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20mph Research Study

Supporting Technical Appendix
Analysis of safety outcomes in case study areas

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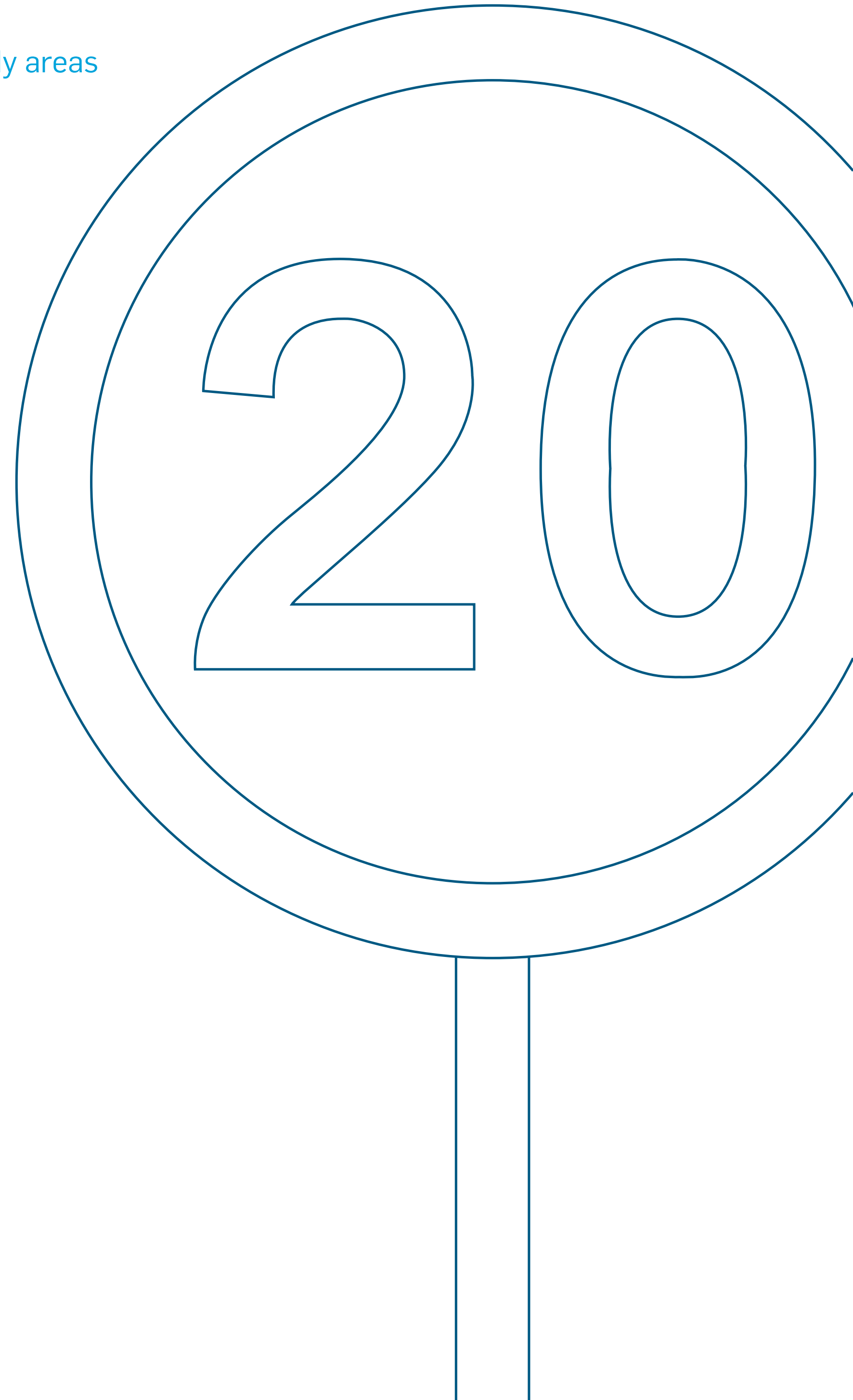

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1. Introduction

1.1. Background

Atkins, Aecom and Professor Mike Maher were commissioned by the Department for Transport (DfT) in 2014, to address a gap in the evidence available on the effectiveness of 20mph speed limit (signed only) schemes. Whilst there is evidence suggesting that 20mph zones are effective in reducing collisions and speeds (as well as leading to other benefits), there is an evidence gap on the effectiveness of 20mph speed limits (i.e. 20mph limits with no physical traffic calming measures). The research is intended to inform future DfT policy development on 20mph speed limits, and influence scheme development and delivery.

A key element of the study involves examining the impact of 20mph limits on the number and severity of road safety collisions / casualties in the case study areas, using geographically coded police data on road casualties (referred to as STATS19 data).

This document reports on the analysis of safety outcomes on **new 20mph limits (signed only)**[1] roads, in the case study areas selected for this research. Separate comparator areas have been selected for each case study scheme to control for background trends in collisions and other factors such as traffic growth, economic trends, weather, etc. The results from other areas of analysis are reported separately, and are brought together in the overarching Technical Report for the study.

1.2. Research themes and hypotheses

The purpose of the safety analysis presented in this report is to test the logic map hypothesis set out in the scoping stage of the study (see **Supporting Technical Appendices – Methodology Description**). This assumes that the introduction of 20mph (signed only) schemes, lead to:

- a reduction in average speed and top percentile speeds,

which means that,

- drivers have more time to and are more likely to respond to road hazards,

which in turn will lead to,

- a reduction in the number of collisions and 'near misses', a reduction in the severity of injuries, and a reduction in speed-related incidents.

This analysis quantifies the change in number, severity and type of injuries, while the social research elements (questionnaires / interviews with residents and drivers, and focus groups) seek to identify changes in driver behaviour and attitudes, which may help identify an association between the introduction of the 20mph limit and change in safety statistics.

The key research questions are therefore:

1. **Has there been a change in the number of collisions and casualties since the introduction of the 20mph (signed only) limits?**

2. **Has there been a change in the number of collisions involving vulnerable road users (pedestrians, cyclists, children, older persons)?**

   A reduction in speed may result in more vulnerable users on the roads, and potentially more incidents involving vehicle collisions with these groups. In addition, the lower speed limit designation may make vulnerable road users more complacent about road safety, and pay less attention to the risks. Alternatively, greater driver awareness of risks and hazards may reduce the number of collisions involving vulnerable groups.

[1] There are two distinct types of 20mph schemes: 20mph limits, indicated by speed limit (and repeater) signs only; and 20mph zones, designed to be 'self-enforcing' through the introduction of traffic calming measures (e.g. speed humps, chicanes). The study is primarily interested in looking at safety outcomes on new 20mph limits (signed only) roads.

3. **To what extent can the above changes be attributed to the change in limit or the observed reduction in speed (as measured using TomTom data[2] and local authority spot speed data[3]), and to what extent does the change reflect a change in flow or a change in background collisions?**

   It should be noted that both the TomTom and spot speed analysis show small reductions in speed across the case study areas.
   - *GPS journey speed data shows that the median speed has fallen by 0.7mph in residential areas and 0.9mph in city centre areas after the introduction of the 20mph limit.*
   - *Spot speed analysis shows a statistically significant reduction in mean speed in four case study areas (based on unweighted and flow weighted data where available) varying from -0.9mph to -2.3mph; and a significant reduction in in a fifth case study area (-1.5mph) based on flow weighted data only. There was no significant change in three case study areas.*

4. **Have the new 20mph limits resulted in any collision migration (or savings) to nearby roads?**

   This may occur as a result of positive or negative changes in speed compliance or driver attention when leaving the 20mph road. TomTom analysis shows no evidence to suggest that drivers are going faster than previously when leaving the new 20mph limit areas. However, driver attention may be higher than previously (due to increased awareness of hazards when driving through the 20mph limit), leading to fewer collisions on surrounding roads; or lower than previously (due to increased levels of frustration), leading to more collisions on surrounding roads.

The study is primarily interested in looking at safety outcomes in new 20mph limits (signed only). These roads form the basis for the analysis.

1.3. Definitions of accidents, collisions, and casualties

Taylor et al. (2010) defines the difference between accidents and casualties. An **accident** may involve a single vehicle (for example, a car colliding with a tree), but more often involves other vehicles or road users. A **casualty** is an individual road user who has been injured in an accident. The severity of the accident is defined by the most severely injured casualty (fatal, serious or slight). Therefore, in a **personal injury accident** there will be at least one, and possibly several casualties. The accident frequency is the number of accidents which occur on a given stretch of road per unit of time (usually per year).

Accidents can also be referred to as **collisions**. With accidents defined as *'an event that happens by chance or that is without apparent or deliberate cause'* some road safety professionals prefer not to use this term, instead using 'collision' which can cover both events that happen by chance and those due to a fault or deliberate act.

The term **personal injury collision** (generally shortened to **collisions**) is used in this report, to reflect the wider definition.

1.4. Structure of report

The remainder of this report has been structured as follows:

- Chapter 2 sets out the existing evidence on safety outcomes.
- Chapter 3 summarises the data sources used for the analysis, and Chapter 4 sets out the methodology used to estimate the safety impact (if any) of the introduction of 20mph limits (signed only) in 12 case study areas around England.
- Chapter 5 presents the findings of the analysis, based on a before and after comparison of collisions and casualties in case study and comparator areas; and Chapter 6 examines change in collisions and casualties on nearby 30mph roads, and the likelihood of this being due to the introduction of 20mph limits (signed only).
- Finally, Chapter 7 summarises the key findings in the context of the above research issues.

[2] Analysis of speed outcomes in 20mph limit areas using GPS vehicle data for 12 case study areas (Atkins, 2017).
[3] Analysis of speed outcomes in 20mph limit areas using spot speed data collected by 12 case study authorities (Atkins, 2017).

2. Existing evidence on safety outcomes

2.1. Introduction

This chapter summarises the existing evidence available on safety outcomes, focusing on:

- the relationship between vehicle speeds and collisions / injuries;
- factors affecting collision and injury rates;
- trends in collisions and injuries over time; and
- safety outcomes in 20mph limits.

It provides the context for the development of the methodology and interpretation of the findings.

The use of the terms collisions and accidents are reflective of the research papers they originate from.

2.2. Relationship between vehicle speeds and collisions / injuries

There is an established positive relationship between speed and injury collisions – the higher the speed, the more collisions and where collisions do occur, the higher the risk of a fatal injury at higher speeds. For example:

- Finch et al. (1994) looked at the validity of this relationship from the early 1960s onwards, using data from across Europe, and concluded that a 1mph reduction in average traffic speed is associated with a 5% reduction in injury collisions.

- Taylor et al. (2000) found that on urban roads with low average traffic speeds, any 1 mph reduction in average speed can reduce collisions by around 6%.

