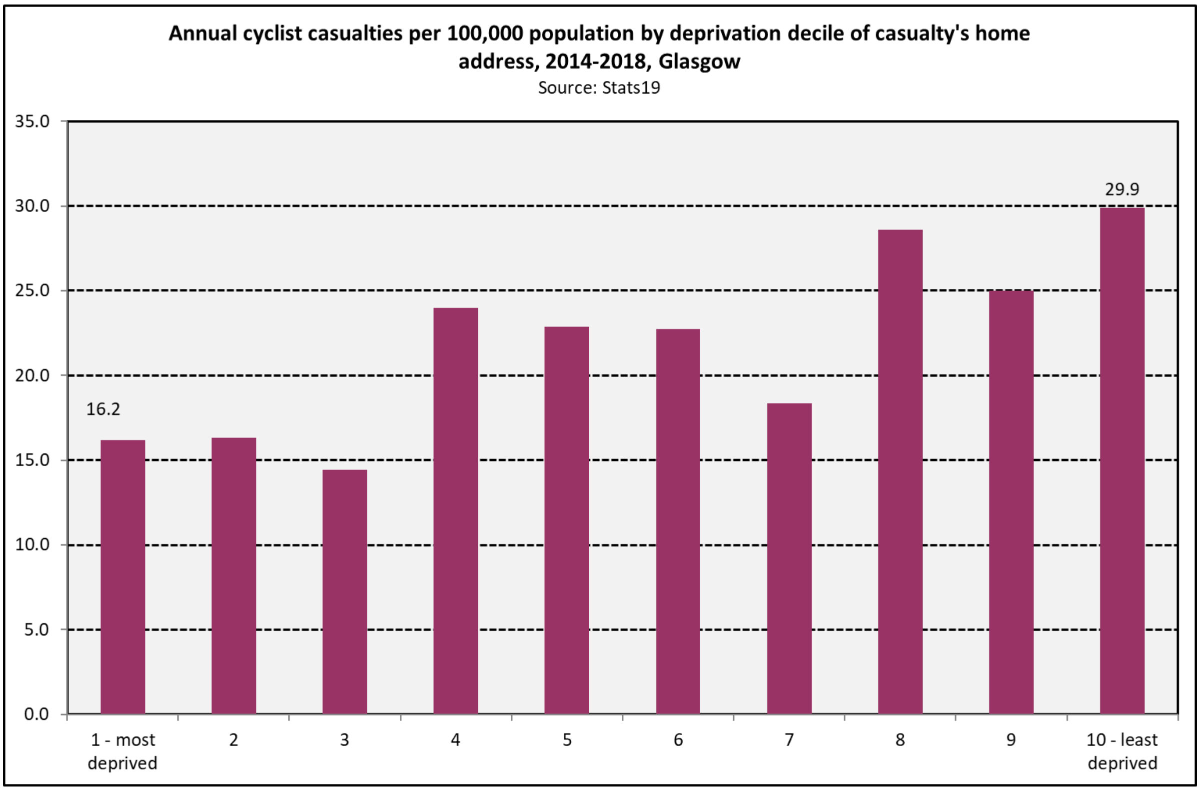
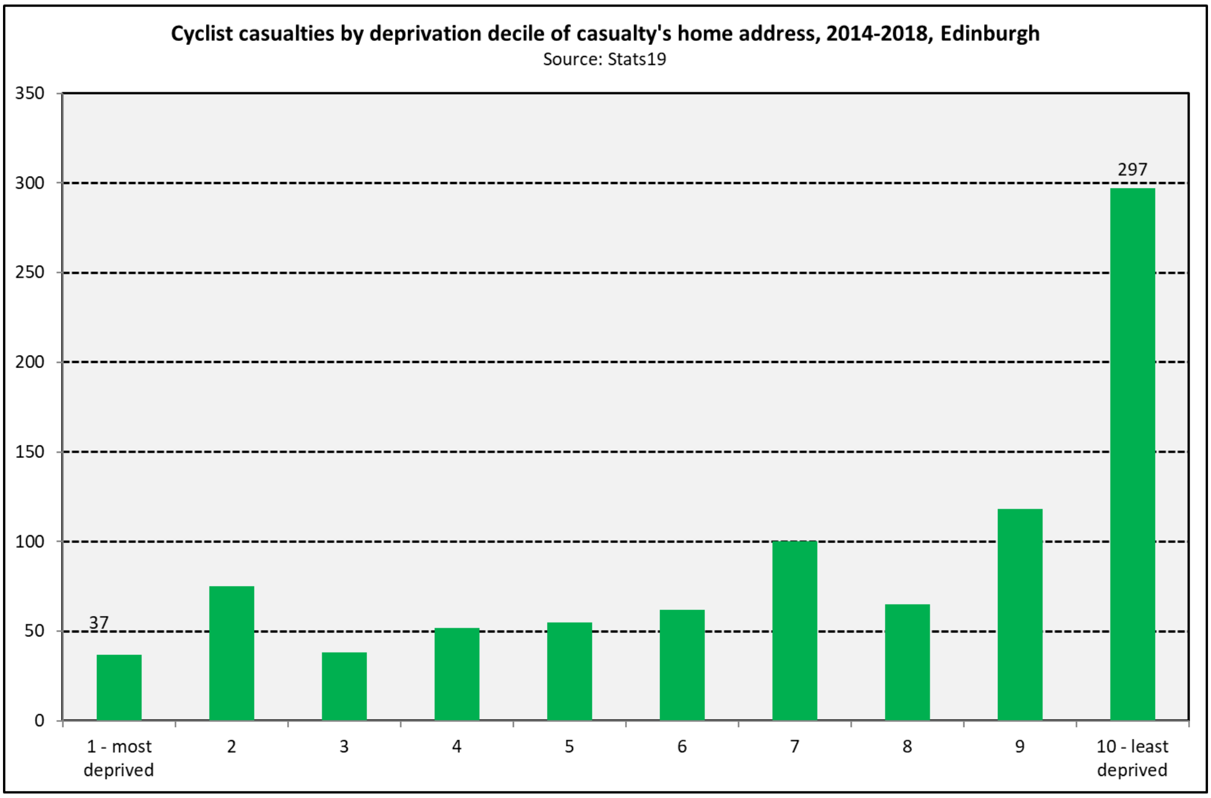


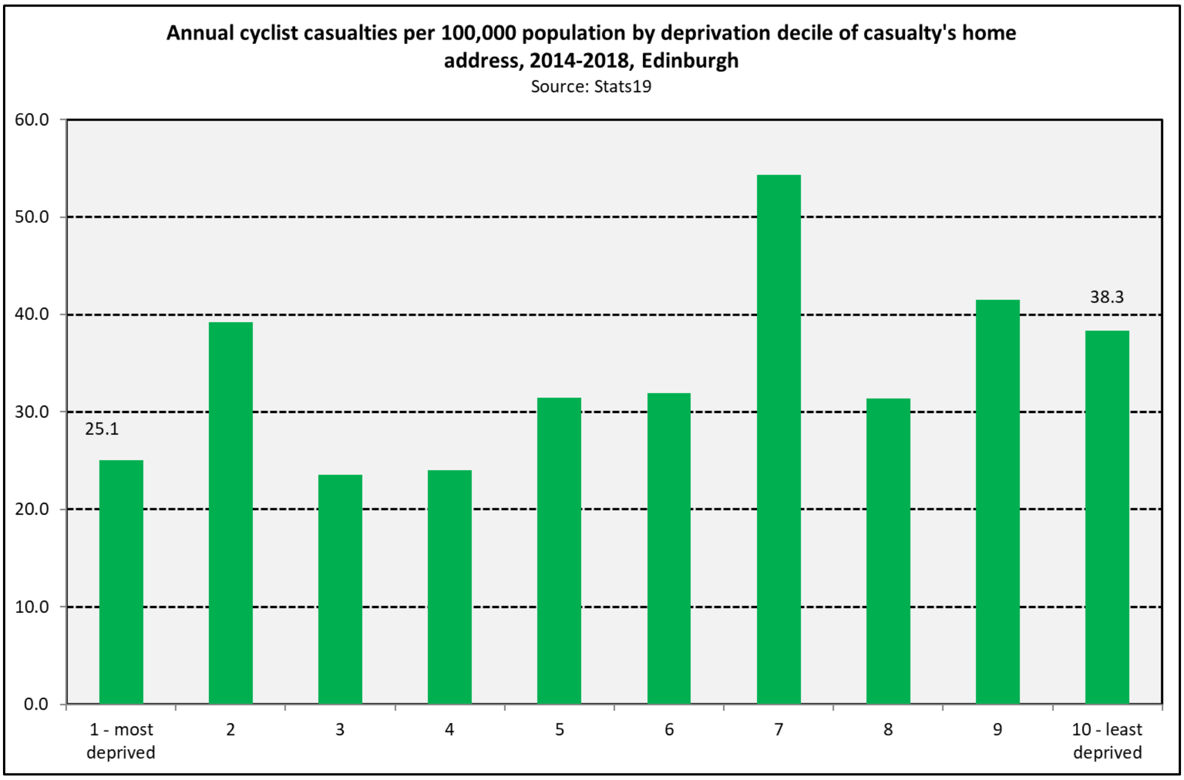
Figure 10 illustrates that cyclist casualties in Edinburgh were skewed in the opposite direction. There were more casualties from SIMD 10 (the least deprived decile) than in any other deprivation decile, reflecting that many people in Edinburgh live in areas which are defined as the least deprived on a national level.

Figure 10; Cyclist casualties by deprivation decile of casualty’s home address, 2014-2018, Edinburgh.



Presenting cyclist casualties in Edinburgh as a casualty rate per 100,000 population demonstrates that casualty rates do not relate strongly to deprivation, although the higher casualty rates tend, in general, to occur in the less deprived deciles (Figure 11).

Figure 11: Annual cyclist casualties per 100,000 population by deprivation decile of casualty's home address, 2014-2018, Edinburgh.

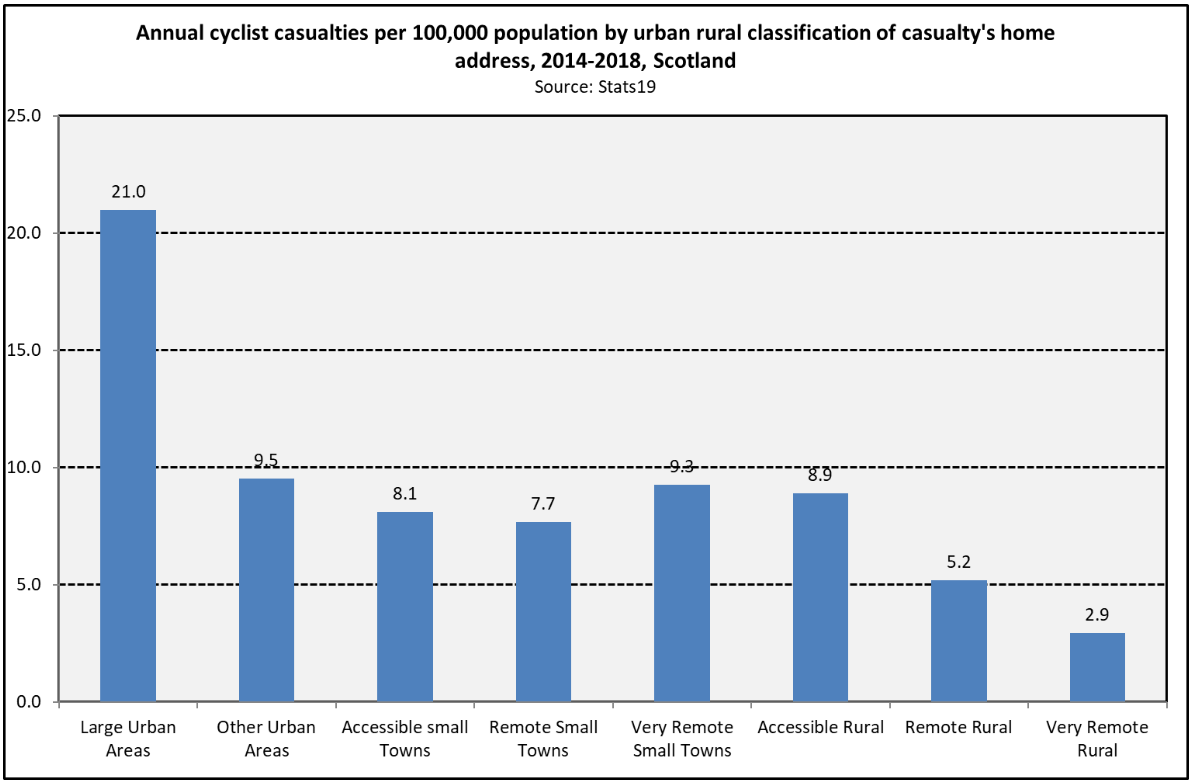


3.2.4 Urban/rural location of casualty's home

An urban/rural categorisation of each casualty's home address was used to analyse the background of cyclist casualties in the five-year period from 2014-2018. The same caveats that applied to deprivation mapping also apply here, in that the categorisation relates to where the casualty lives, not where the accident occurred, and 9% of casualty records could not be assigned an urban rural category.

Over half of all cyclist casualties in this period came from a large urban area. Converting the casualty counts to a rate per 100,000 population provides a population weighted distribution of casualties. Figure 12 demonstrates that the highest reported cyclist casualty rate was for individuals from large urban areas, and the lowest casualty rates were for casualties from remote and rural areas.

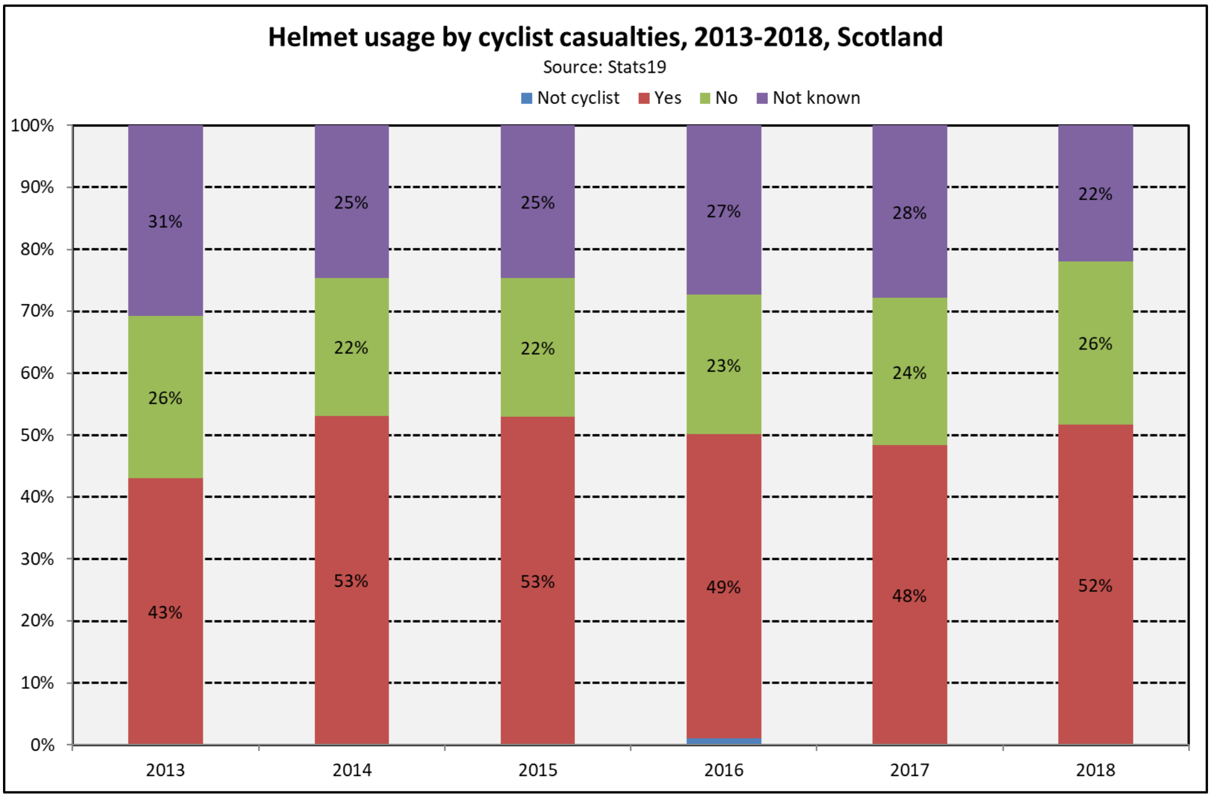
Figure 12: Annual cyclist casualties per 100,000 population by urban rural classification of casualty's home address, 2014-2018, Scotland.