- Elvik (2009) reviewed 115 studies, containing 525 estimates of the relationship between speed and collisions, and concluded that there was good evidence internationally for the effectiveness of reducing the speed and volume of traffic for reducing injury rates. The research also demonstrated that as speeds decline the number of fatal casualties will decrease more than the number of serious casualties.

- Richards (2010) concluded that the risk of fatal injury to pedestrians struck by vehicles rises very slowly at speeds up to 20mph, increases slightly faster between 20mph and 30mph, and rises most significantly at speeds above 30mph. Nevertheless, about half of all fatalities where a pedestrian is killed by a car occur when the car is travelling below 30mph – presumably due to the number of pedestrians on these types of roads.

- Similarly, Wramborg (2005) cites evidence which shows that when collisions between vehicles and pedestrians occurred at 20mph only 5% were killed, whilst half received fatal injuries at 30mph, and 95% were killed at 40mph.

In terms of the reasons for the relationship, Bellefleur and Gagnon (2011) suggest that increasing speed decreases a driver's field of vision, thus reducing the likelihood that a dangerous situation will be noticed in time. Additionally, increasing speed leads to an increased stopping distance, which means the distance travelled by the vehicle during the time it takes a driver to react plus the vehicle's braking time. This reduces the likelihood that the vehicle will stop in time to avoid a collision or reduce its severity.

2.3. Factors affecting collision and injury rates

Research shows that there are a number of differing factors affecting collisions and the severity of casualties which include road type, land use and area type, user type, and socio-demographic characteristics.

Road type

Different types of roads have different levels of risk associated with them. Keep and Rutherford (2013) found that in terms of fatal accidents, 0.6% of casualties on built-up roads (typically speed limits of 30 or 40 mph) resulted in fatality compared with 1.9% of casualties on rural roads (up to 60 mph) and 1.0% on motorways (up to 70 mph) – reflecting design and engineering standards and the number of pedestrian/cyclist conflicts. On average, casualties (fatal and nonfatal) are more likely to occur on built-up roads, but the risk of fatality is decreased.

In addition, Li and Graham (2016) cite a number of papers which show that road casualties are significantly associated with road network characteristics, such as road class, road density and the number of nodes or junctions, the connectivity and accessibility of the road network, and the curvature of the road network (e.g. Huang et al., 2010; Marshall and Garrick, 2011; Rifaat et al., 2011; Jones et al., 2008; Quddus, 2008). The analysis undertaken by Li and Graham (2016) shows an increase in the casualty numbers for all severities for all connected roads, reflecting the findings of others. They hypothesize that areas with a better-connected road network will have more casualties, because pedestrians, cyclists and motor vehicles have better accessibility and total traffic activities tend to be more frequent. Furthermore, they find that road networks with a greater degree of horizontal curvature, are associated with fewer casualties, again reflecting previous findings. The mechanisms for this is believed to be complex, but possible reason is that vehicles have lower speeds when passing curving road sections.

Land use and area type

Li and Graham (2016) also cite previous research suggesting an association between road collisions and employment, deprivation and land use (Wier et al., 2009; Dissanayake et al., 2009; Graham and Stephens, 2008). In particular, a positive relationship has been found in relation to the size of the population and the level of employment, which implies that more casualties may occur in areas with more residents and job opportunities. The analysis undertaken by Li and Graham (2016) shows that higher percentages of domestic and non-domestic areas (offices and businesses, warehousing, etc.) are associated with more casualties, whilst there are fewer casualties in areas with higher percentages of green space. This is consistent with previous findings (Pulugurtha et al., 2013; cited by Li and Graham, 2016), which suggest that land use characteristics such as residential and business areas are generally high traffic activity generators.

Road user type

Casualty data by road user type is available from STATS19, which is classified as occurring on either a rural or urban road. Urban and rural road types do not include motorway casualties. Table 2-1 shows the proportion of casualties on urban and rural roads, comprising pedestrians, cyclists, car drivers or passengers, and motorcyclists. A much greater proportion of all casualties occurred on urban roads than rural roads, with the largest difference being seen for pedestrians and cyclists.

Table 2-1 2015 Casualties by road user type and urban or rural road classification

	Road classification				
Road user type	Urban		Rural		Total (including motorways)
Pedestrians	21,164	87.9%	2,844	11.8%	24,061
Cyclists	15,341	81.4%	3,501	18.6%	18,844
Car (driver or passenger)	58,185	52.1%	38,317	34.3%	111,697
Motorcycle	13,424	67.0%	6,250	31.4%	19,918

Socio-demographic factors

Various studies have shown that the groups most vulnerable to road collisions include: younger and older people; low income groups; minority ethnic groups; those living in areas of high density; and non-car users.

In particular, there is substantial evidence to show that child pedestrian injuries are highest amongst those living in more deprived areas. For example:

- Lawson and Edwards (1991) looked at fatality statistics in Birmingham. They found that the accident rate for Asian children was double that of non-Asian children, including those of other ethnic minorities. They found that there was a much higher incidence of Asian children being injured whilst emerging from between parked vehicles. They also found these areas were in need of regeneration, or showing deprivation.

- On behalf of the Scottish Executive, White et al. (1999) completed a review of literature on road accidents and children in disadvantaged areas. This concluded that children from disadvantaged areas seem to be exposed to greater levels of accident risk. They also found significant differences in child pedestrian injury rates based on ethnicity. They suggest possible reasons are that children in low-income families spend more time walking or cycling as they have less access to other modes of transport, they also lack access to a car for journeys to and from school, and lack of alternative modes of transport, all of which expose them to potentially more dangerous journeys on foot. They found that lack of access to a car could be associated with a doubling of the risk of injury as a pedestrian.

- NICE (2010, reported in Cairns et al., 2014) reported that the likelihood of death from car accidents among children and young people was over five times higher for those whose parents were unemployed, and this figure is over 20 times higher for pedestrians and cyclists. Furthermore, over a quarter of pedestrian injuries in children occur in the most deprived wards, which they suggest is caused by exposure to danger (i.e. high speed traffic being disproportionately located in lower socio economic status neighbourhoods) than individual behaviour.

- Lowe et al (2011) undertook research on road user safety and disadvantaged areas on behalf of the DfT and reported that the likelihood of people from disadvantaged areas being involved in traffic accidents were related to living in more hazardous environments (dense housing and high levels of on street parking), higher exposure to road traffic (not being able to afford a car and hence walking) and not having access to safe spaces for children to play in.

2.4. Trends in collisions and injuries over time

The DfT have published data[4] to show that over time the number of collisions per year are reducing, due to improved vehicle technology and other factors.

Keep and Rutherford (2013) report that within the UK, the risk of being involved in an accident and being hurt or killed whilst travelling on the roads has diminished over time. For example, in 1938 there were 314 casualties for every 100 million kilometres travelled whilst in 2012 there were 41 casualties per 100 million kilometres travelled. Similarly, since the 1970s the number of road deaths has fallen considerably, from over 7,700 deaths in 1972, to 1,754 in 2012. Additionally, the numbers of non-fatal casualties are at the lowest levels since records began, suggesting that over time there has been a relatively significantly reduced risk of being involved in an accident that leads to serious or slight injury.

[4] See statistics published at https://www.gov.uk/government/collections/road-accidents-and-safety-statistics

2.5. Effectiveness of 20mph limits on safety outcomes

Evidence on 20mph zones

Much of the evidence available regarding the effectiveness of 20mph limits relates to zones, where physical traffic calming measures have been implemented alongside the lowering of the speed limit.

Two extensive studies undertaken by the Transport Research Laboratory (Webster & Mackie, 1996; and Webster and Layfield, 2003) suggest that 20mph zones can result in substantial reductions in average speed of around 9mph, and sizeable reductions in collisions. In both studies, the average before speeds for these schemes were around 25mph, dropping to well below 20mph post implementation.

- Webster & Mackie (1996) researched the before and after speeds of 20mph zones across England, implemented in the early 1990s. At the time of the study, 200 schemes had been installed in the UK, and 82 had been granted permanent status. The most quoted reason for applying for authorisation (required at the time) was accident reduction. The average length of road included within zone areas was 2.5km. About 80% were in residential areas, with the remainder in shopping and commercial areas.

  Of the 200 zones considered within the study, before and after speed data had been collected for 32 schemes. This showed an average reduction in speed of 9.3mph, from 25.2mph to 15.9mph). The report also found that traffic flow reduced by 27% within zones and increased by 12% outside the zones, although data was only available for 19 schemes, and not necessarily the same schemes as those included in the speed data analysis. Comparison of before and after accident data for 72 schemes showed that the average annual accident frequency fell by 60%, and child pedestrian and cyclist accidents fell by 70% and 48% respectively. There was a 6.2% reduction in accidents for each 1mph limit.

- A similar study of 20mph zones in London was undertaken by Webster and Layfield in 2003. Initial contact with the London Boroughs indicated that the number of 20mph zones being installed in London had increased from 5 per year (up to 1999) to over 30 per year by 2002, with 137 zones in place at the time of the study. Most of the zones were in residential areas, with over half containing schools and colleges. The average length of road in each zone was 3.4km.

  Before and after speed data was only available for 14 of the schemes, and showed average traffic speed reductions of 9.1mph following implementation. Accident data was obtained for 78 schemes. Before periods of five years were used, and the average length of the after periods was about 3 years. Allowing for background changes in accident frequency on unclassified roads in London, the installation of 20mph zones in London was found to have reduced the frequency of injury accidents within the zones by about 42% and reduced the frequency of injury accidents involving fatal or serious injury (KSIs) by about 53%. Data for 38 zones suggested that little, if any, accident migration had taken place from the 20mph zones.

- There was widespread introduction of 20mph zones in Hull since 1994, and by 2003, there were 120 zones covering 500 streets. Brightwell (2003) undertook an uncontrolled before and after review of casualty statistics covering the seven-year period between 1994 and 2001 which showed an accident reduction of 14% in Hull, compared to an increase of 1.5% in the rest of Yorkshire and Humberside. Furthermore, the zones experienced a 56% reduction in total collisions and a reduction of 90% in fatal and serious injuries. The biggest reductions were child pedestrian casualties, which fell by 74% over the seven-year period.

- The number of 20mph zones in London increased year on year since they were first introduced in 1990/91, to a total 399 zones by 2007/08. A major review of road casualties in London between 1986 and 2006 was published by Grundy et al. (2009). They found that during this time the introduction of London-based 20mph zones was associated with a 42% reduction in road casualties, after adjustment for underlying time trends. They found that 20mph zones were particular effective in preventing fatal or serious injuries to children, which were reduced by half (50.2%). They also established that there was a small reduction in casualties among cyclists, with a reduction of 16.9%.

  The analysis further showed that the reduction in road injuries in 20mph zones occurred at a greater rate than the overall trend of reduction in casualties in London. The publication noted that this was not attributable to any regression-to-the-mean effect[5], and that there had been no displacement in the

[5] Regression to the mean (RTM) – The tendency for locations that have an abnormally high or low rate of collisions to regress towards an ‘average’ number or rate of collisions (Bellefleur and Gagnon, 2011).

accident risk to roads close to the 20mph zones. Whilst they highlighted potential limitations to the research, such as the heavy use of STATS19 data, with its known under reporting they do caveat the fact that STATS19 reporting in London was better than for the rest of the UK, at the time. They also acknowledge that the research cannot wholly attribute the outcomes to the introduction of the scheme as many other measures may have also had an effect.

Evidence on 20mph limits

Evidence available on UK signed only schemes is more limited.

- Between 1998 and 2000, a national trial programme of *advisory 20mph speed limits* was undertaken, involving 75 residential areas across Scotland. Burns et al. (2001) analysed the impact of the *advisory limits* over 18-24 months after they were implemented. The overall average speed reduction was 1.2mph (from 23.4mph before the scheme was introduced to 22.2mph after) and the 85th percentile speed dropped by an average of 1.1mph (from 29.4mph to 28.3mph); with smaller reductions where speeds were already closer to 20mph. Accident data was obtained for 59 sites, and showed a considerable drop (42%) in the number of recorded accidents per year after the introduction of the trial 20 mph scheme (from 31.3 to 18.2), and also a significant reduction in severity, with serious or fatal accidents reduced from 20% to 14% of the total. The ‘before’ period had an average of 35 months while for the ‘after’ the average was 15 months.

- An early evaluation of the city-wide scheme implemented in Portsmouth in 2008-09 (Atkins, 2010) reported an average speed reduction of 1.3mph (from 19.8mph to 18.5mph). Comparing the 3 years before the scheme was implemented and the 2 years afterwards, the number of recorded road casualties fell by 22% from 183 per year to 142 per year. During that period casualty numbers fell nationally - by about 14% in comparable areas. Detailed examination of causation factors did not show any noteworthy change in accidents related to inappropriate speeds or aggressive driving.

  Further analysis was subsequently undertaken by Portsmouth City Council in 2014[6], looking at all injury collisions which occurred in Portsmouth for the three years before the 20mph scheme was implemented (2005-2007) and for the three years after (2009-2011). The analysis shows that in the three-year period prior to the scheme there were a total of 505 collisions. The corresponding figure for the three-year period following implementation is 410 collisions, which equates to a reduction of 19%. Across the rest of Portsmouth’s roads, during the same period the number of collisions fell by 10% - from 1,618 to 1,451. Casualty numbers have remained low since.

  In both studies, the change on predominantly residential roads is compared with the trend on higher flow, more strategic routes where the risk of a collision is known to be higher. It is therefore not possible to draw firm conclusions on the effect of the 20mph limit on casualty numbers.

- Early evaluations of the impact of area-wide limits in Bristol (Bristol City Council, (2012) and Edinburgh (Edinburgh City Council, 2013) were undertaken too soon after implementation, to allow a robust examination of the impact on safety outcomes.

In continental Europe, 30kph (~20mph) speed limits, with and without physical traffic calming measures, have been more common place in recent decades, and this provides some further evidence on the effectiveness of signed only limits.

- Mackie (1998) reviewed research undertaken by Pfundt et al (1989) into the effects/outcomes of twenty-four 30kph schemes with traffic calming measures against thirty-six 30kph schemes without any physical measures (signs only). The analysis showed reductions in the 85th percentile vehicle speeds in signed only schemes averaged just 1kph, compared to 4kph for schemes with traffic calming measures. The average before speed for both sets of schemes was 48kph. Furthermore, the schemes with traffic calming also experienced a significant reduction in injury accidents with a 31% reduction for all injury accidents. Whilst Mackie (1998) states these results are significantly significant (at the 5% level) the results may be overstated as ‘regression to the mean’ was not considered. The changes in accident numbers in signed only schemes were not significant and hence reported as such.

- In Europe, the city of Graz in Austria introduced a city-wide 30kph trial between 1992 and 1994, which covered approximately 75% of the total road network. The trial was part of a city-wide traffic plan which included a strategy to promote walking, cycling and public transport through improving infrastructure and

[6] Unpublished paper, provided to the team by Portsmouth City Council.

an education/awareness campaign to limit the volume and speed of traffic in the city. Research by Wernsperger and Sammer (1995) showed that the average and 85th percentile speeds dropped immediately at the commencement of the trial (from 46.9kmph to 42.7kmph). There was a sharp reduction in the higher speeds, with the proportion travelling at more than 50kph in the 30kph limits falling from 7.3% to 3%. Comparison of one year before and one year after data shows a 12% reduction in slight injury collisions and a 24% reduction in serious injury collisions, found to be statistically significant.

However, by 2002, the mean and 85th percentile speeds had increased and the speed reduction was only 0.4kph for mean speeds and 1.9kph for 85th percentile speeds (Fischer, 2010). Fischer (2010) also found that as time progressed the number of accidents started to increase and fluctuate. The cause of this fluctuation was not concluded.

2.6. Summary of findings

Relationship between vehicle speeds and collisions / injuries – There is an established positive relationship between speed and injury collisions – the higher the speed, the more collisions and where collisions do occur, the higher the risk of a fatal injury at higher speeds. Evidence from Finch et al. (1994) and Taylor et al. (2010) suggests that a 1-2mph reduction in speed, as reported in the TomTom and spot speed analysis undertaken for this study, might be expected to be associated with a 5-10% reduction in collisions.

Factors affecting collision and injury rates – Research shows that there are a number of differing factors affecting collisions and the severity of casualties which include road type, land use and area type, user type, and socio-demographic characteristics. These influences have relevance for the selection of comparator areas to control for confounding factors.

Effectiveness of 20mph limits on safety outcomes – Evidence suggests that 20mph zones can result in substantial reductions in average speed of around 9mph, and sizeable reductions in collisions. This evidence is largely based on schemes which are small scale (typically covering a few kilometres of road length), have a before speed well above 20mph (typically around 25mph), and were implemented in the 1990s and early 2000s primarily to address location-specific safety issues.

Evidence available on signed only schemes is more limited. The results show much smaller reductions in speed, and variable outcomes in terms of the number of collisions.

Methodology considerations – The research papers reviewed highlight a number of methodological issues which have been considered in developing the approach for this study:

- The number of collisions and injuries has diminished over time, and the background trend is an important consideration in any statistical analysis undertaken.
- The importance of matching the characteristics of case study and comparator areas where possible, to control for other influences on casualty numbers (e.g. background reductions in collision rates for different road types, areas, users, etc.; weather; economic trends; traffic growth; national campaigns; etc.). Failure to do this has been identified as a weakness in other studies.
- Issues surrounding regression to the mean (RTM) which can arise in traffic safety studies through the site-selection process. If sites are selected for treatment on the basis of a high accident frequency in the preceding (typically) three years, then a before/after comparison will almost inevitably lead to an exaggerated estimate of the effect of the treatment. The magnitude of this bias can be appreciable (and easily be on a par with the magnitude of the treatment effect itself), as previously studies have demonstrated[7].
- The importance of considering collision migration and the numbers of collisions on the wider / neighbouring road when considering the effectiveness of speed limit schemes.

[7] For example, see Appendix H of the DfT 4-year evaluation report on speed cameras: http://webarchive.nationalarchives.gov.uk/20090104005813/http:/www.dft.gov.uk/pgr/roadsafety/speedmanagement/nscp/nscp/thenationalsafetycameraprogr4597.

3. Data sources

3.1. Introduction

We used the following data sources to undertake this analysis:

- A **TomTom mapping GIS file** for each 20mph case study scheme, marked up with the pre and post-scheme speed limits, and categorising 20mph roads as new or pre-existing, and with or without traffic calming. The TomTom map product has also been used to identify appropriate 30mph roads in comparator areas.
- **STATS 19 data**, provided by the DfT for the period Jan 2005 to December 2016. This includes accident, casualty, vehicle and contributor factors data. The ‘before’ analysis is based on five years of data, and the ‘after’ analysis uses between 17 and 42 months (between 1.4 and 3.5 years) of data reflecting the different implementation dates for the various schemes.

Of the 12 case studies, Portsmouth was implemented substantially earlier than the other case study authorities. Background trends in casualty rates at the time were very different to more recent trends affecting all of the other case studies. The rate of background decline is decelerating over time, so the rate at which collisions were declining at the time the Portsmouth scheme was implemented, would have been greater than that affecting more recent schemes. Data for Portsmouth was therefore excluded from the analysis described in this report. This is consistent with the approach adopted for the analysis of speed outcomes using GPS data, which treated Portsmouth separately.

3.2. TomTom GIS base map

Information on the location of 20mph speed limits in each of the case study areas has been taken from TomTom’s UK Map Product (Shape File). An additional patch was provided by TomTom (September 2016) comprising updated data on the location of 20mph limits in each of the case study areas. This was based on information provided by the relevant local authorities and TomTom’s Mobile Mapping imagery. The 2016 patch provides comprehensive data on the location of current 20mph limits (as of September 2016), but does not identify roads which already had a 20mph limit in place prior to the role out of the area-wide schemes, nor does it distinguish between signed only limits and zones (with physical measures in place).

To address this, the study team also used desktop mapping techniques to view every road within the case study areas, to:

- confirm the existence of the 20mph limit;
- identify what speed limit was in place prior to the role out of the area-wide scheme (using old street-level imagery from Google StreetView archive); and
- record any physical traffic calming measures (e.g. road humps, chicanes) which were in place prior to the role out of the area-wide scheme or have been introduced since.

Each road was then classified as follows:

Table 3-1 Categorisation of Roads for Analysis

Description	Traffic Calming	Before Speed	After Speed
New 20mph limit (signed only)	No / minimal physical traffic calming	30 mph	20 mph
New 20mph limit (existing calming)	Substantial pre-existing traffic calming	30 mph	20 mph
Old 20mph limit (signed only)	No / minimal physical traffic calming	20 mph	20 mph
Old 20mph limit (with calming)	Substantial pre-existing traffic calming, often combined with 20mph zone sign	20 mph	20 mph
30mph (no change)	No / minimal physical traffic calming	30 mph	30 mph
40mph (no change)	No / minimal physical traffic calming	40 mph	40 mph

The above exercise was a substantial task and relied on comprehensive historical imagery to allow before and after comparisons to be made. In general, there was sufficient imagery available for the case studies to allow this task to be completed. The exception was Calderdale, where the images available at the time for most of the case study area pre-dated the implementation of the 20mph scheme. Nevertheless, detailed maps were provided by the Council, and it was still possible to use Google StreetView to check for pre-existing traffic calming and old 20mph limits.