3.2.5 Trends in helmet usage

Helmet use among cyclist casualties was not consistently recorded on Stats19 until 2013. Since then, one fifth of cycling casualty records did not record whether a helmet was worn at the time of the accident. In 2018, 52% of cyclist casualties were recorded as wearing a helmet; 26% were recorded as not wearing a helmet; and for 22% of casualties it was not known whether they were wearing a helmet or not (Figure 13[i]).

Figure 13: Helmet usage by cyclist casualties, 2013-2018, Scotland.

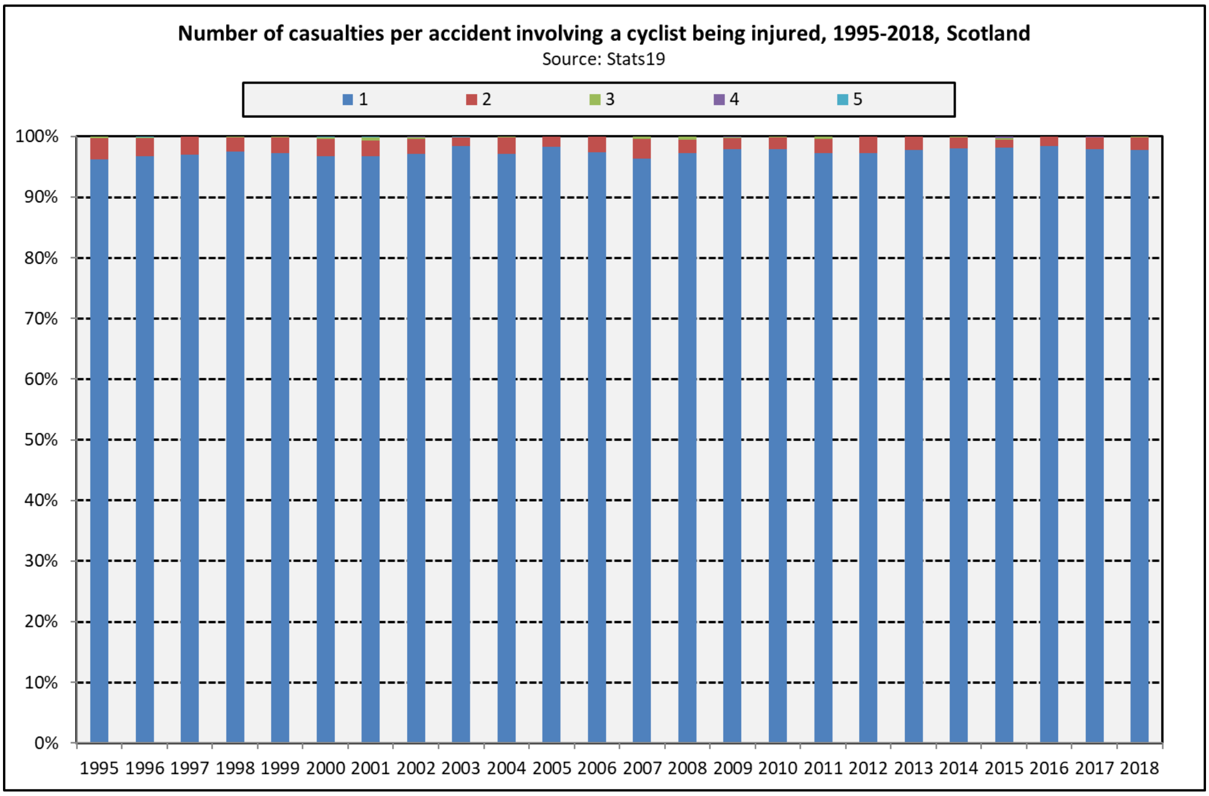


[i] A small number of cyclist casualties were recorded as not being a cyclist in 2016 (n=8). This is likely to be due to a coding mistake.

3.2.6 Accident context

Figure 14 illustrates that across the period examined (1995-2018) in 97% of cyclist casualties only one cyclist casualty was involved, while 3% of incidents involved two or more casualties.

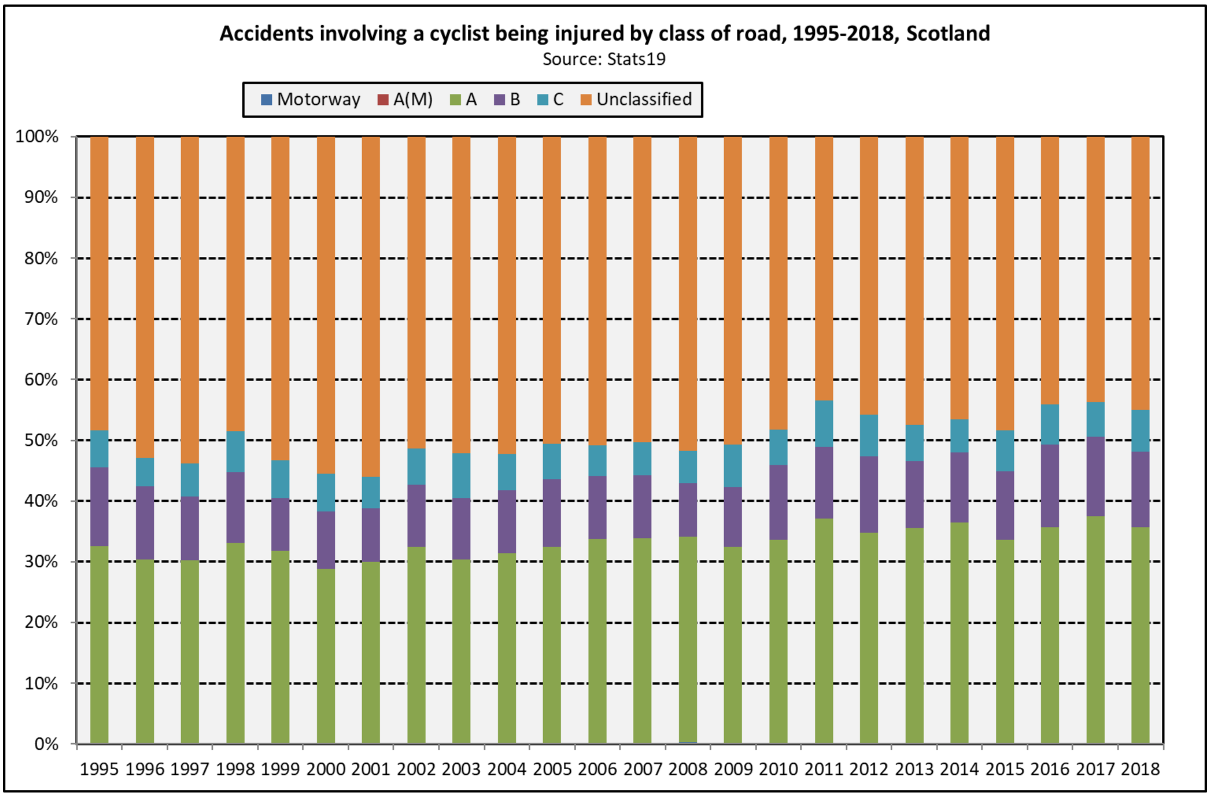
Figure 14: Number of casualties per accident involving a cyclist being injured, 1995-2018, Scotland.



Class of road

Figure 15[j] highlights that over half of all cyclist casualties occurred on unclassified roads and one third occurred on A-roads. The proportion of such accidents occurring on different classes of road did not change substantially over time.

Figure 15: Accidents involving a cyclist being injured by class of road, 1995-2018, Scotland.

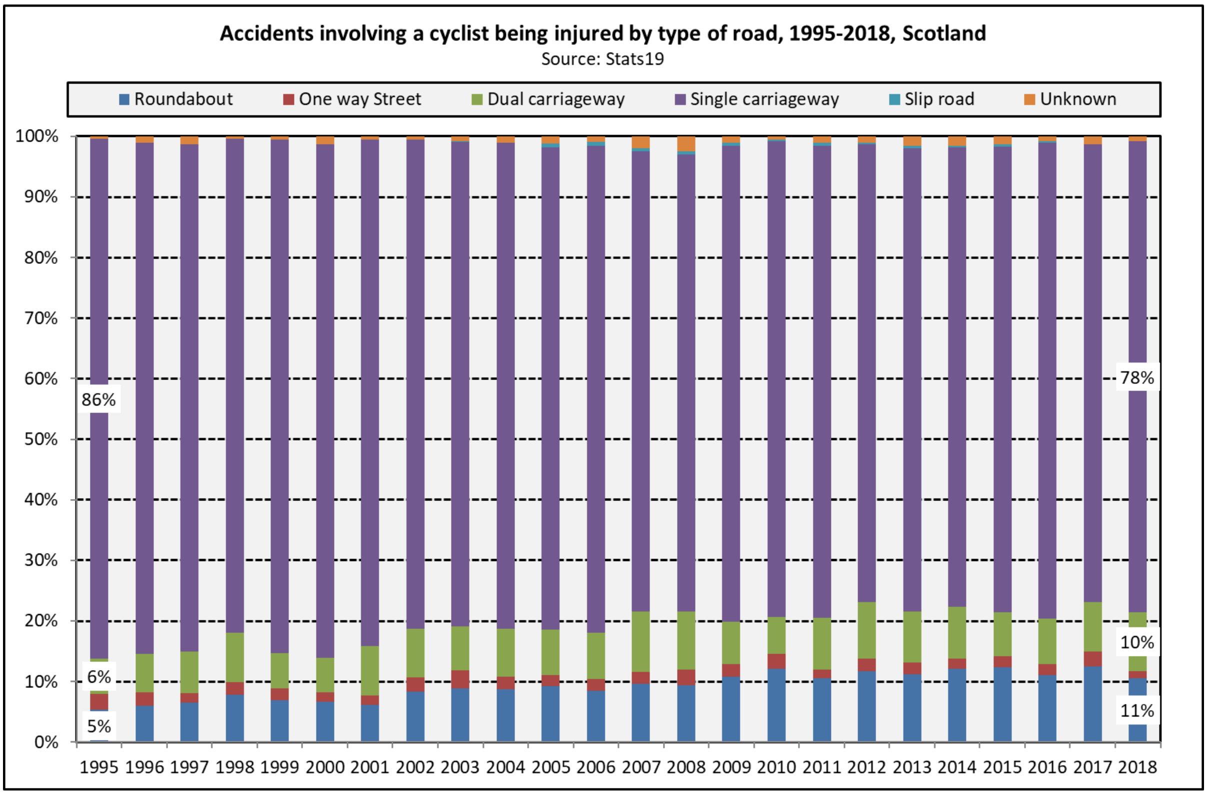


[j] A very small number of accidents involving a cyclist casualty are recorded as occurring on Motorways (N=8, 1995-2018). These may reflect true incidents or may possibly be the result of miscoding.

Type of road

Figure 16 highlights that during the time period examined, most cyclist casualties occurred on single carriageways. The proportion of accidents occurring on dual carriageways and on roundabouts increased over time. In 2018, 10% of cyclist casualties occurred on a dual carriageway compared with 6% in 1995, while 11% occurred on a roundabout in 2018 compared with 5% in 1995. In both cases, the number of accidents has fallen slightly but because of the overall decrease in reported cyclist injury accidents the proportion of all cyclist injury accidents occurring on roundabouts and dual carriageways has increased.

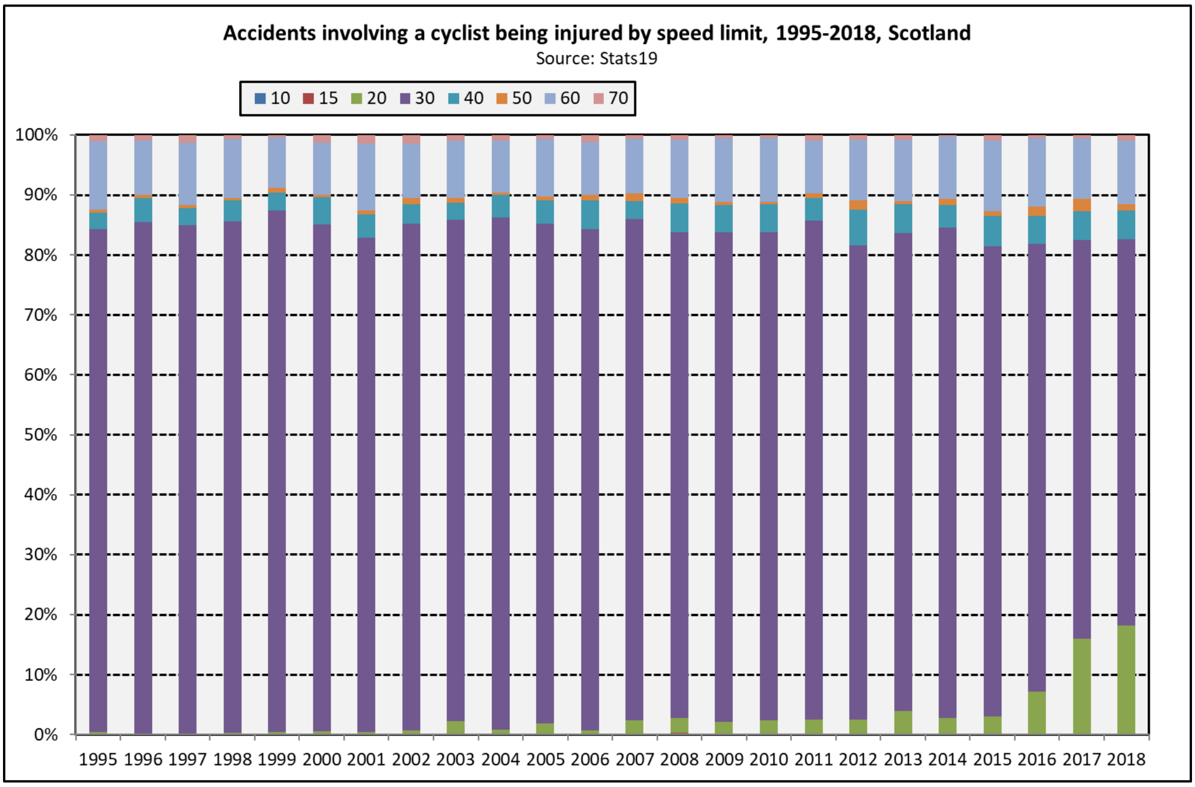
Figure 16: Accidents involving a cyclist being injured by type of road, 1995-2018, Scotland.