These maps have been used to identify accidents occurring on new 20mph limit (signed only) roads in each case study area; and accidents occurring on appropriate 30mph roads in comparator areas.

Functional Road Class

The TomTom map product uses Functional Road Class (FRC) as an interpretation of road classification. It runs from FRC 1 to 8, where 1 are motorways and 8 are very minor roads.

This is a good proxy for the size and strategic nature of each road. For the purpose of this analysis, 20mph roads have been grouped into three categories:

- Major strategic roads (FRC 1-3);
- Important local roads (FRC 4-5);
- Minor local roads (FRC 6-7).

Given the nature of 20mph limit schemes, the majority of segments in the case study areas fall into FRC 4-7.

3.3. STATS19 Data

Personal injury collisions (PICs) on public roads that are reported to the Police, are recorded using the STATS19 accident reporting form. This data contains details of the incident severity, casualty severity and numbers, and a subjective coding of contributory factors. This information is stored, and available for analysis, in two databases maintained by the DfT – an Accident Database and a Contributory Factors Database.

3.3.1. DfT’s Accident Database

Description

DfT’s Accident Database comprises an Accident Table, Casualty Table, and Vehicle Table, detailing the relevant information for each reported collision (see Table 3-2). The data details locations of collisions, allowing for these to be mapped in GIS to look at where clusters occur pre and post scheme. Incidents involving car collisions with pedestrians and cyclists are also included in the dataset.

The dataset only includes collisions involving personal injury, which occur on the public highway (including footways), in which at least one road vehicle is involved and which becomes known to the police within 30 days of its occurrence. One collision may give rise to several casualties. “Damage-only” collisions are not included in this publication.

Annual releases of the Accident Database are uploaded on the data.gov.uk website. This data is available for public use. Validated data for January to December 2016 was therefore released in September 2017, and used in the analysis for this study.

Table 3-2 Fields included in the DfT Accident Database

Accident Table	Casualty Table	Vehicle Table
Accident ID	Accident ID	Accident ID
Accident Year	Vehicle Reference Number	Casualty Reference Number
Police Force	Casualty Reference Number	**Vehicle Type**
Accident Severity	Casualty Class	Towing and Articulation
Number of Vehicles	Sex of Casualty	Vehicle Manoeuvre
Number of Casualties	**Casualty Age**	Vehicle Manoeuvre From
Date	**Casualty Severity**	Vehicle Manoeuvre To
Day of week	Pedestrian Location	Vehicle Location Restricted Lane
Time of accident	Pedestrian Movement	Junction Location

Accident Table	Casualty Table	Vehicle Table
Location (easting and northing)	Pedestrian Direction	Skidding and Overturning
1st Road/2nd Road Class	Car Passenger	Hit object in Carriageway
1st Road/2nd Road Number	Bus or Coach Passenger	Vehicle leaving Carriageway
Road Type	Seat Belt in Use	Hit object off carriageway
Speed Limit	Cycle Helmet Worn	First point of impact
Junction Detail	Pedestrian Road Maintenance Worker	Was vehicle left hand drive
Junction Control	Casualty Type	Journey purpose
Light Conditions		Sex of Driver
Weather Conditions		Age of Driver
Road Surface Conditions		
Special Conditions		
Carriageway Hazards		

The key variables used in the analysis are highlighted in bold (in Table 3-2) and include:

- Accident ID (as a measure of the number of collisions)
- Number of Casualties;
- Casualty Severity (fatal, serious, slight);
- Vehicle Type (to filter to pedestrian or cyclists);
- Casualty Age (to filter to under 16s and over 70s); and
- Date, Location, Road Type, and Speed Limit – *to identify and categorise relevant incidents*.

Other variables have been examined to provide background context. High level numbers are provided, but these variables are not used to draw conclusions. As highlighted below, not all variables are available throughout the analysis period, and not all reported on with the same degree of completeness over time.

Limitations

The following data limitations need to be considered when interpreting the findings presented in this report:

- The dataset only includes collisions where an injury is reported. Damage only incidents are not included in the dataset. This represents a significant limitation in our analysis, as a substantial proportion of collisions in 20mph limit areas are expected to be damage only collisions. While some authorities do record damage-only incidents, the data is unlikely to be consistent or representative, and is not readily available for analysis.

- Within the UK, providing all drivers exchange details, there is no legal obligation to report a road traffic collision, even if someone is injured. This leads to the problem of under-reporting of personal injury accidents. Even when they are reported to the police, the details of the accident and casualties are not always recorded accurately, or indeed not recorded at all. The DfT (2012) introduced questions in the National Travel Survey (NTS) asking respondents whether they have been involved in a road traffic accident in which someone was injured within the last three years and in the last 12 months. These responses can be used to estimate the total number of personal-injury casualties each year, including those that were not reported to the police.

- A major weakness of STATS19 data is the accuracy of the data itself. Essentially, the variables are as accurate as the police record them. Collisions might not be reported at all and are often pinned to the wrong road (and can be out by some distance). Age information might be estimated and rounded, severity, road type and speed limit information might not be accurately recorded, and the level of quality assurance undertaken varies hugely across authorities. Nevertheless, the error within the data is likely to be similar for both the before and after periods.

- Not all variables shown in Table 3-2 are available throughout the analysis period, and not all are reported on with the same degree of completeness over time. Local authorities provide additional local validation to improve accuracy of the Police record. Additionally, before publishing their statistics, the DfT carry out substantial cleaning and validation for values that are outside of the expected range and include data from other sources.

- There is also an issue around the comparability of the 2016 data, following the introduction of the CRASH reporting system. CRASH is an online tool designed to provide standardised collection, storage and validation of police casualty data. It is now in use in around half of England's forces, and is intended to address the longstanding issue of casualty under-reporting. It is an internal police system, with data entry and validation now becoming the responsibility of the police rather than local authority staff with long standing skills and experience in this field. There is a risk that only the minimum amount of data required by the system may be reported, leaving valuable supplementary data unrecorded.

  In addition, an important innovation pioneered by CRASH is the greatly improved recording of the nature of injuries suffered by victims. However, in the short-term, this may result in significant deviation between the number of casualties classified as 'serious' by forces that use CRASH, compared with both preceding years, and to forces that do not. Early indications suggest that this has resulted in an increase in the proportion of casualties categorised as 'serious'. **It has therefore not been possible to undertake any meaningful statistical analysis by casualty type as part of this study**.

3.3.2. Contributory Factors Database

Description

The DfT also maintains a database of road collision contributory factors data, which provides a subjective coding of factors which may have contributed to the collision. Permission to use this data has been sought from the DfT's Head of Road Safety Statistics.

The form used by the Police to report contributory factors includes a list of 78 factors, which fit into 9 categories (see Table 3-1). It is important to note that it may be difficult for a Police Officer, attending the scene after an accident has occurred, to identify certain factors that may have contributed to a cause of an accident. The contributory factors are therefore different in nature from the remainder of the STATS19 data which is based on the reporting of factual information. This should be kept in mind when interpreting the data.

Table 3-1 Contributory factor codes

Category	Codes
Road environment contributed	Poor or defective road surface Deposit on road (e.g. oil, mud, chippings) Slippery road (due to weather) Inadequate or masked signs or road markings Defective traffic signals Traffic calming (e.g. road humps, chicane) Temporary road layout (e.g. contraflow) Road layout (e.g. bend, hill, narrow road) Animal or object in carriageway Slippery inspection cover or road marking
Vehicle defects	Tyres illegal, defective or under inflated Defective lights or indicators Defective brakes Defective steering or suspension Defective or missing mirrors Overloaded or poorly loaded vehicle or trailer
Injudicious action	Disobeyed automatic traffic signal Disobeyed 'Give Way' or 'Stop' sign or markings Disobeyed double white lines Disobeyed pedestrian crossing facility Illegal turn or direction of travel Exceeding speed limit

Category	Codes
	Travelling too fast for conditions Following too close Vehicle travelling along pavement Cyclist entering road from pavement
Driver/Rider error or reaction	Junction overshoot Junction restart (moving off at junction) Poor turn or manoeuvre Failed to signal or misleading signal Driver/Rider failed to look properly Driver/Rider failed to judge other person’s path or speed Too close to cyclist, horse rider or pedestrian Sudden braking Swerved Loss of control
Impairment or distraction	Driver/Rider impaired by alcohol Driver/Rider impaired by drugs (illicit or medicinal) Fatigue Uncorrected, defective eyesight Driver/Rider illness or disability, mental or physical Not displaying lights at night or in poor visibility Rider wearing dark clothing Driver using mobile phone Distraction in vehicle Distraction outside vehicle
Behaviour or inexperience	Aggressive driving Driver/Rider careless, reckless or in a hurry Driver/Rider nervous, uncertain or panic Driving too slow for conditions or slow vehicles (e.g. tractor) Learner or inexperienced driver/rider Inexperience of driving on the left Unfamiliar with model of vehicle
Vision affected by external factors	Stationary or parked vehicle(s) Vegetation Road layout (e.g. bend, winding road, hill crest) Buildings, road signs, street furniture Dazzling headlights Dazzling sun Rain, sleet, snow, or fog Spray from other vehicles Visor or windscreen dirty, scratched or frosted etc. Vehicle blind spot
Pedestrian only (casualty or uninjured)	Crossing road masked by stationary or parked vehicle Pedestrian failed to look properly Pedestrian failed to judge vehicle’s path or speed Pedestrian wrong use of pedestrian crossing facility Dangerous action in carriageway (e.g. playing) Pedestrian impaired by alcohol Pedestrian impaired by drugs (illicit or medicinal) Pedestrian careless, reckless or in a hurry Pedestrian wearing dark clothing at night Pedestrian disability or illness, mental or physical

Category	Codes
Special Codes	Stolen vehicle Vehicle in course of crime Emergency vehicle on a call Vehicle door opened or closed negligently Other

Each collision can be attributed between none and six contributory factors believed to be related to the collision. The contributory factors are for information purposes only and not intended to assign blame.

While subjective on the part of the police attending the scene, there could be information within this data of use to making sense of changes in collisions due to the introduction of 20mph limits. For example, the 20mph limit may have increased levels of frustration, and resulted in an increase in collisions caused by aggressive driving, or incidents resulting from drivers being in a hurry.

Limitations

While potentially useful, there are a number of caveats associated with this dataset which need to be considered and limits the extent to which the data can be used to address the research questions:

- Not all collisions are included in the contributory factor data. Only collisions where the Police attended the scene and reported at least one contributory factor are included. A total of 77% of all collisions reported to the Police in 2015 met these criteria. This proportion, however, is likely to be much lower in 20mph limits, as most injuries are likely to be slight injuries and incidents are less likely to be attended by the Police.