Speed limit

Figure 17 illustrates that 65% of all cyclist casualties in 2018 occurred on roads with a 30mph speed limit. Accidents on roads with a 20mph speed limit increased over time to 18% in 2018. It is worth bearing in mind this was over a period when the number of roads designated as 20mph limit increased substantially.

Figure 17: Accidents involving a cyclist being injured by speed limit, 1995-2018, Scotland.

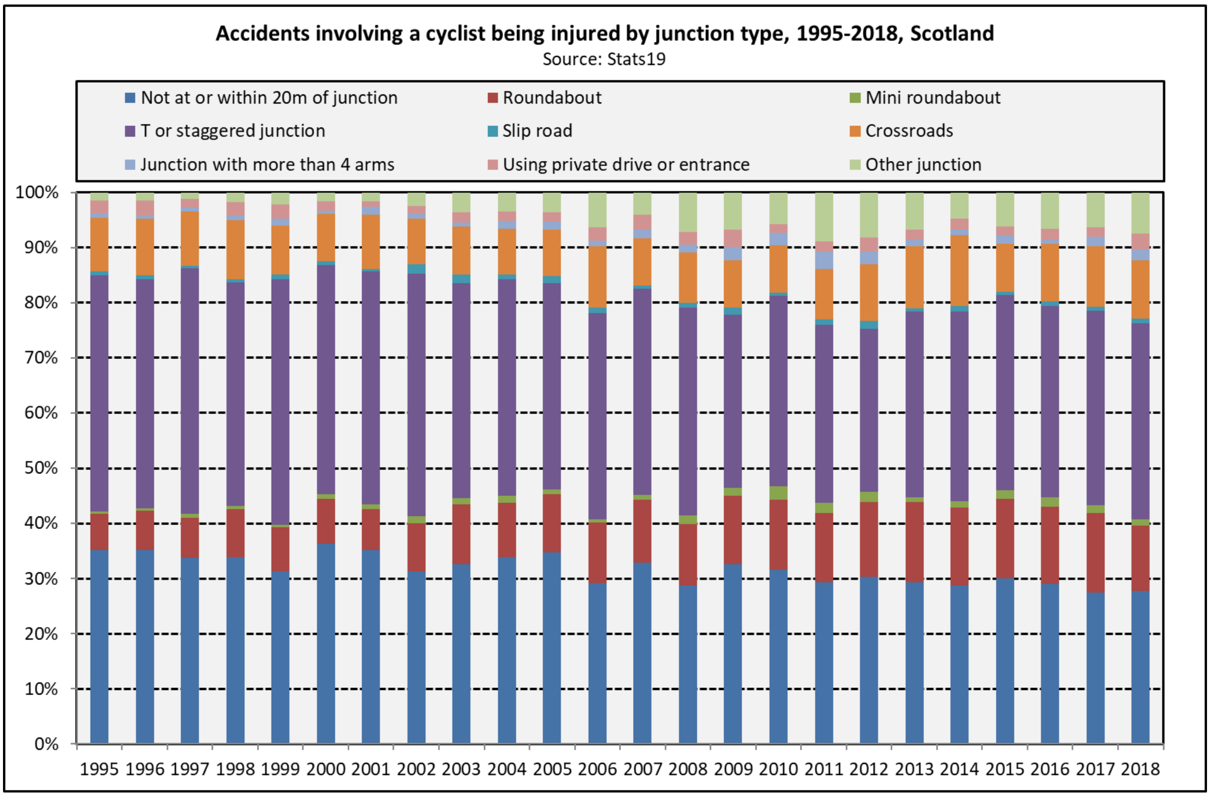


Junction type

Figure 18 illustrates that trends in cyclist casualties at different types of junctions[k] have changed over the time period examined with two emerging patterns.

Firstly, accidents which do not occur at junctions are still a significant minority but have reduced proportionately between 1995-2018 from 35% to 28%. Likewise, accidents at T-junctions or staggered junctions have reduced from 43% to 36% in the same time period. Secondly, over the same time period it is notable that accidents at roundabouts accounted for a greater proportion of accidents in 2018 (12%) as did accidents at 'other' junctions (7%).

Figure 18: Accidents involving a cyclist being injured by junction type, 1995-2018, Scotland.

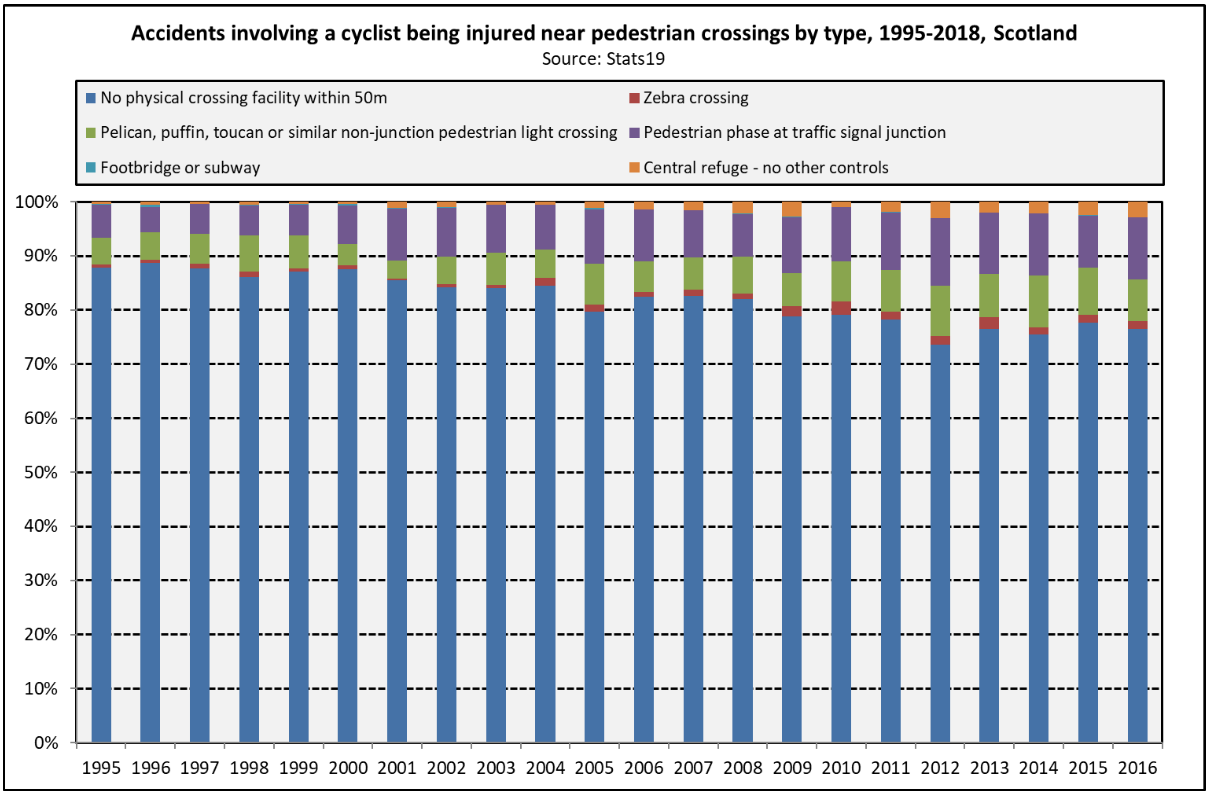


[k] These analyses of junction types associated with cyclist accidents are similar to the analyses shown in Section 4.2 of KSI casualties, but here there is a broader focus on cyclist casualties of all severities.

Accidents near pedestrian crossings by type

Figure 19 highlights that 76% of cyclist casualties in 2018 occurred away from pedestrian crossings. Over the period 1995-2018 there was an increase from 12% to 23% in the proportion of casualties which occurred close to, or at a pedestrian crossing.

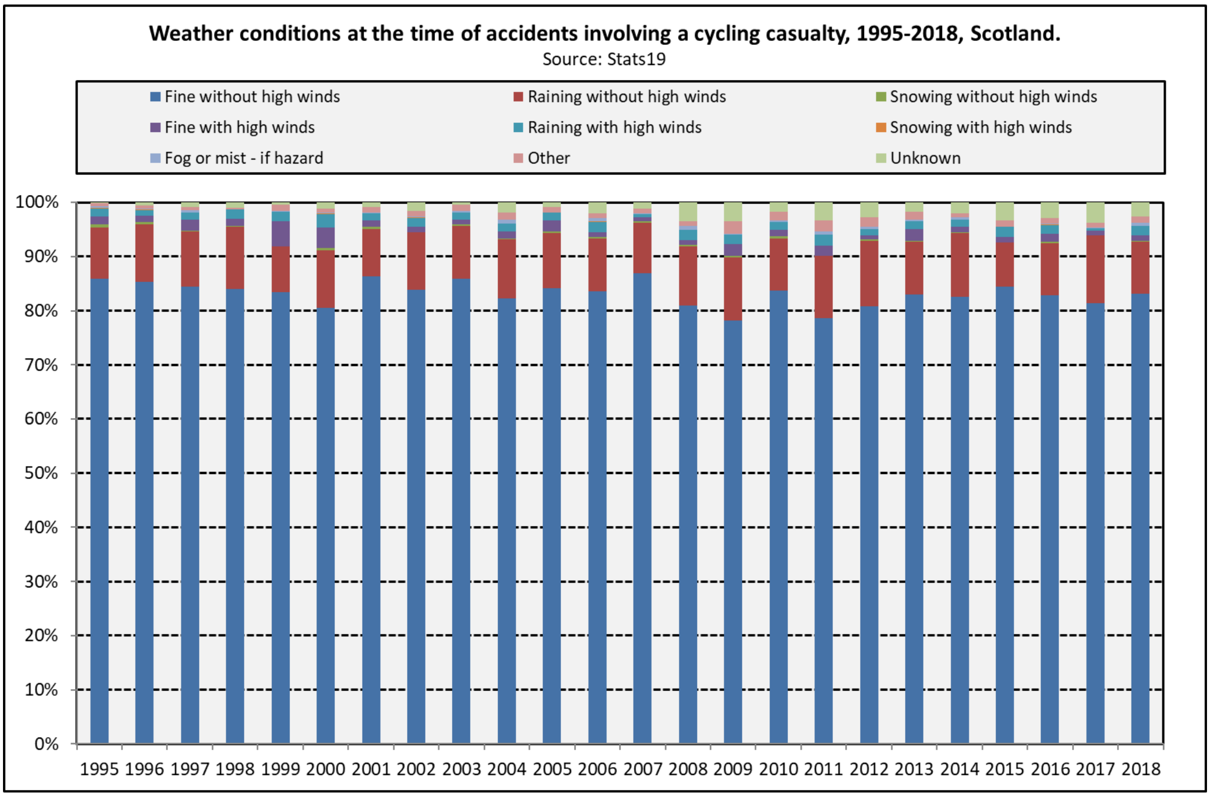
Figure 19: Accidents involving a cyclist being injured near pedestrian crossings by type, 1995-2018, Scotland.



Weather, road, and light conditions

Figure 20 highlights that in the period 1995-2018, 83% of cyclist casualties occurred in calm weather conditions. A further 10% occurred in rainy conditions without high winds. The road surface conditions (data not shown) at the time of the cyclist casualties reflected the predominant weather condition of the day. The data shows that for 75% of incidents involving a cyclist casualty, the road surface was dry, and in 24% of cases the road surface was wet.

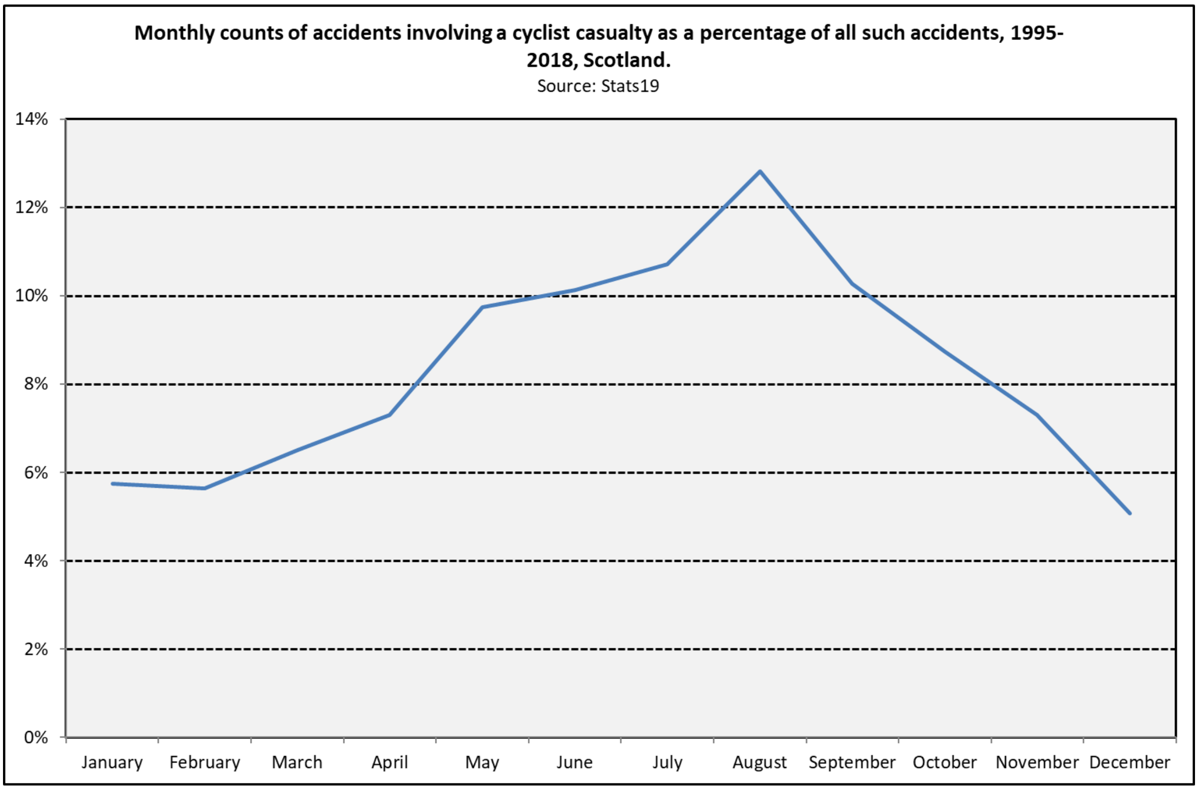
Figure 20: Weather conditions at the time of accidents involving a cycling casualty, 1995-2018, Scotland.



Time of year, day and time, of accidents

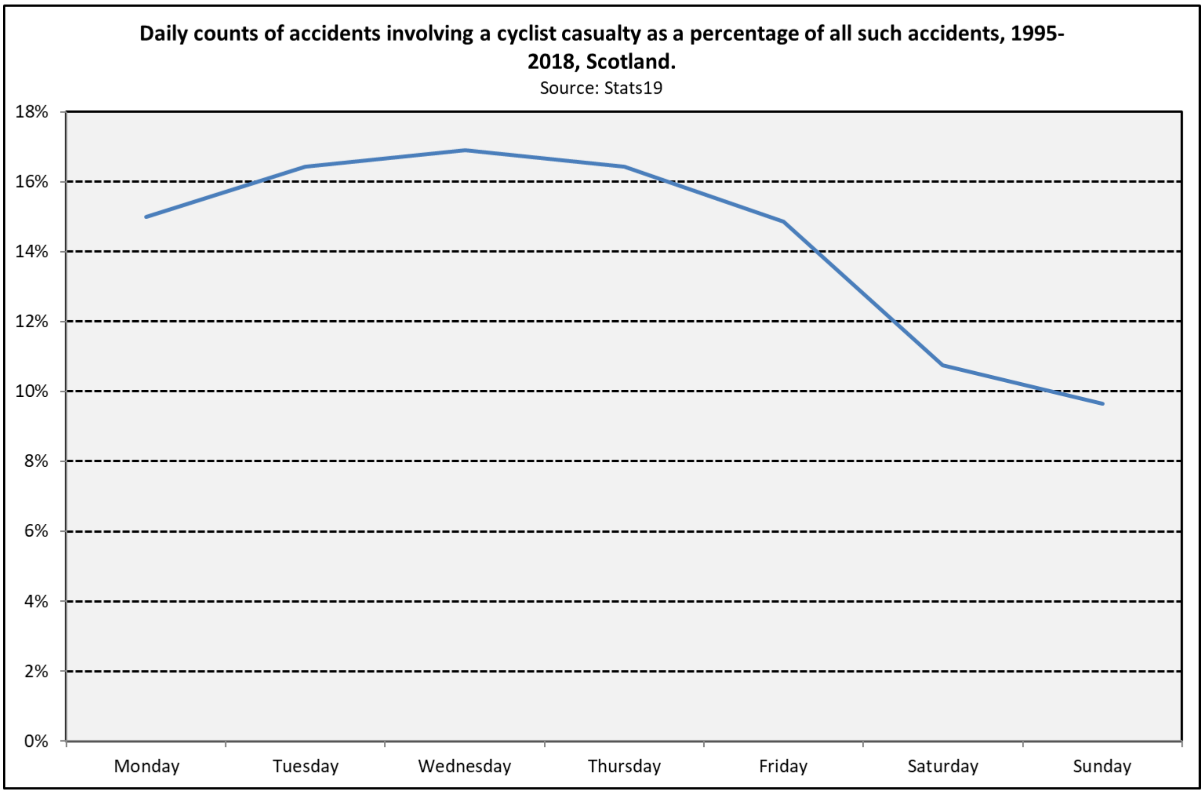
Figure 21 illustrates that in the period 1995-2018 cyclist casualties peaked in the month of August (13%), while casualties which occurred in each of the winter months (December to February) accounted for less than 6% of the annual total. This is likely to reflect the fact that fewer people cycle over the winter period.

Figure 21: Monthly counts of accidents involving a cyclist casualty as a percentage of all such accidents, 1995-2018, Scotland.



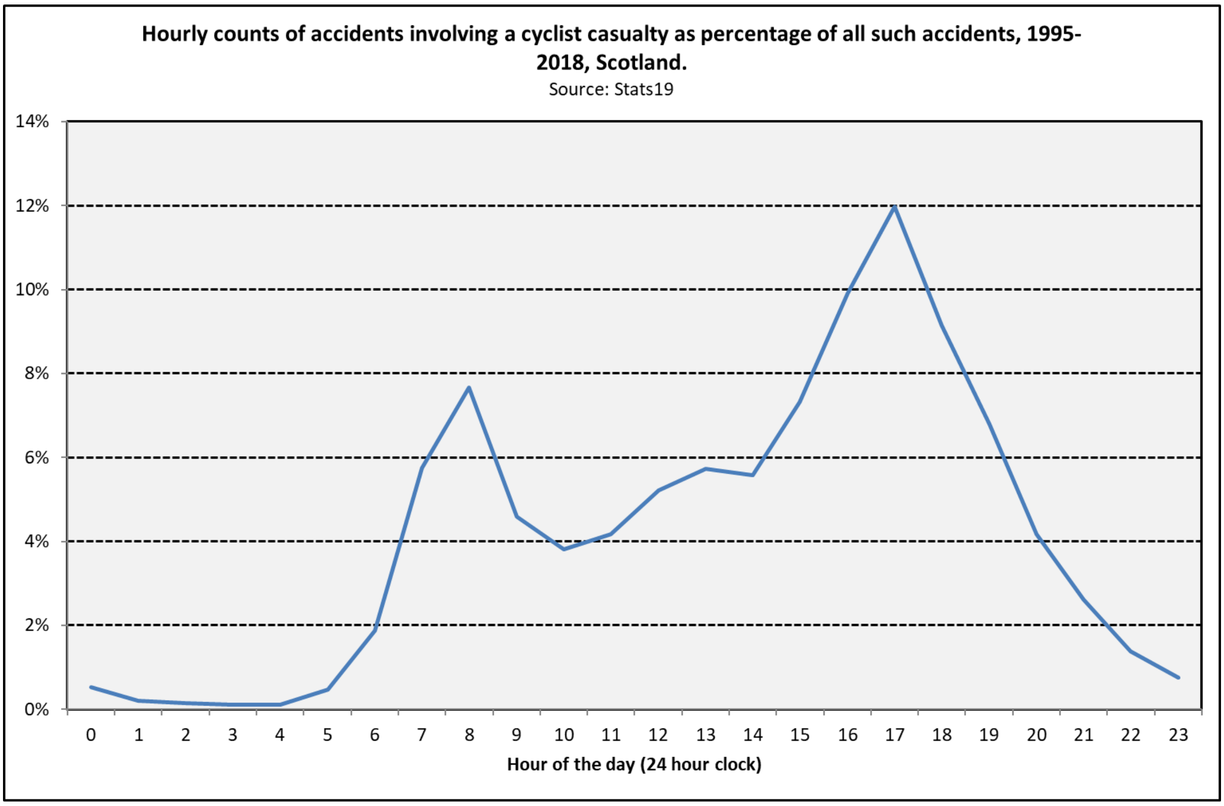
In the time period examined there were more cyclist casualties on weekdays than at the weekend. Figure 22 illustrates that the peak day of the week for casualties was a Wednesday (17% of all casualties) and the lowest proportion of casualties occurred on a Sunday (10%).

Figure 22: Daily counts of accidents involving a cyclist casualty as a percentage of all such accidents, 1995-2018, Scotland.



The pattern of casualties occurring by time of day reflects the commuting times when more people are likely to be cycling. Figure 23 highlights that the peak time for cyclist casualties in the period 1995-2018 was between 7-10am (accounting for 21% of such casualties) and a larger peak between 3-7pm (accounting for 34% of such casualties). In contrast, only 1% of cyclist casualties occurred overnight between 12am-6am.

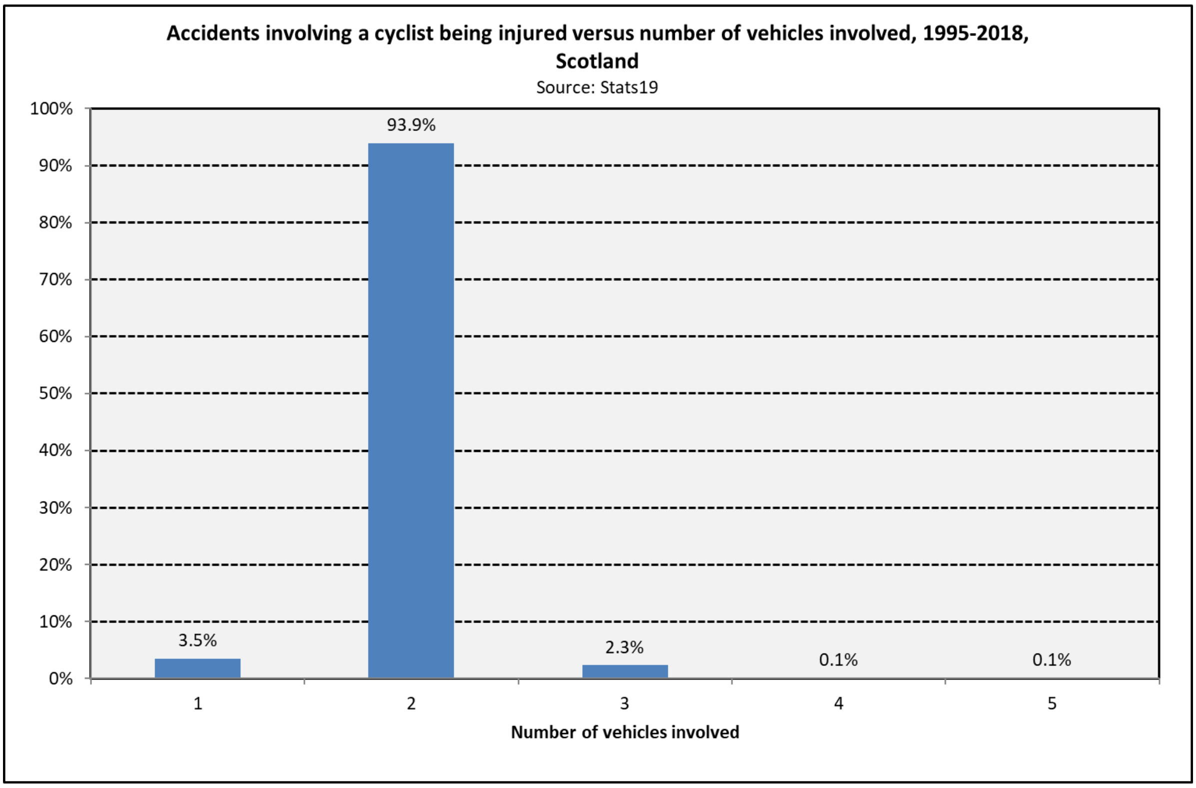
Figure 23: Hourly counts of accidents involving a cyclist casualty as percentage of all such accidents, 1995-2018, Scotland.



3.2.7 Vehicles involved

In the 23-year period from 1995-2018 there were 21,309 reported cyclist casualties. Figure 24 highlights that in 94% of incidents involving cyclist casualties, one other vehicle was involved; 2.5% of incidents involved three or more vehicles; and in 3.5% of incidents involving casualties, no other vehicle was involved.

Figure 24: Accidents involving a cyclist casualty versus the number of vehicles involved, 1995-2018, Scotland.



The number of vehicles involved in incidents resulting in cyclist casualties is almost double the number of cyclists injured. As the number of such incidents has reduced over time so has the number of vehicles involved. Figure 25 illustrates that in 1995 there were 2,548 vehicles involved in cyclist casualties, and approximately half of these vehicles were bicycles. In 2018 the overall figure of vehicles involved in cyclist casualties had dropped to 1,262 vehicles.

Figure 25: Casualties and vehicles in accidents involving a cyclist being injured, 1995-2019, Scotland.

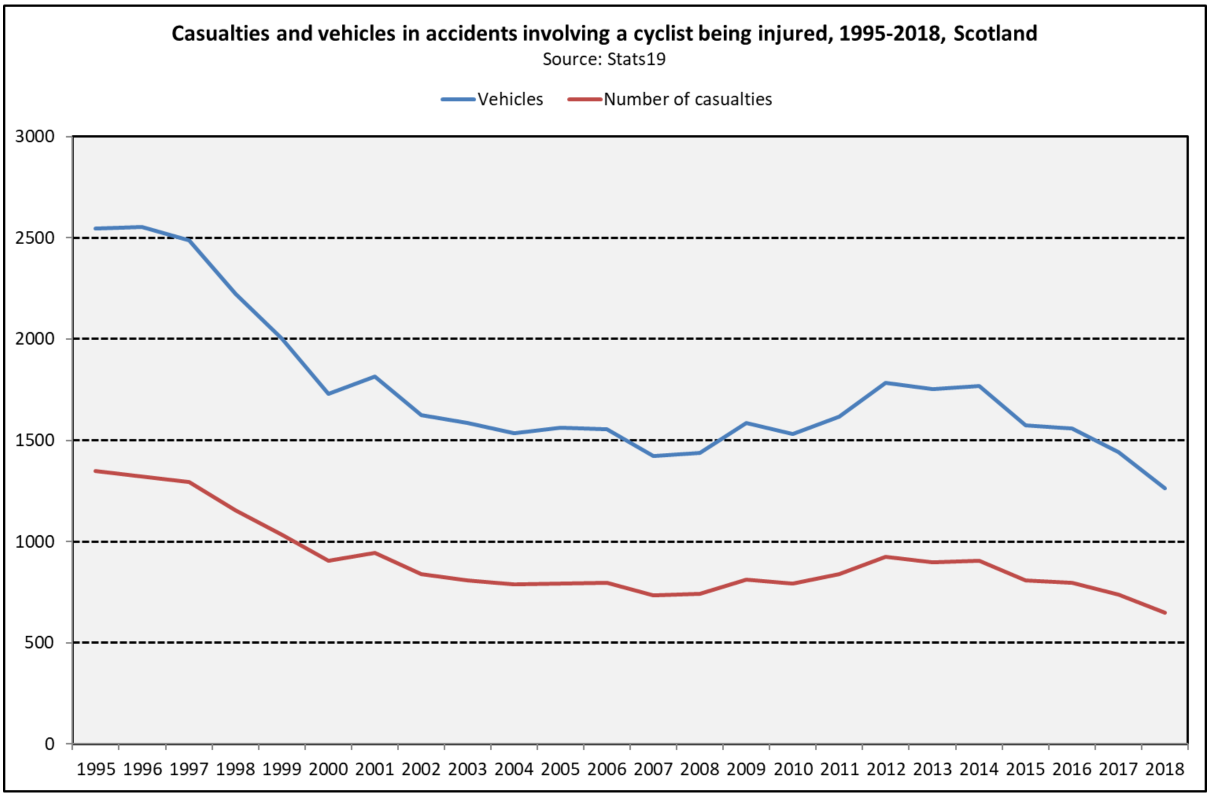
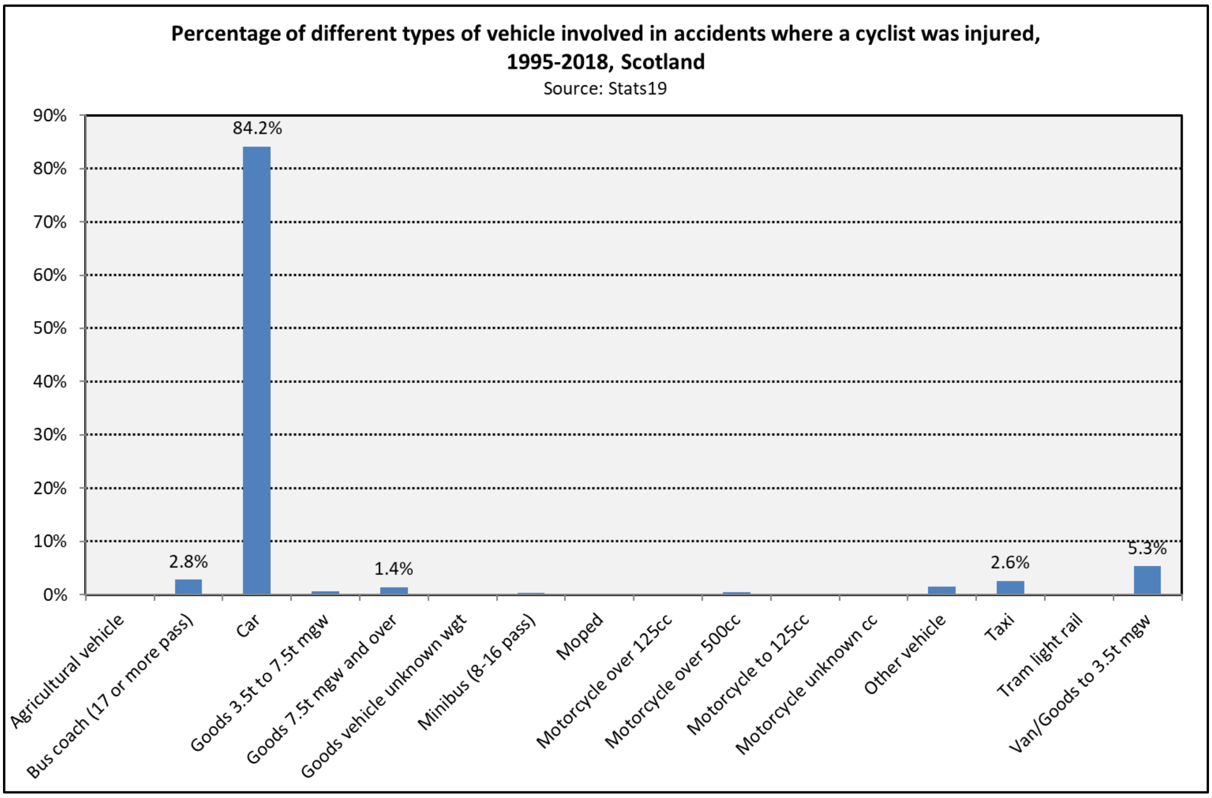


Figure 26 shows that in the time period 1995-2018 cars represented the majority (84%) of motor vehicles involved in a cyclist casualty. Vans or goods vehicles represented 7% of vehicles involved, buses and mini-buses represented 3%, and taxis represented less than 3% of vehicles involved.