- Officers do not need to carry out a full investigation of the incident before allocating contributory factors. They usually use professional judgement about what they can see at the scene. Some contributory factors, such as exceeding the speed limit, may not be obvious to the officer and are therefore likely to be under-reported.

Given the above caveats, and the small number of collisions involved, contributory factors are used to provide background context only. High level numbers are provided, but the variables are not used to draw statistical conclusions.

3.4. Role of STATS19 data in addressing research questions

The following tables and fields have been used to address the research questions outlined in Chapter 1.

Table 3-4 Fields required to answer research questions

Question	Table	Field	Why
1 - Has there been a change in the number of collisions and casualties since the introduction of 20mph?	Accident	Count of ID	Number of collisions
	Accident	Sum of Number of Casualties	Number of casualties
	Accident	Sum of Casualty Severity	Number of fatal, serious, and slight casualties*
2 - Has there been a change in the number of collisions involving vulnerable road users (pedestrians, cyclists, children, older persons)?	Accident	Count of ID	Number of collisions
	Vehicle	Vehicle Type	To filter to pedestrian or cyclist*
	Casualty	Casualty Age	To filter to under 16 and over 70s*
3 - To what extent can the above changes be attributed to the change in limit or the observed reduction in speed, and to what extent does the change reflect a change in flow or a change in background collisions?	As above	As above	Changes observed on new 20mph limit roads in case study areas are compared with changes on 30mph roads in comparator areas. If there are changes observed in study areas that are not observed in the comparator areas we can reason that this may have been due to the new 20mph speed limit scheme.
4 - Have the new 20mph limits resulted in any collision migration (or savings) to nearby roads?	Accident	Count of ID	Changes observed on nearby 30mph limit roads in case study areas are compared with changes on 30mph roads in comparator areas. If there are changes observed in study areas that are not observed in the comparator areas we can reason that this may have been due to the new 20mph speed limit scheme. However, it is unlikely that we will be able to draw any firm conclusions. Tomtom analysis shows no evidence to suggest that drivers are going faster than previously when leaving the new 20mph limit areas; and the contributory factor data is not sufficiently robust to detect any changes in the cause of collisions.

** Note, that it is likely that these variables will have too small a sample to provide robust evidence, so will be indicative only (see below).*

4. Methodology

4.1. Introduction

This chapter outlines our methodology for measuring the safety impact (if any) of the introduction of 20mph signed only limits in 12 case study areas around England. In particular, it:

- outlines the use of a generalised linear model to estimate the effect of the change in speed limit;
- describes the selection of comparator areas to control for background trends in collisions; and
- covers methodological details relating to the before and after analysis periods, the process for matching collision data to road segments, and consideration of regression to the mean.

The approach has been developed by Atkins and Professor Mike Maher of University College London.

4.2. Use of a generalised linear model to estimate the effect of the change in speed limit

In developing an analysis approach, it was necessary to consider the following challenges and issues:

- How to measure the impact when all study area schemes went 'live' on different dates, and have different before and after data?
- How to account for background changes such as traffic flow and background trends in collisions?
- How to measure the impact when the number of personal injury collisions on 20mph roads are likely to be low, and the change is expected to be small?

The following approach was therefore developed with Professor Mike Maher, to address the above key challenges.

The model used to analyse the data and to estimate the effect of the change in speed limit is a Generalised Linear Model (GLM) of multiplicative form and employing a Poisson / Negative Binomial error structure. In order to allow for background change in collisions, flow, etc. over time, the model compares the change in collisions in each case study area with a relevant comparator area.

The model looks like this:

$E(y_{it}) = k_i R_{it}$ for the *before* period; and

$E(y_{it}) = k_i R_{it} \propto$ for the *after* period (with a dummy variable used to represent the after period).

Where:

$E(y_{it})$ = Expected number of collisions in case study area *i* in year *t*

R_{it} = Number of collisions in comparator area *i* in year *t*

k_i = Coefficient measuring the relative magnitudes of the collisions rates in the study and comparator areas *i*.

α = The factor by which collision rate is multiplied in the after period.

The crucial parameter is α, which is the factor by which collision rate is multiplied in the after period, and indicates the extent to which the implementation of the lower speed limit has led to a decrease in collisions.

A key element of the approach is the identification of a separate comparator area for each case study scheme. The 'comparator' could be collisions in the rest of the city, the wider region or based on similar roads to those in the study area. The comparator area should generally comprise a larger number of collisions, to provide a clear background trend, and should cover the same period as the study area.

It should be noted that it is not essential to use annual data and, indeed, part years could be used alongside full years, so long again as the comparator area data and study area data use the same periods. It should also be noted that the years used need not be consecutive (e.g. there could be a gap where the change of speed limit was being implemented across the area), providing the case study and comparator area data both reflect this.

Due to the small number of collisions in each area, the analysis will likely be more conclusive if all case study areas are considered together. An aggregated approach has therefore been adopted. The statistical analysis is therefore primarily reported at a case study wide level, with less emphasis on the change within individual case study areas.

Purpose of model

The model aims to look at the number of collisions before and after the introduction of 20mph limits and compare the collision rates. The model attempts to take account of other background factors (e.g. background reductions in collision rates, weather, economic trends, etc.) by using comparator areas with similar characteristics (see Section 4.3) to the case study areas to adjust for these impacts in the time periods used.

The outcome, after controlling for these changes, is a parameter that explains the percentage that would be multiplied by the pre-scheme collision rate to get the outturn collision rate. If this is less than 100%, then collisions have reduced, and if greater than 100%, then collisions have increased. A 95% (or 90%) confidence interval can be placed around this parameter to consider the confidence in the impact observed.

Example

Based on purely artificial data, the example below shows how the analysis would proceed. Note that the period indicator variable is 1 for before and is 2 for after (the dummy variable).

Table 4-1 Typical form of data for generalised linear model (using artificial data)

Site i	Year t	Study area collisions y_{it}	Comparator area collisions R_{it}	Period (1 = before, 2 = after)
1	1	10	100	1
1	2	8	107	1
1	3	11	124	1
1	4	9	97	2
1	5	13	121	2
2	1	8	65	1
2	2	11	76	1
2	3	6	88	2
2	4	9	56	2
3	1	16	127	1
3	2	12	135	1
3	3	7	98	1
3	4	5	76	2
4	1	20	212	1
4	2	17	189	1
4	3	20	167	1
4	4	13	188	2
4	5	9	156	2
4	6	8	178	2

Fitting a model as described above (in software package R), would give an output as follows:

Table 4-2 Model output coefficients (example R output, using artificial data)

	Estimate	Standard Error	Z Value	$Pr(>\|z\|)$
(Intercept)	-2.26754	0.14827	-15.293	<2e-16 ***
site2	0.28194	0.22193	1.270	0.2039
site3	-0.07494	0.21314	-0.352	0.7251
site4	-0.12780	0.17673	-0.723	0.4696
period2	-0.30038	0.14872	-2.020	0.0434 *

The principal parameter of interest is the one on the last line, labelled 'period2'. This is the estimate of the log of the parameter α. So the estimate of $\propto = exp(-0.30038) = 0.741$. This indicates (in this artificial scenario) the implementation of the lower speed limit has led to a decrease in collisions of around 26%.

A 95% confidence interval on α can be estimated using the standard error and can be calculated as $\propto = (0.553, 0.991)$. Therefore, the 95% confidence interval in this example is marginally significant at the 5% level (i.e. the confidence interval does not contain the value 1 which would indicate "no change").

In addition to giving the 95% Confidence Interval and testing if the estimate of ∝ is significantly different from 1 at any specified significance level (e.g. 5%), we can also state the P value – in this case P = 4.34%. This is the significance level at which the result would be right on the boundary of significance.

Reason for calculating the log of the parameter α

If the model specified at the start of this section is written in the following form:

$$E(y_{it}) = \mu_{it} = k_i R_{it} \alpha^{x_{it}}$$

so that x_{it} = 0 if year t is in the before period for site i and 1 if it is in the after period, then taking logs gives a linear additive form of regression model:

$$\log(\mu_{it}) = \log(k_i) + \log(R_{it}) + \log(\alpha)x_{it}$$

The coefficient in front of the dummy variable x_{it} is $\log(\alpha)$ and that, along with the scaling parameters $\log(k_i)$, are the parameters in the fitted regression model. So, using logs allows the model to be put in the form of a standard linear regression model (with additive terms).

Use of Negative Binomial / Poisson model

A Negative Binomial model will be used to undertake the before and after analysis for the aggregated case study data, and estimate the treatment effect (rather than a pure Poisson model).

The accident frequency at any site in a given time period (y) is assumed to be Poisson distributed about an unknown mean. The Negative Binomial model assumes the collision / casualty data follows a Poisson distribution, but also allows for over dispersion (i.e. greater variability in the data than might be expected using a standard Poisson model). This approach is now standard practice in collision modelling.

However, this approach is not appropriate when considering just one case study area, or just one set of aggregated data. In these circumstances a Poisson model is used instead.

Key strengths of approach

The proposed approach:

- Does not require all schemes to have opened at the same time, and does not require all case studies to have the same amount of before and after data. This means that all data available (to December 2016) can be used.

- Aggregation of areas maximises the sample of data and increases the opportunity to measure an impact if one exists.
- Background trends are picked up by the model using comparator areas to understand the relative impacts.

Likelihood of being able to detect a safety effect

The likelihood of being able to detect a change in collisions or casualties with a defined level of probability, depends on the scale of change in the data and the amount of data available (the sample size). The larger the sample size, the greater the likelihood of being able to detect a smaller change.

Table B-1 in Appendix B provides an approximation of the likelihood or probability of detecting a significant safety effect, for different levels of change and before/after sample sizes. Further detail on the calculations and assumptions behind the probability figures is provided in Appendix B.

Hence, the likelihood of being able to detect a significant change in the number of collisions or casualties is substantially higher than the likelihood of being able to detect a significant change in the number of fatal / serious / slight injuries, pedestrian / cyclist, or under 16s / over 70s.

4.3. Selection of comparator areas

A key element of the approach is the identification of a separate comparator area for each case study scheme. The purpose of the comparator is to control for background trends in collisions, and other factors such as environment, road type, weather, economic trends, traffic growth, etc. i.e. anything which could affect driver behaviour and the number of collisions expected in 20mph areas independently of the change in speed limit.

The comparator area should generally comprise a larger number of collisions, to provide a clear background trend; but still be representative of the case study area in other characteristics that are likely to impact on safety outcomes (e.g. land use and area type, socio-demographic characteristics, and road type and function – see Chapter 2). For the purpose of this analysis, the comparator needs to comprise collisions on 30mph roads, with similar characteristics and function to the 20mph roads in the case study areas.