Figure 26: Percentage of different types of vehicle involved in accidents where a cyclist was injured, 1995-2018, Scotland.



Given the predominance of cars involved in collisions with cyclists it is useful to examine the circumstances of such incidents in further detail. In the time period examined the proportion of cyclist casualties involving several specific vehicle manoeuvres has increased.

Figure 27 highlights that cyclist casualties where a car was turning right has increased as a proportion of all manoeuvres from 15.3% in 1995 to 25.6% in 2018. The proportion of casualties where a vehicle was making a left turn has increased from 7.9% in 1995 to 13.8% in 2018. While cyclist casualties where a car is moving off has increased from 1% in 1995 to 9.2% in 2018. Cyclist casualties involving a car driving straight ahead (i.e. not making a left or right turn) still accounts for one quarter of all cases, but this has reduced by half over the time period.

Figure 27: Types of manoeuvre by cars involved in accidents where a cyclist was injured, 1995-2018, Scotland.

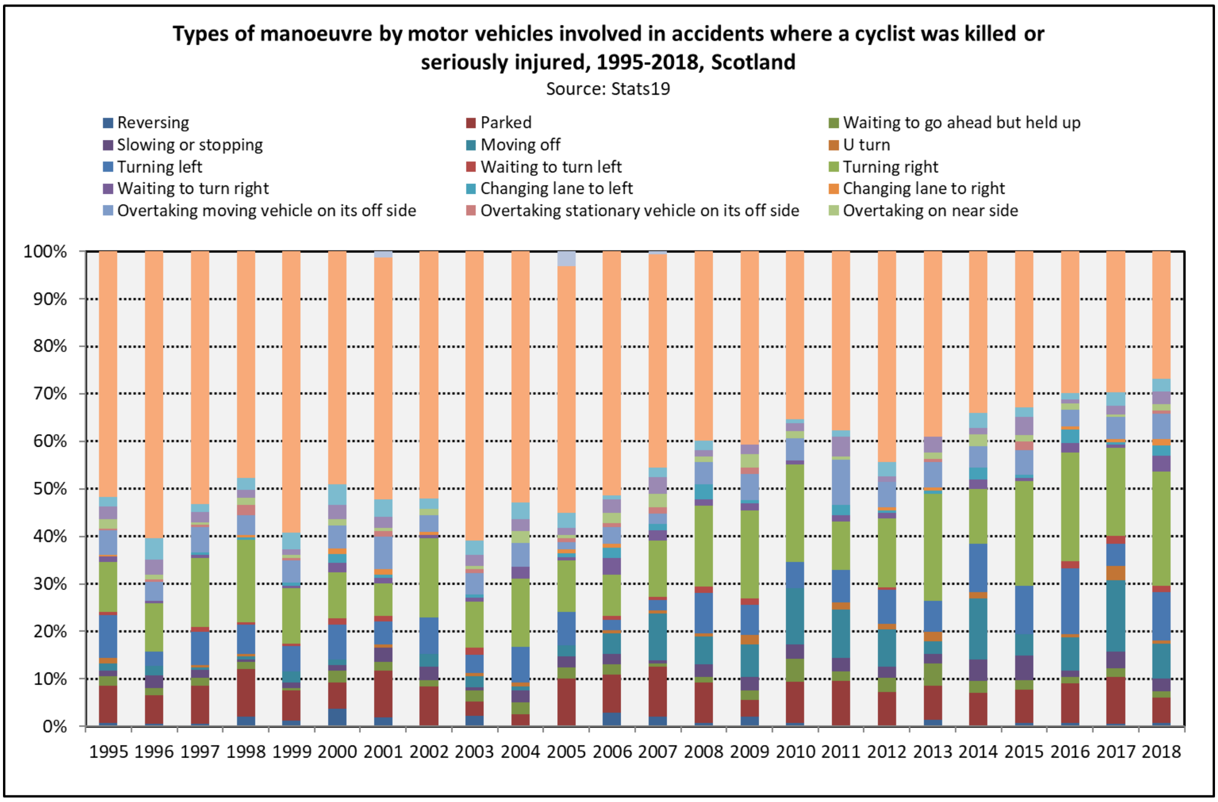


Figure 28 illustrates that in 2018, 25% of cyclist casualties involving a car and a bicycle occurred away from junctions. Incidents involving a cyclist casualty where a car was approaching a junction or waiting at a junction approach increased proportionately, accounting for 13% of all cyclist casualties in 1995 and rising to 26% of such casualties in 2018.

In 2018, 24% of incidents involving a car and a bicycle which resulted in a casualty occurred mid-junction: this represents a reduction proportionately over time. A small proportion (8%) of incidents involving a car and a bicycle which resulted in a casualty occurred when a car was entering a roundabout.

Figure 28: Junction location of accident: cars involved in accidents where a cyclist was injured, 1995-2018, Scotland.

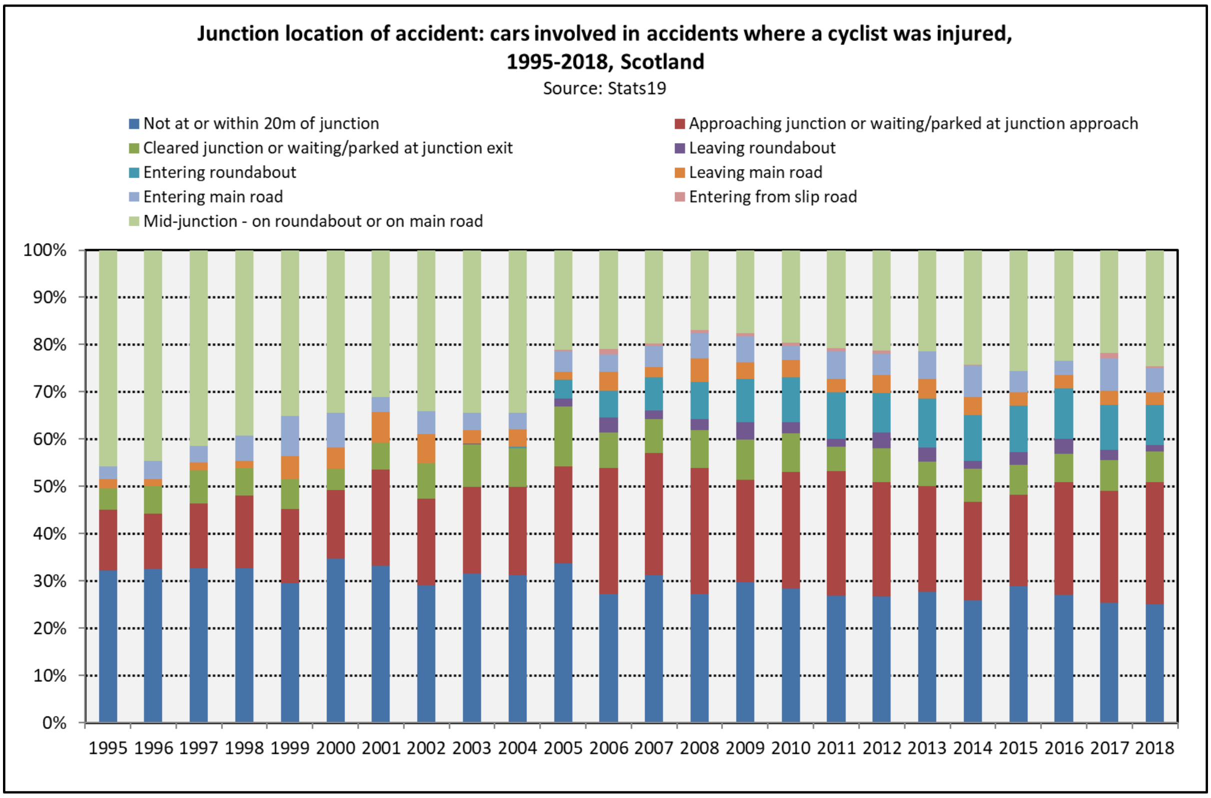
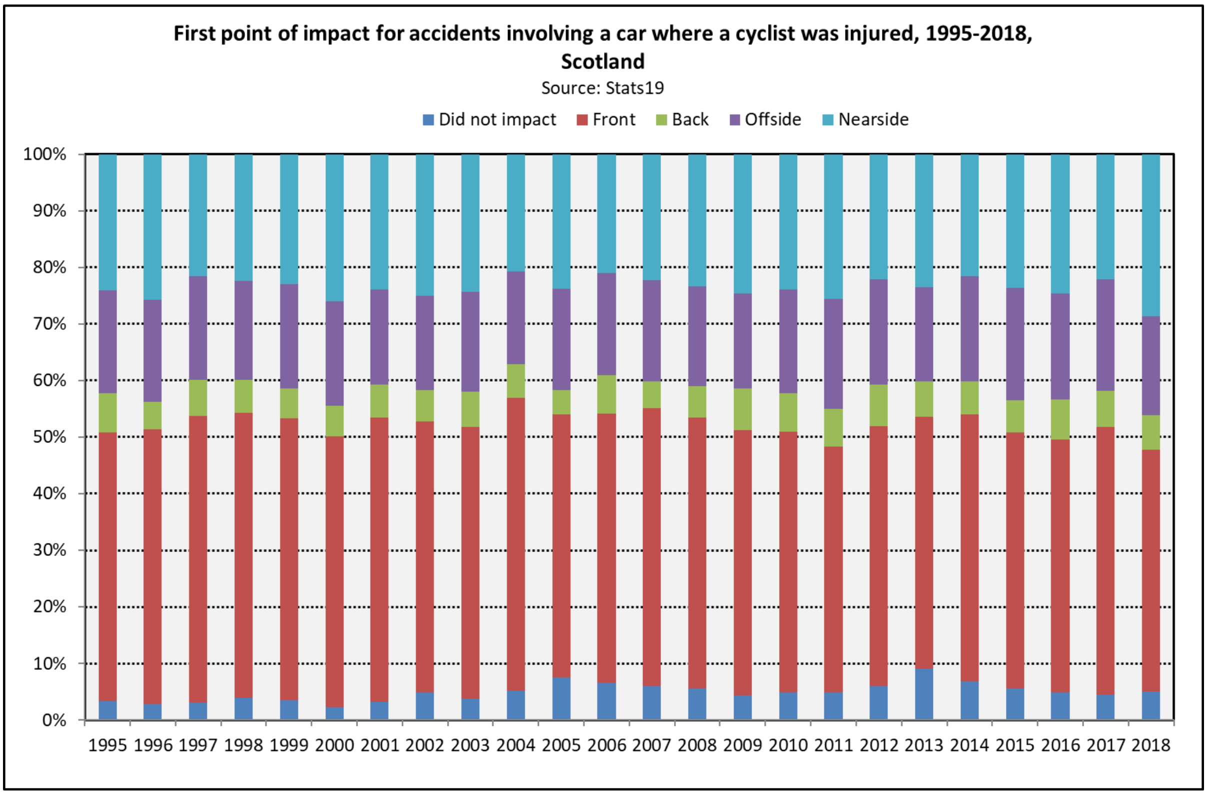


Figure 29 illustrates that in 2018, in 43% of incidents the front of the car was the first point of contact. While collisions on the nearside of a car occurred in 29% of accidents where a cyclist was injured.

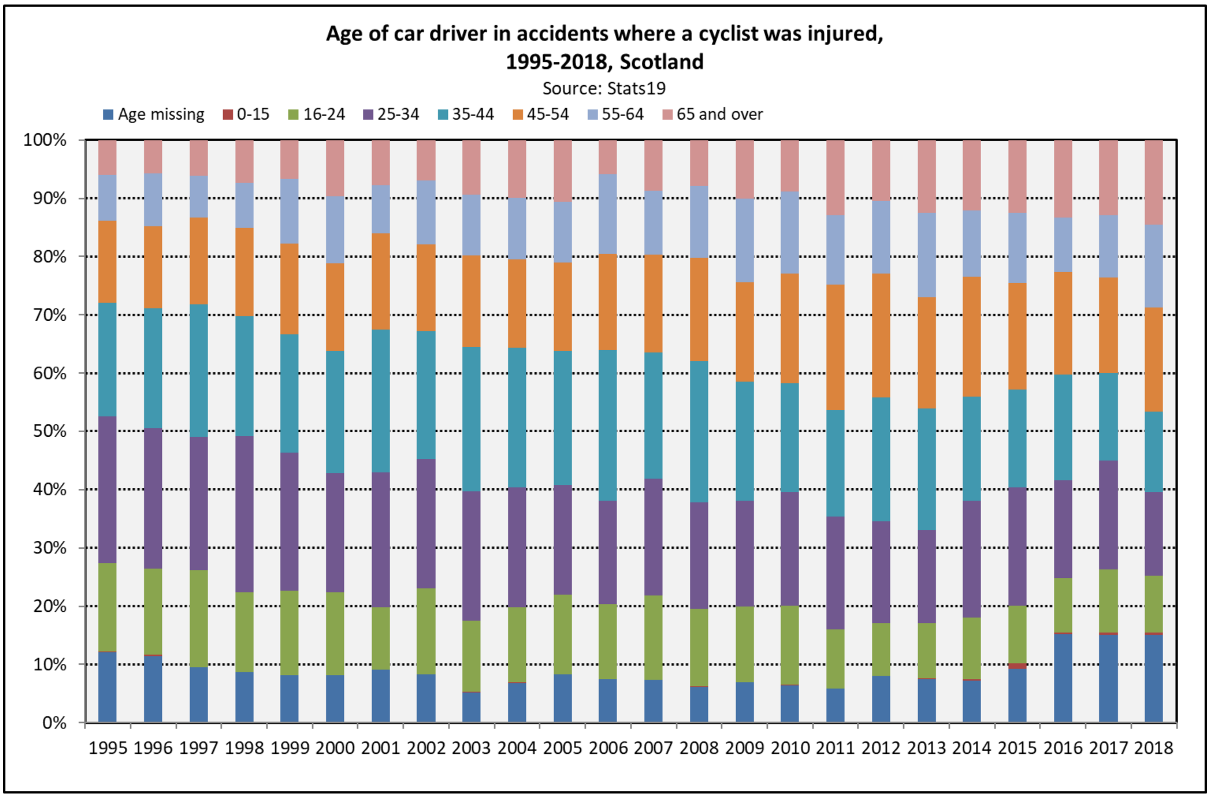
Figure 29: First point of impact for accidents involving a car where a cyclist was injured, 1995-2018, Scotland.



3.2.8 Age of car drivers involved in collisions with cyclists

The age profile of car drivers in incidents involving a car and a bicycle which resulted in a casualty has increased over the time period examined. Figure 30 highlights that in 1995, 28% of car drivers involved in incidents were aged 45+ years and this proportion had increased to 47% in 2018.

Figure 30: Age of car driver in accidents where a cyclist was injured, 1995-2018, Scotland.

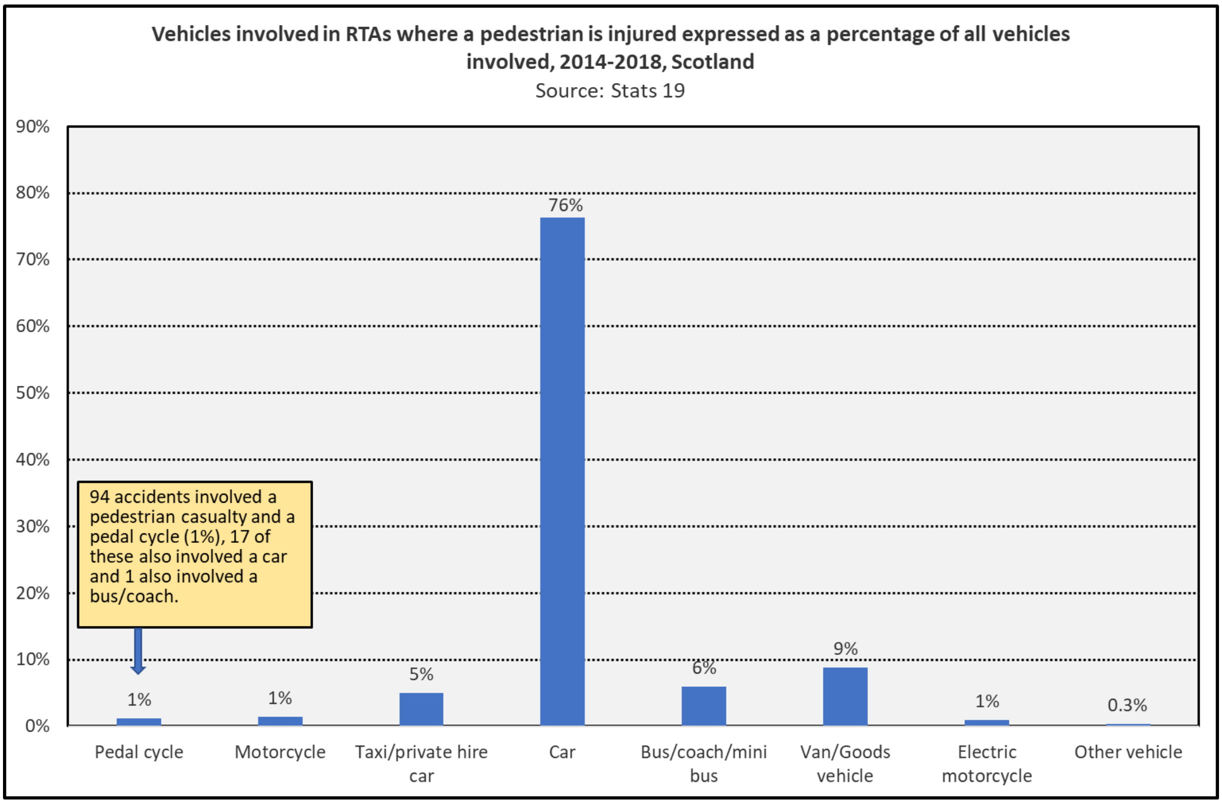


3.2.9 Pedestrian casualty accidents where a cyclist is involved

In the five-year period from 2014-2018 there were 7,713 pedestrian road casualties with 7,911 vehicles involved. Figure 31 illustrates that 76% of vehicles involved in these incidents were cars, 9% were vans or goods vehicles, 6% were buses of coaches and only 1% (n=94) were bicycles. Of the 94 incidents involving a pedestrian casualty and a pedal cycle, 17 also involved a motor vehicle and one involved a bus/coach.

Among pedestrian casualties resulting from all types of accident, 3% were fatalities, 26% were serious injuries, and 72% were slight injuries. In comparison, in accidents involving a pedestrian casualty following a collision with a pedal cycle, there were no fatalities, 26% were seriously injured and 74% of casualties were slightly injured.

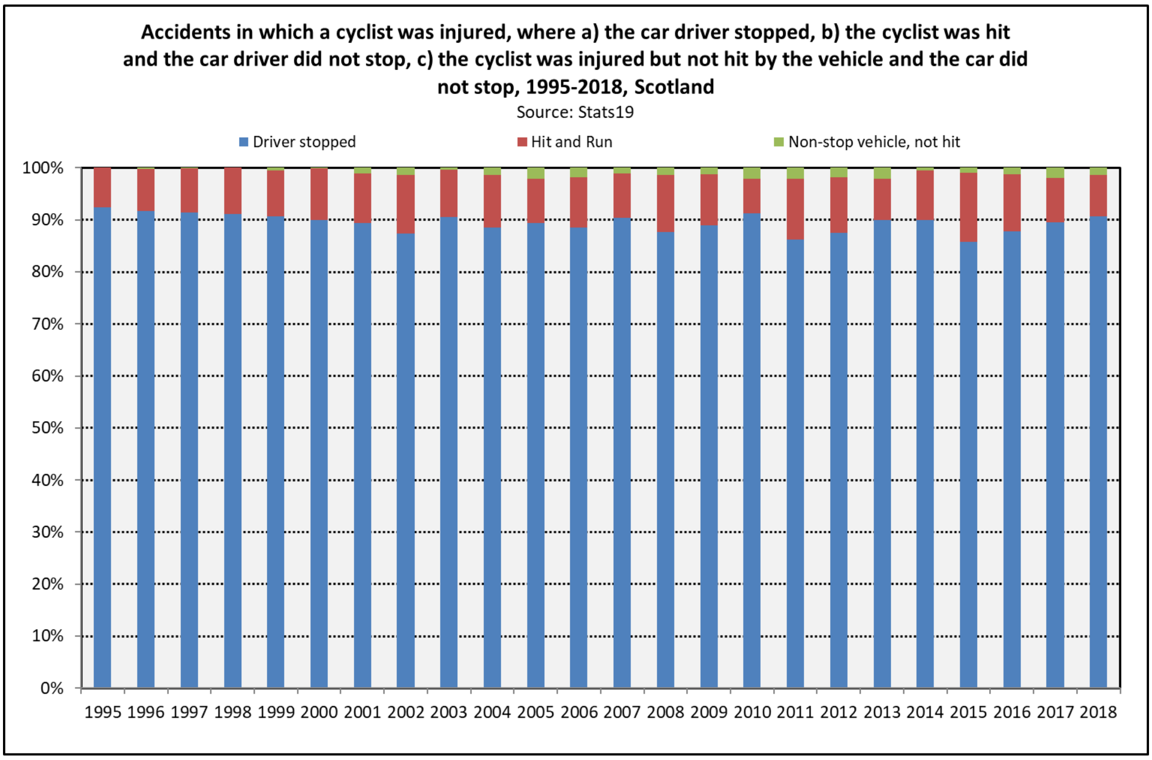
Figure 31: Vehicles involved in road traffics accidents where a pedestrian is injured expressed as a percentage of all vehicles involved, 2014-2018, Scotland



3.2.10 Hit and run accidents

Figure 32 highlights three types of accident in which a cyclist was injured in the period 1995-2018, where: a) the car driver stopped, b) the cyclist was hit and the car driver did not stop, c) the cyclist was injured but not hit by the vehicle and the car did not stop. This highlights that in 9.3% of such accidents, the motor vehicle did not stop. In a further 1% of incidents there was no actual collision, but a cyclist was injured and the motor vehicle did not stop. These findings suggest that approximately 10% of cyclist casualties involving a vehicle were 'hit and run' incidents where the driver of the vehicle did not stop.

Figure 32: Accidents in which a cyclist was injured, where a) the car driver stopped, b) the cyclist was hit and the car driver did not stop, c) the cyclist was injured but not hit by the vehicle and the car did not stop, 1995-2018, Scotland.



3.3 Cycling near misses

Near misses are incidents where a cyclist may not come into direct contact with a vehicle, pedestrian, other cyclist, or stationary object (e.g. street furniture or parked cars) but which is still associated with a risk of injury and reduced safety. Examples of near misses are outlined below.

- **Dooring**: when a cyclist is knocked off their bike by a vehicle door opening in their path[118].
- **Tailgating**: when another road user follows closely behind a cyclist without leaving room to avoid a potential collision[119].
- **Hooking**: when another road user turns across a cyclist's path[119].
- **Close pass**: when another road user passes a cyclist closer than the recommended 1.5 metres. 'Punishment passes' are when the action is perceived as deliberate[119,120].
- **Drive at**: when another road user drives or cycles towards the cyclist head on[119].
- **Blocking**: when the cyclist's way is blocked by another road user, pedestrian or stationery object[119].
- **Pulling out**: when another road user pulls out or across a cyclist's path[119].

In relation to injury and risk, some forms of near misses are considered more pertinent than others. For example, near misses such as 'dooring', 'hooking', and 'close passes' (see Box 1) are associated with a higher risk of collision and injury. Incidents such as 'driving at' and 'blocking' while can increase cyclist's perception of risk and are potentially careless or dangerous driving offences, may not be considered risky in relation to the likelihood of sustaining an injury[82].

Analyses of Stats19 data highlighted that in 1% of reported cyclist casualties involving a vehicle in Scotland there was no collision, yet the cyclist still sustained an injury. This strongly suggests that the incident was a near miss. While 1% may appear to be a relatively low figure it is important to note that near misses are frequently under-reported, therefore this figure is not likely to reflect cyclists' experiences.

3.4 Under-reporting of cycling near misses and casualties

There is no requirement for the public to report a casualty to the police, and so this leads to under counting of cycling casualties in the Stats19 data[118]. Under counting also arises from casualties not being recorded on Stats19 and misclassification of injuries by police[121].

Cycling collisions and near misses, particularly those resulting in less severe injuries[121], are significantly under-reported compared with collisions by any other road user. The exception lies in the reporting of fatalities and in these instances reporting rates can be as high as 100%[10]. Therefore, the numbers of cycling-related casualties and near miss experiences on UK roads are likely to be vastly underestimated[122].

A study of self-reported[l] cycling habits, attitudes and crashes across 17 countries highlighted that only 9% of cyclists reported their most serious crash to the police[122]. In the UK, rates of reporting serious injuries to the police were low at 30% and rates of reporting slight injuries were lower still at 4%[122]. Even within countries such as the Netherlands where cycling rates are high and cycling safety is a national priority, under-reporting was shown to still exist[122].

While Stats19 is a reliable measure of trends in cycling fatalities, due to under-reporting, under recording[m], and misclassification[n], slight and serious cycling casualties in Scotland are significantly under counted. A 2011 report by Transport Scotland[123] used data from the Scottish Household Survey, Department for Transport, and combined police and hospital records to estimate under counting of cycling casualties and near misses in 2010. This report showed that published figures for cycling fatalities were accurate however serious injuries were estimated to be as high as 4,000 compared with the Stats19 figure of 1,964 (representing an increase of 104%)[o]. Slight injuries were estimated to be 23,300 compared with 11,162 recorded on Stats19, suggesting the true casualty figure was 109% higher than the reported figure. Combined estimates for killed and seriously injured casualties were 4,200 per year compared with Stats19 reports of 2,172 (representing an increase of 93%)[123].

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[l] As data is not routinely collected on near misses, self-reported near miss data is considered reasonably accurate[6].
[m] Under recording occurs when reported road traffic accidents are not recorded on the Stats19 form[118].
[n] Misclassification occurs when the police officer reports what they find at the scene of the road traffic accident but where, for example, some casualties appear uninjured or a serious injury may appear slight[118].
[o] Estimates accounted for under reporting, under counting and misclassification.

3.5 Factors which influence the likelihood of near misses and under-reporting

Various factors which influence the likelihood of a near miss occurring and under-reporting have been identified.

3.5.1 Driver behaviour

Research has indicated that driver behaviour can increase the likelihood of cycling near misses.

A UK study examining the experience of cycling near misses found that 80% of self-reported near misses are caused by one of three factors: (1) the road/path was blocked which necessitated a cyclist swerving onto traffic (38%); (2) a problematic pass[p] (29%); and (3) a vehicle pulling into the cyclist's path (16%). This study also highlighted that cyclists felt they had little control in preventing near misses but that most incidents were preventable either by changes to the environment or changes to road user behaviour[82]. The Near Miss Project highlighted that cycling injuries were rare however near misses could be regular frightening experiences for cyclists, and many near misses are perceived by cyclists as deliberate actions against them. For example, 'punishment passes' where a driver swerves towards a cyclist[76].

A further UK survey of almost 15,000 respondents who cycled reported that one of the main hazards people encounter could be categorised under the behaviour of vehicle drivers[83]. The top hazards identified were: vehicles overtaking too closely; unsafe road surfaces; vehicles travelling dangerously fast; and cycle lanes which are too narrow or ended suddenly[83]. The Police Scotland Vulnerable Road Users Assessment of casualties between April 2018 to March 2019 highlighted that driver error was the primary contributory factor in 63% of cyclist-driver collisions resulting in a fatality or serious injury[124].

3.5.2 Cyclist perceptions

Under-reporting of cyclist casualties and near misses has been linked to perceptions among cyclists that their complaint will not be taken seriously, will not result in a prosecution or they cannot report to the police if they cannot identify the vehicle involved or if it was a near miss[125]. Consequently, police recorded data (which is routinely used for most road injury research) does not reflect the rate of near misses that cyclists experience on a daily basis[9] and is not wholly representative of cyclist

[p] Examples of problematic passes include close pass, dangerous or careless driving[81].

casualties[126]. This only further perpetuates a wrongful assumption that near miss incidents are uncommon events and means there is little data on road traffic accident hotspots[127].

Low reporting has also been linked to a perception among cyclists that there is no need to inform the police[8,9,35,128] particularly when no vehicle was involved and there are no subsequent insurance implications[8,16,35,128,129]. In a French study of 495 respondents, the authors highlighted that if there were no third-party involved, individuals did not deem it necessary to involve the police[130]. Although even when a third party was involved, it was still not deemed necessary to involve the police if the incident was resolved amicably, or no one was deemed to be seriously injured.

3.5.3 Age

Under-reporting was also found to be associated with age, whereby the younger the cyclist, the less likely they are to report the incident[9,16,35,128,130]. Associations between probability of reporting and gender were reported to be of statistical significance[78]: under-reporting was found to be higher among women[130].

3.5.4 Helmet wearing

There is also evidence to suggest a tentative link between reporting and helmet wearing. A Danish study of under-reporting highlighted that casualties where the cyclist was wearing a helmet were more likely to present at hospital and be reported to the police[131]. However, Denmark has the lowest levels of helmet use in the world despite being a country with one of the highest cycling rates[132]. Therefore, the authors suggested that cyclists in Denmark who *do* wear helmets may naturally exercise more caution and thus be more likely to report being a casualty.

3.5.5 Severity of injury

Under-reporting of cycling incidents has been associated with severity of injury: the less severe the injury, the less likely it will be reported to police, while fatalities can have a reporting rate as high as 100%[122].

A survey of Danish residents identified that people using e-bikes were more likely to report cycling crashes. This was attributed to the fact that e-bikes were typically used in city traffic and can achieve high speeds, and so cyclists were at a greater risk of being involved in a collision with another vehicle[133].