One approach could be to select a similar size settlement in the neighbouring area, and identify all collisions on 30mph roads. However, choice of comparator settlements will be subjective, and choosing the optimum comparator would be difficult. A different approach was therefore required.

Consequently, a decision was made to use the Urban and Rural Area Definitions developed by central government in 2011, to identify suitable region-based comparator areas for each case study. This approach draws comparator data from a number of settlements, which are considered similar to the case study area within the same region. This approach improves the likelihood of identifying a comparison scenario which represents what would have happened in the 20mph case study areas if the new limit had not been introduced.

4.3.1. Rural-Urban Classification for case study areas

The Rural Urban Classification (RUC) system is an Official Statistic, used to distinguish rural and urban areas. At the most aggregate level, this data is available by local authority area. It is also available for small area geographies, including Output Areas (OAs). Data is also available for Super Output Areas (SOAs), where OA level data is agglomerated at two geographic levels:

- Lower Layer Super Output Areas (LSOAs) – comprising between 400 and 1,200 households; and
- Middle Layer Super-Output Areas (MSOAs) – comprising between 2,000 and 6,000 households.

For the purpose of classifying the case study areas and establishing comparator areas, lower super output areas (LSOAs) were considered to be the most appropriate size.

The ‘urban’ domain comprises all physical settlements with a population of 10,000 or more. If the majority of the population of a particular OA live in such a settlement, that OA is deemed 'urban'; all other OAs are deemed 'rural'. At the LSOA and MSOA scales, the settlement form tends to be more homogeneous, and the RUC can be recognised as one of the following four urban or four rural typologies:

- Urban:

- Major Conurbation
- Minor Conurbation
- City and Town
- City and Town in a Sparse Setting

- Rural
  - Town and Fringe
  - Town and Fringe in a Sparse Setting
  - Village and Dispersed
  - Village and Dispersed in a Sparse Setting

Table 4-3 shows the RUC for each case study area, and the size (km^2) of similar comparator areas in the same region.

Table 4-3 Case study rural urban classifications and size of comparator areas within the same region

Case Study	RUC Classification	Region	Case Study size (km^2)	Comparator Area size (km^2)[1]
Walsall (Rushall) (R-SM1)	Urban Major Conurbation	West Midlands	0.5	872
Winchester (Stanmore) (R-SM2)	Urban City and Town	South East	3.6	4,184
Liverpool (Area 7) (R-AW1a)	Urban Major Conurbation	North West	15.8	1,589
Liverpool (Area 2) (R-AW1b)	Urban Major Conurbation	North West	19.3	1,589
Middlesbrough (R-AW2)	Urban City and Town	North East	18.6	737
Calderdale (Phase 1) (R-AW3)	Urban Major Conurbation	Yorkshire and the Humber	4.2	830
Nottingham (Bestwood) (R-AW4)	Urban Minor Conurbation	East Midlands	7.9	359
Brighton (Phase 2) (R-AW5)	Urban City and Town	South East	24.9	4,184
Chichester (R-AW6)	Urban City and Town	South East	7.6	4,184
Brighton (Phase 1) (TC-AW1)	Urban City and Town	South East	7.0	4,184
Winchester (City Centre) (TC-AW2)	Urban City and Town	South East	1.0	4,184

1. The comparator areas exclude all other case study areas within the region.

Maps illustrating the rural urban classification for each case study area, and the corresponding comparator areas are provided in Appendix C.

4.3.2. Additional considerations for comparator area selection

Additional analysis was undertaken to ensure that the comparator areas selected provide good guidance in terms of collision trends (for seasonal variation and long-term drift in the mean collision rate), when compared with the case study areas.

The following analysis was undertaken to determine whether the comparator areas selected for the analysis are fit for purpose (presented in more detail in Appendix E.3):

- **Initial test of fit between case study and comparator areas** – Expected values for the number of collisions in case study areas were estimated by adjusting the number of collisions in the relevant comparator area, taking account of the different collision rates between case study and comparator areas due to their difference in size. The observed and expected collisions were then compared to determine whether the differences were within the limits to be expected through natural random variation (according to a Poisson distribution). While the comparator areas cannot be expected to provide a perfect predictor of what the mean collisions would be in the case study areas, the results obtained from the chi-squared tests show a remarkably small amount of over-dispersion[8].

- **Should the comparator areas be adjusted to reflect road types included in the case study areas?** – The analysis then considered whether the above fit could be improved by undertaking a weighted analysis, where the collision data for the respective lengths of the three road classes[9] in comparator areas were weighted to represent the relative proportions in the case study areas. The results showed little difference between the weighted and unweighted analyses. Both models showed a good fit (based on a chi-square test) and no significant evidence of "over-dispersion".

- **Is there a good fit between each individual case study area and its comparator area?** – Separate chi-squared tests to assess individual case study area fit with its comparator area gave satisfactory results and provide no grounds for omitting any of the case studies from the analysis.

- **Assessing the fit using aggregated data across all case study and comparator areas** – Finally, we tried another approach, where all the sites' data was tested within one Poisson Generalised Linear Model. Again, this showed a good fit (chi-square test) and no significant evidence of "over-dispersion".

It was therefore concluded that the comparator areas selected for the analysis are fit for purpose, and that there is no need to adjust for the respective lengths of the three road classes between comparator and case study areas.

4.4. Before and after data spans

A key strength of the approach set out in Section 4.2, is the ability to make use of all data available for each case study, however, limited or extensive. The before and after data spans used for each of the case study areas (and the corresponding comparator areas) are summarised in Table 4-4 below. This shows the amount of before and after data available for analysis.

The 'before' data leaves a gap of one year prior to implementation of the 20 mph limits in the case study areas, to avoid any changes in behaviour in the run up to implementation, as a result of consultation and education activities, disruption due to works, or phased implementation in the immediate area. This is consistent with the approach used in the analysis of area-wide speeds.

Ideally, a six-month buffer period would be applied to the 'after' data span, to match the approach for speed analysis and to allow time for the scheme outcomes to establish. The speed analysis was based on one year's before and one year's after TomTom data, and leaving a 6 months gap post implementation did not affect the sample of data available for analysis. However, adopting the same approach for the safety analysis would substantially reduce the amount of collision data available; to around 2 years in most cases, and to just 11 months in the case of Calderdale. As the number of collisions in the 'after' period is small, this would further reduce the chances of being able to detect a statistically significant change. All after data has therefore been used in the statistical analysis undertaken for the safety element.

Table 4-4 Before and after data spans for case study schemes

Case Study	Scheme Implementation Date	Before period (5 years before, with 1 year buffer)	After period (no buffer)	Number of months of after data
Walsall (Rushall) **(R-SM1)**	**Mar 2014**	01 Apr 2007 – 31 Mar 2013	01 Apr 2014 – 31 Dec 2016	33 months (2-3 years)
Winchester (Stanmore) **(R-SM2)**	**Jul 2014**	01 Aug 2007 – 31 Jul 2013	01 Aug 2013 – 31 Dec 2016	29 months (2-3 years)

[8] In statistics, over-dispersion is the presence of greater variability (statistical dispersion) in a data set than would be expected based on a given statistical model. It would be unreasonable to expect no over-dispersion in the data.
[9] Major strategic roads (FRC 1-3), important local roads (FRC 4-5), and minor local roads (FRC 6-7).

Case Study	Scheme Implementation Date	Before period (5 years before, with 1 year buffer)	After period (no buffer)	Number of months of after data
Liverpool (Area 7) (Adj. to City Centre) **(R-AW1a)**	**Apr 2014**	01 May 2007 – 30 Apr 2013	01 May 2013 – 31 Dec 2016	32 months (2-3 years)
Liverpool (Area 2) (NE of City Centre) **(R-AW1b)**	**Jan 2015**	01 Feb 2008 – 31 Jan 2014	01 Feb 2015 – 31 Dec 2016	23 months (1-2 years)
Middlesbrough (Phase 1 and 2) **(R-AW2)**	Mar 2012 – **Jun 2012**; Mar 2013 – **Jun 2013**	01 Jul 2005 – 30 Jun 2011	01 Jul 2013 – 31 Dec 2016	42 months (>3 years)
Calderdale (Phase 1) **(R-AW3)**	**Jun – Jul 2015**	01 Aug 2008 – 31 Jul 2014	01 Aug 2015 – 31 Dec 2016	17 months (1-2 years)
Nottingham (Bestwood) **(R-AW4)**	**Apr 2014**	01 May 2007 – 30 Apr 2013	01 May 2014 – 31 Dec 2016	32 months (2-3 years)
Brighton (Phase 2) **(R-AW5)**	**Jun 2014**	01 May 2007 – 30 Jun 2013	01 Jul 2014 – 31 Dec 2016	30 months (2-3 years)
Chichester **(R-AW7)**	**Jul 2013**	01 Aug 2006 – 31 July 2012	01 Aug 13 – 31 Dec 2016	41 months (>3 years)
Brighton Phase 1 **(TC-AW1)** (City Centre and Adjacent Residential Area)	**Apr 2013**	01 May 2006 – 30 Apr 2012	01 May 2013 – 31 Dec 2016	44 months (>3 years)
Winchester (City Centre) **(TC-AW2)**	**Sep 2014**	01 Oct 2007 – 30 Sep 2013	01 Oct 2014 – 31 Dec 2016	27 months (2-3 years)

4.5. Matching STATS 19 data to the TomTom GIS base map

A key challenge has involved matching the collision data from STATS 19 (which includes coordinates and a road reference) to the road segments in the TomTom GIS map layer, marked up with the pre- and post-scheme speed limits and presence / absence of traffic calming (see Sections 3.2 and 3.3).

The geographical coordinates of the collisions from STATS19 data were used to identify the road segments on the base map where the collisions occurred. When a collision could not be matched to a road segment (likely due to lack of reporting accuracy), a buffer of 10 meters was applied around the collision location. As a result, collisions were matched to the nearest road segment on the base map, within 10 meters of the collision location. For each match, the road number in the TomTom file was also checked against the road number in the STATS 19 file (when provided) as further verification.

This process has been undertaken using software called Feature Manipulation Engine (FME), to identify the collisions that occurred in case study areas. FME is a data processing tool that enables collision data to be overlaid onto the GIS map layer (where 20mph signed only areas are identified), and onto the TomTom data (where a road number is assigned to each road segment):

The algorithm is based on the following process:

1) Identification of the case study road segments (20mph sign only) from the GIS map;
2) Assigning a road number to each case study road segment, using the TomTom data;
3) Using STATS19 data, to plot and identify collisions that occurred on 20mph and 30mph roads and that occurred on the road numbers identified in step 2;
4) Match collisions to case study road segments by using the collision easting and northing coordinates; and
5) Where a collision cannot be matched onto a road segment, a 10-meter buffer is defined around the collision location to identify the closest road segment. Validation is then undertaken on the match, by checking that both the road number for the collision and the road number for the road segment (from step 2) are the same.

Where collisions occur at junctions with 20mph / 30mph limits, the collision has been assigned to whichever segment is closest (the Eastings and Northing references will always be closer to one segment). Maps of the collision locations (Appendix C) show what proportion of collisions occur in these locations.

See Appendix H for further information on the collision matching process.

4.6. Regression to the mean

Regression to the mean (RTM) arises in traffic safety studies through the site-selection process. If sites are selected for treatment on the basis of a high accident frequency in the preceding (typically) three years, then a before/after comparison will almost inevitably lead to an exaggerated estimate of the effect of the treatment. The magnitude of this bias can be appreciable (and easily be on a par with the magnitude of the treatment effect itself), as previously studies have demonstrated[10].

One approach to avoid RTM (as described in the RAC Foundation report by Allsop - 2013) is to collect historical accident STATS19 data for the sites from a number of years before the scheme implementation, and use this as the baseline period to compare with the after data.

As the case study schemes are intended to deliver area-wide benefits, and are not wholly safety driven, we do not consider RTM to be a problem for this study. Nevertheless, the use of five years of before data will mitigate against any effect which might exist.

[10] For example, see Appendix H of the DfT 4-year evaluation report on speed cameras: http://webarchive.nationalarchives.gov.uk/20090104005813/http:/www.dft.gov.uk/pgr/roadsafety/speedmanagement/nscp/nscp/thenationalsafetycameraprogr4597).

5. Change in collisions and casualties in 20mph (signed only) limits

5.1. Introduction

This chapter examines how the number of collisions and casualties on 20mph roads has changed in the case study areas, and explores the extent to which the change can be attributed to the introduction of 20mph (signed only) limits.

It first sets the context by describing the number and types of collisions occurring in the case study areas, prior to the change in speed limit.

It then looks at how collisions and casualties have changed in (i) residential and (ii) city centre case study areas, and compares the change in the number of collisions and casualties in the case study areas, with that observed in the corresponding comparator areas. A generalised linear model (as described in Chapter 4) is used to estimate the extent to which the change in the case study areas differs significantly from that which might be expected to occur given background trends in collision rates, and other factors such as economic trends and traffic growth, weather, etc. Specifically, the analysis focuses on the change in:

- total collisions;
- total casualties (and the number of fatal casualties); and
- collisions involving vulnerable road users (pedestrians, cyclists, under 16s, and older persons).

In each instance, quarterly collisions or casualty numbers from the case study areas have been filtered to the specific type of collisions (e.g. fatal collision, pedestrians etc) and their comparator areas to analyse the impact.

Further analysis is then presented to understand whether the observed changes are being driven by specific case study areas or by certain types of case study area, and why this might be occurring.

Finally, the Contributory Factors data is compared to determine whether there has been a change in the factors recorded as being related to the collisions in 20mph limit areas, recognising that this data is subjective on the part of the police attending the scene.

Collision – A ‘personal injury collision’ (referred to here as a ‘collision’) is an incident involving personal injury, which occurs on the public highway (including footways), in which at least one road vehicle is involved and which becomes known to the public within 30 days of its occurrence.

Casualty – For every one personal injury collision, there will be one or more casualty. These casualties can be the driver or passengers in a vehicle, or be vulnerable road users such as cyclists, pedestrians and equestrians.

Casualties are categorised by severity as fatal, serious injury, and slight injury. The recent introduction of CRASH, the new police system for recording collisions has greatly improved recording of the nature of injuries suffered by victims. However, in the short-term, this may result in significant deviation between the number of casualties classified as ‘serious’ by forces that use CRASH, compared with both preceding years, and to forces that do not. Early indications suggest that this has resulted in an increase in the proportion of casualties categorised as ‘serious’. It has therefore not been possible to undertake any meaningful statistical analysis by casualty severity as part of this study.

5.2. Characteristics of before collisions in case study areas

5.2.1. Overview

This section provides an overview of the scale and type of collisions occurring in the case study areas, prior to the introduction of the 20mph limits. The location of collisions in each of the case study areas is presented in Appendix C and detailed before data is provided in Appendix D.

- During the five year ‘before period’ there were 2,393 personal injury collisions and 2,903 casualties in the case study areas.
- The majority of injuries were slight (87%), with most of the remaining injuries (13%) categorised as serious. There were three fatal injuries during this period.
- Two fifths of those injured were pedestrians (24%) or cyclists (17%), accounting for a substantial proportion of total injuries. These vulnerable groups are expected to benefit from a safer environment following the introduction of the 20mph limits.
- The majority of those injured were aged 16-74, however, 6% were under 11, 7% were aged 11-16, and 5% were 75 or over. These groups are also identified as vulnerable groups, and 20mph limits are expected to deliver specific safety benefits, for example greater driver awareness, easier crossing, and improved perceptions of personal safety.
- In terms of location, collisions are dispersed across the case study areas, but are often more prevalent at road junctions.
- Brighton Phase 1 has a larger number of collisions and casualties per km per year, than elsewhere. The area represents 12% of the case study area total road length but 56% of all collisions and 55% of all casualties. Winchester also shows a high number of collisions and casualties when the length of road is considered. Both these case studies involve implementing 20mph limits on key strategic roads through the city centre where flows are higher. The implications of this are discussed further in later sections of the chapter.
- Amongst the residential case study areas, Brighton Phase 2 has a larger number of collisions overall and casualties per km per year, than other residential areas. The area represents 19% of the case study area total road length, and 19% of all collisions and casualties.
- Both Brighton case study areas comprise a large number of collisions and casualties, relative to other areas. Change in collisions in these areas will therefore have a strong impact on the overall results.
- As expected (see Chapter 2), higher classification roads (with higher flow) have much higher collision rates per kilometre than lower road classifications. Average collision rates per kilometre per year are 7.921 on important strategic roads (FRC1-3), 2.353 on important local roads (FRC4-5), and 0.303 on minor local roads (FRC6-7).
- When considering individual case study areas, it is important to note that the majority of road length considered is in the minor local road category (FRC6-7), with this category representing over 90% of road lengths included in the case study areas overall and for most individual case study areas. The exceptions are Brighton Phase 1 where 10% of road length is FRC1-3 and 16% is FRC4-5; and Winchester where close to 40% of roads are FRC4-5.

5.2.2. Contributory factors associated with before collisions in case study areas

When a police officer attends the scene of a personal injury collision, additional data is recorded about the collisions referred to as ‘contributory factors’. These are a list of pre-defined terms that could be an explanatory reason for a collision, and the police attending the incident can record up to six of these factors as contributing to the collision occurring. Contributory factors are therefore a subjective form of explaining the cause of a collision, and only relevant to those collisions where police officers attend the scene.

The analysis of contributory factors therefore focuses on the proportion of collisions where the police attended the incident and recorded details about the contributory factors. Further, as some contributory factors occur very irregularly, this analysis will focus on just the most commonly occurring 10 contributory factors.

Table 5-1 shows the most frequently reported contributory factors for before collisions, on roads included in the case study areas; with the most frequently identified factors highlighted in bold. The table also shows whether each contributory factor is one of the top ten contributory factors from the 2015 GB data, as published by the DfT[11]. Where an entry is 'N/A' the contributory factor was not in the top ten of 2015.

Table 5-1 Most frequently reported contributory factors for before collisions on roads included in the case study areas

Top 10 contributory factors (vehicles unless stated)	**Case study areas**		**GB 2015 Top 10 contributory factors**	
	No.	%	Rank	%
Failed to look properly*	528	**37%**	**1**	46%
Pedestrian - Failed to look properly*	248	**17%**	6	9%
Failed to judge other person's speed*	219	**15%**	**2**	23%
Poor turn or manoeuvre	171	12%	4	17%
Careless/ Reckless/ In a hurry*	162	11%	**3**	19%
Pedestrian - Careless/Reckless/ In a hurry*	98	7%	N/A	N/A
Slippery road (due to weather)	87	6%	7	8%
Loss of control*	80	6%	5	13%
Disobeyed Stop sign/ markings	77	5%	N/A	N/A
Stationary or parked vehicles	75	5%	N/A	N/A

**Factors most likely to be affected by a change in speed limit are highlighted in pink.*

It is possible to argue that the following contributory factors (highlighted in pink) could be affected by a change in speed limit:

- Failed to look properly (road users in general and pedestrians only) – If speeds were lower this may give road users / pedestrians more time to judge safe times to interact with the road.
- Failed to judge other person's speed – Lower and more consistent speeds could make judgement of speeds easier.
- Careless/reckless/in a hurry (road users in general and pedestrians only) – If speeds are lower then this could reduce reckless driving.
- Loss of control – If driving at lower speeds it is less likely a driver would lose control of their vehicle.

In most cases, reducing the speed limit to 20mph is expected to have a positive impact on safety and reduce the frequency with which these factors are reported. However, it is also possible that reducing the speed limit may make pedestrians complacent or drivers frustrated, resulting in an increase in 'failed to look properly' incidents or frequency of 'careless/reckless' behaviour.

Beyond these, the remaining contributory factors are less likely to be affected by a speed limit change. However, if traffic speed reduces, more time would be available for the right observation of risk to be made, and the consequences of any incidents would be less.

[11] From https://www.gov.uk/government/statistical-data-sets/ras50-contributory-factors

The most common contributory factors on case study area roads are all related to the failure to observe what is happening on the road network.

Most of the common contributory factors are present in the list of top 10 contributory factors nationally. The exceptions are ‘Pedestrian - Careless/Reckless/ In a hurry’, ‘Disobeyed Stop sign/ markings’ and ‘Stationary or parked vehicles’, which perhaps indicates how the characteristics of the case study roads differ from GB roads as a whole; and the fact that 20mph limits have generally been introduced on minor roads with more pedestrian activity.

5.3. How have collision and casualty rates changed in residential case study areas?

5.3.1. Overview

Collisions and casualties per year – A summary of the average number of collisions and casualties per year in the residential case studies and corresponding comparator areas is presented in Table 5-2. Data is presented for the five year before period, and the available after period, along with the percentage change between the two periods (before and after implementation of the change in speed limit).