E-bikes are considerably more expensive than pedal bikes and could influence the likelihood of reporting an incident (particularly if there was damage to the bike). However, the authors only considered the cost of e-bikes as a proxy indicator of the quality and safety of the bike rather than having an influence on reporting[133].

3.5.6 Casualty context

In relation to the road traffic accident context, under-reporting was higher in remote locations, but interestingly the risk of hospitalisation is five times higher among cycling incidents in rural locations[134]. Stats19 data has been criticised for only capturing data on public roads therefore off-road cycling collisions which do not involve a vehicle are under-represented, despite comprising a large portion of cycling collisions.

An Australian and a French study both found strong associations of under-reporting of cycling incidents with the road type. Both studies demonstrated that reporting a cycling incident to the police was less likely if the incident occurred on a ‘low status’ road (i.e. local road and off-road environment) and more likely if the incident occurred on a ‘high status’ road (i.e. state roads, highways)[130,134]. This has been linked to higher speed limits on high status roads, therefore an increased risk of injury. A study of under-reporting of road casualties in Rhone, France, found incidents occurring in the daylight were less likely to be reported to the police than those occurring at night[128]. While under-reporting does vary according to the time of year that the incident occurs, the strength of association is less robust[128,130].

The low levels of reporting of casualties and near misses is a concern because research indicates these are everyday occurrences for cyclists. A large research project into attitudes and experiences of cyclists on traffic risk in San Francisco, USA, showed that cyclists were more likely to experience a near miss compared with a crash. Furthermore, there was a relationship between the likelihood of a near miss experience and cycling frequency, which indicates that near misses are a pervasive threat to cyclists[135]. There is also growing evidence to suggest that near misses negatively affect cycling experience more so than collisions, and near misses are significantly associated with increasing a cyclist’s perception of risk, and impact on cycling uptake overall[135].

4 Discussion

This section presents an integrated summary of the key findings from the data analyses of cyclist casualties from Stats19, and the literature of under-reporting of cyclist casualties and near misses. Risks associated with cycling and factors which can mitigate these risks are discussed. The strengths and limitations of the study are presented, conclusions drawn, and recommendations given.

4.1 Summary of findings

4.1.1 Reported cyclist casualties

Through the time period examined, 1995-2018, reported cyclist casualties on Scotland's roads have more than halved with the largest reduction occurring before 2007. There were reductions in casualties across all injury categories although the weaknesses in the data discussed elsewhere need to be considered. Reductions in cyclist casualties are attributed to reductions in slight injuries across the whole period between 1995-2018, and reductions in fatalities and serious injuries in the period 1995-2004. Against these positive trends, serious injuries have increased by 34% in the latter half of the period between 2005-2018, and the rate of killed or seriously injured casualties (expressed as a casualty rate per head of population) increased by 18% over the period 2004-2018. The number of cyclist casualties reported in Scotland is disproportionate to the relatively low volume of cycling compared with other modes of travel; in 2018, pedal cycle casualties represented 8% of all road casualties[136].

4.1.2 Age, gender and ethnicity of casualties

The reduction in reported cyclist casualties among children and young people, coupled with the increase in casualties in later adulthood may be related to changing trends in cycling prevalence by age, but there is very limited evidence to back this up. However, it is worth noting that current participation in cycling is reportedly highest among the 35-44-year age group (closely followed by 25-34 years and 45-59 years age group)[45] which accords to some extent with the increases in reported casualties among middle-aged adults.

In relation to cycling among children and young people, the most reliable data available is the Hands Up Scotland Survey[59]. However, Hands Up only records cycling to school. As there are no robust datasets on *all forms* of cycling among children and young people it is not possible to establish with certainty what is causing a reduction of reported cycling casualties among this age group. As anticipated, based on the gender divide in cycling uptake, cyclist casualties among men/boys were almost five times higher than cyclist casualties among women/girls. These findings are also consistent with the higher rates of under-reporting of cyclist casualties among women[130].

As previously highlighted in this report, there are distinct barriers to cycling experienced by members of ethnic communities. Furthermore, there are significant associations between ethnicity and cycling injuries[17,128] and ethnicity and likelihood of reporting cycling causalities to the police[35]. Yet, ethnicity is not currently recorded on Stats19 in Scotland.

4.1.3 SIMD casualties

When calculated as a rate per 100,000 of the population the highest casualty rates were for people in the least deprived decile (SIMD 10). This finding reflects the higher cycling rates among the higher income groups compared with the lower income groups[63,64]. However, casualties are less skewed toward less deprived deciles compared with, for example, access to bikes, suggesting further research into causes is needed.

4.1.4 Helmet use

Helmet use is still not recorded comprehensively on Stats19 and making any associations between helmet use (or non-use) and the likelihood of being injured or reporting being injured is fraught with uncertainty. Stats19 data highlighted that in the period 2013-2018 around half of all reported cyclist casualties were recorded as wearing a helmet, while a quarter of casualties were not wearing a helmet and in a further quarter of cases it was not known whether a helmet was worn. In this period the proportion of casualties who were killed or seriously injured was the same among those wearing a helmet compared with those who were not (23%).

Findings from a Danish study suggested that helmet wearing was associated with police reporting of being a casualty[131]. However, these findings do need to be treated with caution, particularly as this was not in a UK context, where helmet wearing is more embedded within the cycling culture, and the underlying mechanisms of this relationship (as put forward in the study) were somewhat opaque.

That said, there are associations between helmet use and the potential for cyclist casualties and near misses. For example, helmet wearing is linked with driver attitudes and behaviours. It is evidenced that drivers perceive cyclists who wear helmets as sensible, and among those drivers who did not cycle many believed that a helmet was a crucial piece of cycling equipment and should be obligatory[137]. Furthermore, an English experimental study demonstrated that cyclists wearing helmets were more likely to experience closes passes than those not wearing a helmet[138,139].

4.1.5 Speed

Stats19 data showed that over two thirds of cyclist casualties occurred on roads with a 30mph speed limit while cyclist casualties occurring on roads with a 20mph speed limit have increased over the time period examined. As speed limits in towns and cities in Scotland have been reduced, many 30mph roads have been re-designated as 20mph, thus there are now more 20mph roads in Scotland, which is likely to explain the increase in cyclist casualties on 20mph roads. Yet the literature shows that under-reporting is in fact higher among casualties occurring on roads with a lower speed limit. This has been attributed to the fact that casualties on lower speed roads are likely to incur less severe injuries, which is associated with under-reporting[130]. Therefore casualty figures may well be higher than those reported.

There is a direct relationship between vehicular speed and mortality in relation to cyclist casualties and near misses. If a cyclist is hit by a car travelling at 20mph there is a 10% fatality rate. This increases to a 50% fatality rate at 30mph and 90% at 40mph[140]. Consequently, there have been widespread calls to decrease the restricted roads default speed limit from 30mph to 20mph in Scotland[141]. While many local authorities in Scotland have already implemented the 20mph speed limit it is not supported by national legislation. In fact, in June 2019 the Scottish Parliament voted *against* the Safer Streets Bill which would have reduced speed in built-up areas and benefited people who walk or cycle[142].

4.1.6 Type of road

The reduction in cyclist casualties occurring at T-junctions, staggered junctions, and away from junctions; and the increase in casualties at pedestrian crossings, on dual carriageways and on roundabouts may be related to the changes in the road environment rather than changes in the safety of cycling overall. Unfortunately, there is limited information on trends in the prevalence of different types of infrastructure on Scottish roads. The proportion of dual carriageways in Scotland has increased by 11% since 2000[131], but data on other types of infrastructure were less readily available. Transport Scotland has no time series data on pedestrian crossings and only holds information on roundabouts on the trunk road network (there has been a slight increase in the last five years) but not on local authority roads (Paterson, A. Transport Scotland, personal communication 2019). It is also worth noting that Stats19, like most police recorded data, only captures casualties which occur on public roads. Therefore, off-road cycling collisions which do not involve a vehicle will not be recorded despite comprising a large portion of collisions[75].

4.1.7 Weather

It is difficult to assess cycling risk in relation to weather conditions because it is not possible to determine the proportion of people who cycle in different conditions. Stats19 data analysed in this study demonstrated that weather may in fact play only a small role in the number of cyclist casualties, because during the timeframe analysed, most incidents involving a cyclist casualty occurred in calm weather conditions with dry road conditions.

4.1.8 Time of year/week/day

Within Scotland, a higher proportion of reported cyclist casualties occurred during August, mid-week, and peaked between commuting hours 7-10am and 3-7pm. These findings reflect reported commuter cycling behaviour. Similar patterning was found in Glasgow's cycle hire scheme whereby the most popular day for cycle hire was Wednesday and cycle hire peaked at 8.30am and 5.30pm[53]. These findings are indicative that a major purpose of cycling is commuting, and that a significant proportion of casualties may have been commuters. Although it does conflict with a French study which suggested casualties which occurred during the day were less likely to be reported than those occurring at night[130].

4.1.9 Risk posed by cyclists to pedestrians

Our findings indicate that cyclists pose a minimal risk to pedestrians and other cyclists. Throughout the 23-year period examined only 1% of collisions involving a pedestrian casualty also involved a cyclist; and a fifth of these also involved a motor vehicle. Of those collisions involving a pedestrian casualty and a cyclist, 74% of casualties were slightly injured and 26% were seriously injured, and there were no fatalities. The burden of injury for pedestrian-cyclist collisions has never been documented[128]. Yet based on the average time spent in hospital, casualties from pedestrian versus cyclist collisions have a lower severity of injury compared with casualties of pedestrians versus vehicles[128].

4.1.10 Risk of cars to cyclists

Findings showed that in 84% of reported cyclist casualties a car was also involved. Similar findings were reported in Australia where the majority (85%) of reported cyclist casualties also involved another vehicle, most of which were cars[138]. The evidence points to the fact that motor vehicles continue to represent a large threat to cyclist safety[143]. In contrast, in Sweden (a country with high cycling rates) as little as one third of the 'conflicts and critical events' that cyclists experienced in 2014 involved a motor vehicle. These findings indicate there is a higher level of risk associated with road sharing in countries with low cycling rates compared with countries with high cycling rates[144].

We have noted that the age of car drivers involved in collisions with cyclists has increased such that in 2018 drivers aged 45+ years represented almost half (47%) of all drivers involved in such incidents. This may relate, in part, to an ageing population; or it may be related to a higher proportion of adults aged 45+ years having a driving licence compared with the under 40 years age group, therefore there are proportionately more drivers aged 45+ years on the roads[131].

Our findings also highlighted that 10% of reported collisions involving injury to a cyclist were 'hit and run' collisions and this has been a consistent pattern over the last 20 years. This is a concerning issue and, as discussed later in this report, is linked to driver behaviours and attitudes. These findings are also likely to influence perceptions of cycling safety among people who currently cycle and among most people who do not currently cycle regularly.

4.1.11 E-bike safety

There are suggestions that e-bikes pose a greater threat to road user safety due to the speed that e-bikes can achieve[133]. Yet despite their speed, there is no evidence to date that e-bikes are more likely to be involved in a collision than pedal bikes[27]. There have been suggestions that this may be mediated by cycling infrastructure and segregated cycle networks[133,145]. Injury severity *is* likely to be higher in an e-bike collision, and injury severity is linked with an increased likelihood of reporting to the police. Furthermore, users of e-bikes are also more likely to report casualties and near misses to the police[122]. Therefore, any increases in reported e-bike casualties may be attributable to cyclists' greater propensity to report rather than an increased safety risk. However, this is perhaps a moot point, as Stats19 does not currently record the type of bicycle involved in an RTA and so there is no way currently to determine how many reported casualties in Scotland involve a person on an e-bike.

4.1.12 Near misses

Our analysis of Stats19, highlighted that in the period 1995-2018, 1% of incidents resulting in a cyclist casualty involved a motor vehicle in which there was no direct collision, and in which the vehicle did not stop. While Stats19 does not record near misses, these findings strongly indicate a reported near miss. This figure may appear low however it is evidenced that near misses are highly under-reported, thus this figure is not indicative of the persistent and everyday risks that cyclists face.

Under-reporting has been attributed to the lower severity of injury which is likely to be sustained from a near miss, and a belief that a near miss does not warrant reporting to the police[8,9,35,127]. Currently, many police forces across the UK allow crimes to be reported to the police via an online system. If this online reporting system was extended to road traffic accidents it *may* increase rates of reported cyclist casualties as it makes the process of reporting incidents more convenient for road users. Equally, the terminology 'road traffic accident' may deter cyclists from reporting near misses and close passes because these are not viewed as accidents unless there was direct contact.

The occurrence of near misses has been linked to driver behaviour and inadequate infrastructure for cycling.

4.1.13 Driver behaviour

Driver behaviour towards cyclists has formed a wide body of research. Surveys focusing on the role of social norms and attitudes have evidenced that many car drivers held negative attitudes towards cyclists and perceived cyclists as a minority group distinct from other road users[138,146].

In a 2002 Australian survey of driver attitudes towards cyclists it was notable that 51% of drivers agreed or strongly agreed there should be no cycling on roads during peak hours[147]. This contrasts with the UK where a 2018 survey of driver attitudes demonstrated that 74% of respondents agreed or strongly agreed that cyclists have *the same rights* as car drivers to be on the roads[148].

A study focusing on driver behaviour also found distinct differences in how drivers perceived and treated other road users[134]. It appeared that courtesy formed the basis of what made drivers considerate towards other motorists and discourteous towards cyclists was justified because cyclists were perceived as not ‘proper’ road users. Many drivers, but particularly those who drove for a living, did not accept that cyclists were equal to motorists on the road because cyclists did not contribute financially to road usage (i.e. Vehicle Excise Duty, insurance) and were not seen to abide by the Highway Code[137]. Other studies have shown similar negative attitudes towards cyclists among professional drivers whereby drivers of smaller and larger vehicles (i.e. taxis, HGVs, and buses) were more likely to take risks when driving near cyclists, and carry out close passes[137,139].

Such negative attitudes and stereotyping of cyclists among other road user groups is widely documented and increases the risk of cyclists being ‘othered’. This body of work has evidenced that negative stereotypes can serve to dehumanise cyclists by turning them into an outsider, and such attitudes are shown to predict aggressive behaviour towards cyclists[149,150]. Safer driving behaviour is found among those with positive attitudes towards cyclists[138].

There are several theories as to how these stereotypes are formed. Some have suggested that because cyclists are more visible compared with drivers, cyclists are an easy target for people to project resentments onto[151]. Others have suggested that a confirmation bias can serve to perpetuate negative attitudes towards cyclists. For example, if a pedestrian or a driver has a negative perception of cyclists (i.e. cyclists are ‘erratic’ or ‘dangerous’) then the individual is bound to only notice cyclists who fulfil this perception even if they encounter a minority[152]. It is also evidenced that negative attitudes towards cyclists are more prevalent among non-cyclists[76] and this is associated with limited knowledge regarding the rules of the road[138].

Hostile driver behaviour has been cited as a contributory factor in a reluctance to cycle[149], a point made earlier in relation to ‘hit and run’ incidents. Given the links between driver attitudes and behaviours and its impact on cycling safety, it is therefore essential to change public perceptions surrounding cycling in order to reduce the risk, improve safety, and improve cycling uptake[18]. Some have suggested that until cycling becomes a social norm the othering of cyclists and its negative consequences will continue[72,151]. Furthermore, if cyclists are treated as low status road users then it is perhaps no surprise that the prevailing attitude surrounding near misses or injuries, is that cyclists do not report incidents.

4.1.14 Cycling infrastructure

Our findings highlight that cycling-friendly infrastructure can improve cycling uptake[6,61,62], benefit the economy[39], improve social contact and reduce isolation among communities[40], improve confidence in cycling[72], and increase independence and autonomy[40]. Furthermore, investment in cycling infrastructure can be shown to be exceptional value for money, can contribute to lowering carbon emissions[36] and bring health benefits.

In the UK, road users are often required to share road space, albeit with some minor modifications for cyclists in urban settings. These include bus lanes, which are also designated for cyclists, painted on-road cycle lanes and advanced stop areas for cyclists. Segregated cycle lanes have started to be built but are still relatively rare and limited in extent. On many roads there are no additional measures to protect cyclists. The safety of current infrastructure has been called into question for not protecting cyclists from increased motor speed and close passes. Such road sharing is shown to result in increased (real and perceived) risk for cyclists, and frustration for drivers[153].

Infrastructure investment alone is not enough for complete modal shift from car to active travel, however it is a necessary condition and can have a great impact on increasing cycling rates and reducing causalities in low-cycling countries. For example, New York City (renowned for its high level of motorised traffic) has installed over 600 miles of cycle lanes since 2006. In subsequent years cycling rates have reportedly doubled and traffic fatalities have dropped to the lowest number on record[151]. It is suggested that investment in adequate infrastructure which supports cycling, such as dedicated cycle lanes and traffic free routes[18], may precede and develop a cycling culture, which improves outcomes for all road users[154].

Cities with the highest levels of active travel have moved beyond basic infrastructure and instead consider active travel in a wider context. This takes the form of a systems-based approach which considers issues such as spatial planning, education, marketing, car movements, interactions with other modes of transport, and the quality of urban spaces[155]. Consequently, many European cities have a comprehensive network designed for cycle traffic, often completely separated from motorised traffic. This approach ensures adequate and safe infrastructure to suit people of all ages and capabilities; and ensures cycle journeys are more pleasant, safer, and faster thus encouraging people to choose a bike over a car. Such investment also sends the message that cycling is a normal mode of transport[67].

In order to encourage greater cycling uptake in Scotland, sustained commitment and investment from the Government, at a recommend spend of £10-£20 per person, would bring Scotland in line with spending level of other European countries with high levels of cycling[67].

4.1.15 Risk associated with cycling

Cycling in countries with high levels of cycling contrast starkly with the current situation in Scotland. The most notable difference is in how people perceive cycling. In countries with high cycling rates (i.e. Denmark, Holland, Germany) cycling is considered a normal part of everyday life. Cyclists do not consider expensive equipment, high levels of fitness or courage to be pre-requisites to getting on their bike[52]. In these countries, people's *perception* of risk when cycling is so low that few people wear safety equipment such as helmets[52]. Meanwhile in the UK, cycling is perceived by many as something 'sporty people' do[18] and which requires high levels of fitness; helmets are perceived to be a requirement; and there appears to be an embedded perception that cycling carries a degree of risk[76].

It is difficult to determine the cause of this negative perception, but as evidenced in the introduction of this report, it may derive from a complex interplay of social norms[70-72], individual identity[55,72], and the perception of what constitutes a cyclist in a UK context. For example, the pervasive image of UK cyclists includes athletes, men, Lycra clothing, middle-aged commuters, and professionals: which is again in stark contrast with the image of cycling in countries with high levels of cycling[52]. Therefore, if people do not see a reflection of themselves within the current cycling community in the UK then cycling will not be an attainable or practical aspiration.

It would be easy to conclude that cities with high cycling rates experience equally higher rates of casualties. Yet data shows that such cities have *higher* safety records for all road users[154]. For example, in the Netherlands, Germany, and Denmark, cycling levels are more than ten times higher than in the UK and USA and yet the risk when cycling is much lower. Cycling in the Netherlands is reportedly five times safer compared with the USA and three times safer compared with the UK. Furthermore, at an average rate between 2002-2005 the Netherlands has the lowest cycling-related injury and fatality rates at just 1.1 per 100 million kilometres cycled (compared with the reported 3.6 in the UK and 5.8 in the USA)[52].

Within Scotland, it is difficult to accurately determine the risks associated with cycling because there is less reliable information on the number of cyclists, the number of cycle trips they take, and the number of miles cycled. The UK Department for Transport publishes estimates of distances cycled on public highways and adjacent paths annually. However, there are limitations associated with these data: cycle activity elsewhere e.g. on canal towpaths, byways and bridal ways are not included, estimates are based on surveys on only a selection of roads and regional and urban estimates within Scotland are not provided. In addition, the methodology for creating these estimates changed in 2016, creating a discontinuity. The impact seems to have been to reduce estimates of cycling mileage across the UK, but that impact was greater in Scotland and under the new methodology the estimates of distance cycled in Scotland reduced by 18% (Paterson, A. Transport Scotland, personal communication 2019). In summary, currently there is a lack of accurate, comparable trends for distances cycled in Scotland. What is more, our literature review highlights it is also not possible to accurately describe the number of cyclist casualties and near misses because they are so frequently under-reported. However, it is evident that an increased perception of risk in the UK contributes to a fear of sharing the road with motorists, which is a major contributing factor in the low level of cycling uptake[149].

4.2 Strengths

To our knowledge, this is the most up-to-date and detailed study of cycling causalities and near misses in Scotland. This report builds on previous work focusing on the causes of cycling causalities and near misses; and adds to the evidence that speed, infrastructure, and cultural norms are key mechanisms which influence cycling uptake.

One of the key strengths of this report is the inclusion of the Stats19 dataset which incorporated accident, vehicle, and casualty records over a 23-year period between 1995-2018. While Stats19 is known to under-estimate the true levels of casualties, it is still a useful source of comparable data on cyclist collisions involving injury. Its national coverage and consistent use over time allowed us to examine longitudinal trends in the demographics and contextual factors associated with cycling causalities. Finally, a literature review is an important component of this report as it enabled exploration of near misses and the under-reporting element of cycling casualties, which are not reflected in the Stats19 data. This allowed us to expand on the mechanisms underpinning the relationship between cyclist casualties and safety and risk.

4.3 Limitations

Presenting statistics on cyclist casualties presents some methodological problems. Ideally a denominator is required to compare casualty rates accounting for exposure to risk. The most suitable denominator would be one that considers the number of people cycling and the distance that they cycle, yet such accurate statistics do not exist in Scotland. For this reason, the data shown were counts of casualties or casualty rates per head of population instead. Suggestions for how to improve data for these purposes are made in the recommendations section.

There are also some limitations associated with the data available from Stats19. First, as evidenced in this report, there is large scale under-reporting of cyclist casualties; albeit the new Collision Reporting and Sharing System (CRASH) may reduce this to some extent, although this may also lead to a discontinuity in casualty trends[q,156].

Secondly, the system is designed to capture road traffic collisions which involve an injury, therefore cyclist near misses cannot be captured in this reporting process. Consequently, Stats19 does not reflect the rate of near misses that cyclists experience

[q] The introduction of injury based reporting systems (IRBS) in police forces in England, where the severity of the injury is determined automatically from the most severe type of injury suffered, replacing the old system whereby a judgement of casualty severity was made by the reporting police officer, has led to some casualties previously categorised as ‘slight’ being recorded as ‘serious’ in IBRS.

on a daily basis[9]. This can perpetuate the wrongful assumption that near misses are uncommon events, and in turn means we have little data on collision hotspots[127].

Thirdly, there are significant associations between ethnicity and cycling injuries[17,128], and significant associations between ethnicity and the likelihood of reporting to the police[35] yet ethnicity is not recorded on Stats19. Fourthly, in Scotland police forces should, in theory, update the severity of injuries on their records but it is reported this is not always the case in practice. There is also no adequate system for healthcare providers to update police officers about changes in the severity of a patient's injury. Both can have implications on the interpretation of the data[79]. Finally, Stats19 must investigate the potential causes of a collision when there may be different interpretations and recollections of the cause.

4.4 Recommendations

If our findings are generalisable across the UK then the under-reporting element of cycling casualties and near misses could have implications for the identification for accident hotspots, and development of remedial measures (i.e. traffic calming, new road layouts) which relies on the completeness and accuracy of Stats19 data.

4.4.1 Data

Reliable and accurate information in several areas is required to better understand cycling casualties and near misses in Scotland.

We recommended that information pertaining to the type of bicycle be included within the Stats19 form and the new CRASH system. This would enable us to determine the proportion of cycling casualties which involved pedal bikes or e-bikes. In addition, we recommend giving consideration to the addition of 'ethnicity' on the Stats19 and CRASH systems. This would enable analysis of casualties for all types of road user in relation to this key equality dimension.

Currently, assessing the risk of being a cyclist casualty is hampered by a lack of data on who cycles and how far they cycle on a regular basis. This level of information would improve monitoring of cycling trends, assist with evaluation of the impact of new infrastructure, and facilitate calculation of risk when cycling. Improved cycling prevalence information combined with casualty data would provide a more accurate assessment of the risk of cycling in Scotland.

Creating reliable and accurate estimates of who cycles is likely to be a complex endeavour involving different organisations and datasets. Nevertheless, the current Department for Transport estimates of distances cycled have clear limitations and do not provide a demographic breakdown – for example by age or gender - of who cycles and how far they cycle on average. In theory a survey-based approach, capturing the demographic profile of cyclists alongside the trips they make, and distances cycled, could be combined with other data from automatic counters (which are increasingly used), from bike share schemes and from apps such as 'Strava'[r]. This would be a complicated endeavour and our recommendation would be to undertake a feasibility study into how to provide better cycling metrics as a first step.

Furthermore, improved monitoring information on all modes of transport, but particularly cycling, would be a key marker of progress for the shift to lower carbon transport systems. While measuring changes in transport behaviour such monitoring may also be able to track changes in measures of risk associated with increased cycling uptake.

4.4.2 Policing

In terms of policing there are promising initiatives currently undertaken by Police Scotland. For example, Operation Close Pass[120] involves cycling officers targeting drivers carrying out close passes to educate them on the safe passing distance with cyclists. It is recommended these schemes continue nationally and particularly in the contexts identified in this report where cyclist casualties are high.

Currently in development, the new Collision Reporting and Sharing System (CRASH) will allow police officers to record details of a collision at the scene, online using an app on a handheld device. The benefits of this online system are that the process of recording is made faster; and highway authorities will be able to access accurate and up to date information meaning local authorities can better plan safety improvements and in a shorter timeframe[146].

The All Party Parliamentary Cycling Group (APPCG) has recognised that weak investigations can undermine subsequent cases and has called for higher standards of investigation (i.e. eyesight testing, checks of mobile phone records) to be

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[r] Strava is a free to use social fitness network which is primarily used to track cycling and running exercises using GPS data[157].

introduced. Furthermore, the APPCG has recommended that video and camera footage be accepted as evidence[158]. We too recommend this action and agree it would strengthen confidence that the police view cyclists' safety as a priority.

4.4.3 Investment

Substantial and sustained investment from the government is required to increase cycling in Scotland through adequate and safe infrastructure to suit people of all ages, capabilities, and socioeconomic status. A recommended spend of £10-£20 per person is estimated to bring the UK in line with spending levels in other European countries with high cycling rates[67]. Such investment would send the message that cycling is a normal mode of travel and would encourage a modal shift from cars to bikes[67,76] while reducing inequalities in cycling uptake. As highlighted earlier in this report, compared with the UK, countries with high cycling rates show less socioeconomic division in cycling participation and in the perception of cycling as a normal mode of transport[67].

Furthermore, policies focusing on generating a shift from car use to active travel are required. This includes prioritising non-motorised modes of travel and public transport over private motor traffic. Authorities and planners ought to consider where e-bikes fit within wider policies to promote active and safe travel[93]. There are many successful examples of this shift in policy throughout Europe[40]. For example, the Netherlands is often viewed as being an exemplar of best practice through its pro-cycling polices and the high levels of bike use. A literature review highlighted that the success of cycling policy in Dutch cities was correlated with how the policy was implemented along with the provision of adequate infrastructure leading to a decreasing appeal in the car[159].

4.4.4 Infrastructure, training and speed restriction

Substantial and sustained investment is needed to create networks of quality cycling infrastructure, protected from motor vehicles. This is a vital to increasing cycling rates and reducing risk[160]. Investment in cycling infrastructure should avoid reinforcing existing health inequalities by targeting places where fewer people cycle as well as where cycling is already well established.

Despite the shift to building dedicated cycle paths and segregated cycle lanes, most roads in Scotland do not have protected bike lanes, and so work to reduce danger on the existing road network is also required. Cycle training, through Bikeability

Scotland and other organisations[161], is well-established and expanding across Scotland. However, efforts are also needed to improve driver behaviour and awareness of cyclists. For example, in a first for the UK bus industry, Lothian Buses has partnered with Cycling Scotland to provide bespoke Practical Cycle Awareness training to all drivers. This training enables bus drivers to achieve a better understanding of the difficulties faced by other roads users and learn more about shared road space[162].

Another key factor is the speed of traffic on our roads and there is good evidence that reducing road speeds, particularly in built-up areas, will help reduce cycling and pedestrian casualties and severity of injury. While the Member's Bill to create a 20mph limit on residential streets across Scotland was not supported by the Scottish Parliament, Edinburgh has introduced a city-wide 20mph limit. The evaluation of this scheme is at an early stage, but the early evidence is that the scheme has led to a statistically significant reduction in average speeds, casualties have fallen since the scheme was implemented (although it is not yet possible to ascribe these reductions to the 20mph scheme) and is supported by a majority of people in Edinburgh[163]. Furthermore, following recommendations from Glasgow's Environment, Sustainability and Carbon Reduction Policy Committee[164], a city-wide 20mph speed limit in Glasgow was also agreed in 2020[165].

5 Conclusion

The aim of this report was to combine analysis of reported cyclist casualties in Scotland using Stats19 data in the 23-year period from 1995-2018, with a literature review of under-reporting of cyclist collisions and near misses.

Findings showed that in the period examined, reported cyclist casualties on Scotland's roads had more than halved. However, between 2004-2018 the rate of cyclist casualties killed or seriously injured increased by 18%. Despite this data it was not possible to accurately determine the risk associated with cycling in Scotland due to under-reporting of casualties and a lack of accurate data on who is cycling and how far. There is clear evidence that slight or serious injuries were vastly under-reported. It is estimated that approximately half of all serious and slight injuries are recorded on Stats19. Under-reporting was associated with individual perceptions surrounding the necessity of reporting, while the occurrence of near misses was linked with infrastructure and driver behaviour.

To our knowledge this is the most up to date and detailed study of cycling casualties and near misses in Scotland. These findings add to the evidence that motor vehicle speed, infrastructure, cultural norms and individual attitudes are key mechanisms which influence cycling participation and can contribute to cycling casualties. Scotland's target of net-zero emissions of all greenhouse gases by 2045 demands a shift away from cars to sustainable transport modes such as cycling. In order to achieve these targets and improve safety for cyclists, we recommended the following actions:

1) There should be new and accurate monitoring data of who cycles and how far in order to calculate risk when cycling and monitor progress in shifts towards lower carbon modes of transport.
2) Ethnicity and type of bicycle (i.e. pedal bike or e-bike) should be included on Stats19 reporting forms to better understand the contextual factors and demographics of cycling casualties.
3) Improvements to police investigation of cycling casualties should be introduced to strengthen cycling safety as a priority.
4) The Government should agree to substantial and sustained Government investment to increase spending levels in line with European countries with high

cycling rates and enact policies which generate a modal shift from car use to active travel.

5) There should be substantial and sustained investment in quality cycling infrastructure, protected from motor vehicles, and retrofitting the existing road system to reduce danger where required.

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