A number of key observations can be drawn from this table:

- The number of collisions / casualties per year in the case study areas is generally small (typically less than 20).
- There is considerable variability between the case study areas, in terms of the percentage change between the before and after periods. This is not surprising given the small sample sizes and the random nature of collisions.
- The comparator areas are much larger than the case study areas, and consequently there is generally less variability between the different comparator areas.
- While a number of case studies show a greater reduction in collisions / casualties than in the corresponding comparator areas, these results are based on very small case study sample sizes.
- The comparator areas for Liverpool Area 2 and Liverpool Area 7 stand out as showing a substantial reduction in collisions / casualties between the before and after period, over around a third. This is much greater than the reduction recorded in any of the other comparator areas. Much of the north-west comparator area is focused on Greater Manchester, alongside roads in Liverpool which still have a 30mph limit in place. Collision data shows that the number of collisions per year has declined steadily between 2008 and 2016. The reasons for the decline are unclear, however, discussion with Transport for Greater Manchester identified two factors which may have contributed to the trend:
  - Firstly, the closure of public counters and phone lines at some police stations, making it more difficult for public to report collisions which have not been attended by the police.
  - Secondly, increasing levels of congestion, partly linked to roadworks associated with development and construction sites, which may have reduced speeds and collisions on 30mph roads.
- There is considerable month-to-month variability within each case study area, and statistical modelling (presented below) is required to determine the relative change in the case study and comparator areas.

Table 5-2 Average number of collisions and casualties per year in residential case studies and corresponding comparator areas

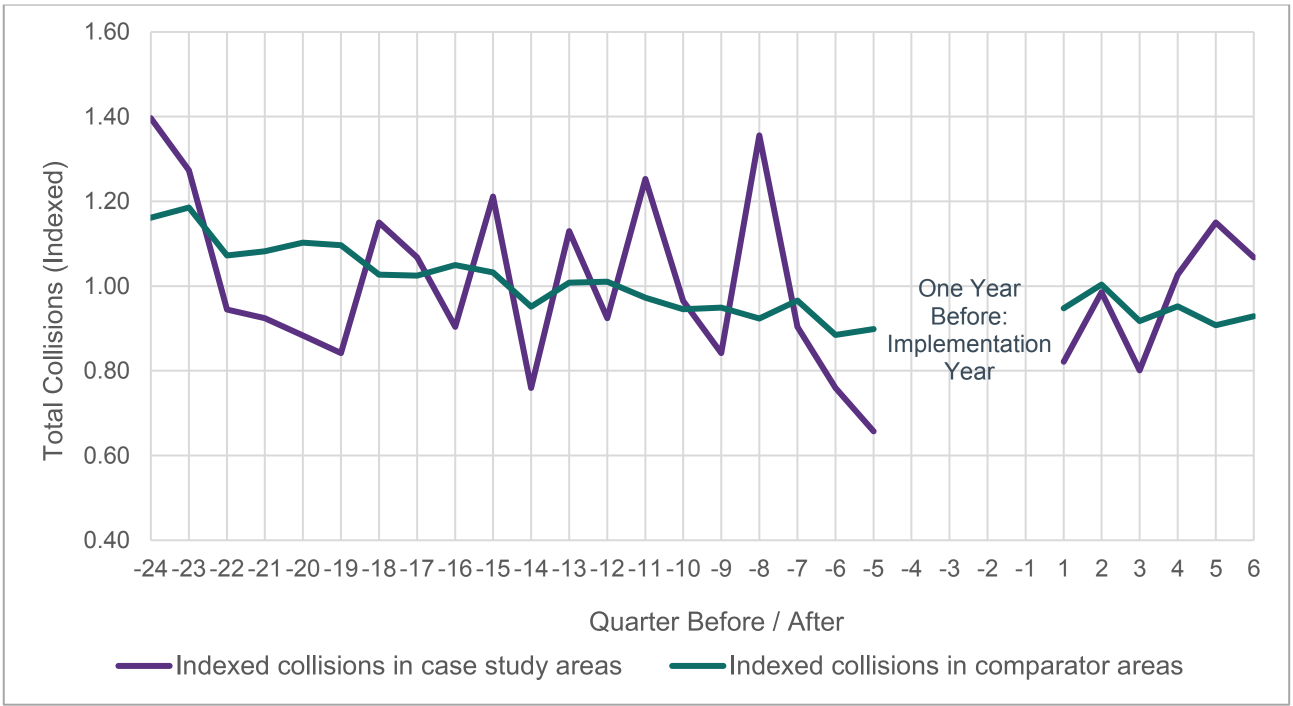
	Case study areas			Corresponding comparator areas		
	Average number / yr - before	Average number / yr - after	% Change	Average number / yr - before	Average number / yr - after	% Change
Number of collisions						
Walsall (Rushall) (R-SM1)	1	0	-74%	4,689	4,376	-7%
Winchester (Stanmore) (R-SM2)	4	4	-15%	7,657	7,743	+1%
Liverpool (Area 7) (R-AW1a)	15	14	-7%	6,027	3,983	-34%
Liverpool (Area 2) (R-AW1b)	17	10	-41%	5,641	3,625	-36%
Middlesbrough (R-AW2)	28	21	-26%	1,179	1,037	-12%
Calderdale (R-AW3)	13	11	-20%	3,142	2,548	-19%
Nottingham (Bestwood) (R-AW4)	13	14	+9%	1,259	1,280	+2%
Brighton (Phase 2) (R-AW5)	92	93	+1%	7,837	7,903	+1%
Chichester (R-AW7)	13	14	+13%	7,819	7,869	+1%
All residential areas	**196**	**180**	**-8%**	-	-	-
Number of casualties						
Walsall (Rushall) (R-SM1)	2	0	-85%	6,423	5,925	-8%
Winchester (Stanmore) (R-SM2)	5	6	+16%	9,524	9,506	0%
Liverpool (Area 7) (R-AW1a)	23	18	-20%	8,380	5,458	-35%
Liverpool (Area 2) (R-AW1b)	24	13	-47%	7,806	4,976	-36%
Middlesbrough (R-AW2)	34	25	-26%	1,619	1,409	-13%
Calderdale (R-AW3)	19	15	-21%	4,405	3,413	-23%
Nottingham (Bestwood) (R-AW4)	16	15	-6%	1,595	1,598	0%
Brighton (Phase 2) (R-AW5)	108	107	0%	9,743	9,677	-1%
Chichester (R-AW7)	15	19	+26%	9,726	9,644	-1%
All residential areas	**245**	**218**	**-11%**	-	-	-

Although a number of the case studies are based on the same comparator area (e.g. Liverpool Area 7 and Liverpool Area 2), the timespans are different for each case study and hence the before and after data for the comparator areas differs.

As some comparator areas are used more than once it is not appropriate to sum the rates and compare with the aggregated results for the case study areas.

Overall trend – Figure 5-1 shows the change in collisions in the aggregated set of residential case study areas and their associated comparator areas over time.

Figure 5-1 Quarterly indexed collisions for case study and comparator areas – Predominantly residential case study areas



The data is presented on a quarterly basis over the period that all case study areas have in common. This means that there is quarterly data for 6 years before to 1 year before the scheme (spanning five years in total), and from the first quarter after implementation until quarter six after implementation. While some case study areas have more than six post-scheme quarters of data available, others do not and so this period is shown for consistency across all case study areas. The data is indexed to the average value of each dataset to allow the trend to be observed without the comparison being obscured by the fact that the volume of collisions in comparator areas is much higher than in the case study areas.

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The comparator data shows a gradual decline during the before period, followed by a levelling off in the after period. We would expect the before trend to be replicated in the case study areas as it is most likely due to factors other than speed limit reductions such as improved vehicle performance and safety, road safety awareness and training, etc. This provides a baseline for the statistical model to consider whether there has been a significant change in collisions in case study areas, in the period following the introduction of 20mph speed limits.

While not shown here, when the individual comparator area trends are examined, the trend is much less smooth. Some comparator areas show an increase in collisions in the after period while others show a decrease; but with considerable fluctuation between quarters.

The case study data also shows an overall decline in the before period, followed by a levelling off in the after period. However, the data fluctuates substantially over time due to the small size of the case study areas, seasonality effects, and the random nature of collisions. This makes it difficult to understand the relative change in the after period, requiring use of the statistical model to determine whether the relative difference between the case study and comparator areas is significant.

Statistical analysis – Table 5-3 shows the results for the statistical analysis for the above residential case study areas. The form of the input data is described in Chapter 4. The data for the case study and comparator areas has been aggregated on a quarterly basis (i.e. a 3 month period). See Appendix F for detailed statistical output.

Table 5-3 Change in collisions and casualties in residential case studies, relative to comparator areas

	Estimated Change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample required for 95% signif
Change in collisions (n = 1575)	-0.5%	-10.4%	+10.4%	0.925	✗	688,943
Change in casualties (n = 1936)	-0.8%	-9.7%	+9.1%	0.873	✗	289,315
Change in fatal casualties (n = 5)	Poor fitting model					
Change in pedestrian casualties (n = 436)	-7.3%	-24.1%	+13.2%	0.456	✗	3,009
Change in cycling casualties (n = 298)	Poor fitting model					
Change in under 16yrs casualties (n = 196)	-4.1%	-23.2%	+19.7%	0.712	✗	10,234
Change in over 75yrs casualties (n = 79)	Poor fitting model					

n = combined before and after sample for case study areas

The above changes (relative to the comparator areas) are all non-significant, and should not be reported.

The 'estimated change' has been calculated by the statistical model, based on quarterly data for the case study and comparator areas. It therefore differs from the change that might be inferred from Table 5-2, which is based on the average number of collisions / casualties per year.

As an aide to interpretation:

- The first column shows the categories of casualties and collisions tested.
- The second column shows the estimated change in collisions / casualties across the case study areas following the change in limit, relative to the comparator areas, i.e. collisions are estimated to have fallen by 0.5% more in the case study areas than they did in the comparator areas.
  - *So, for illustrative purposes only, assume that there were 100 collisions in a hypothetical case study area in the before period and the reduction in its comparator area was 10%. The model is estimating that, on average, the reduction in the case study area due to the background trend is 10 collisions (i.e. 10%) reducing the after collisions to 90, with a further 0.45 collisions (0.5%*90 collisions) associated with the introduction of the 20mph limit. In this hypothetical scenario, the number of collisions in the after period is, on average, 89.55, i.e. 100 * (1-0.1) * (1-0.005). The model provides an estimate of the real situation, so does not necessarily predict whole numbers of collisions.*

  In broad terms, the model uses the ratio of before collisions vs. after collisions in the individual comparator areas to estimate the expected change in the corresponding case study areas in the absence of any '20mph effect', and uses the residual change to estimate the '20mph effect'. Overall, greater weight is given to case study areas with larger numbers of collisions and less to those that have smaller numbers of collisions.
- The third and fourth columns indicate the confidence interval, associated with the observed change. This is the range within which the real change across all 20mph limits with similar characteristics to the case study is believed to lie. In the case of the change in collisions, there is a 95% likelihood that the real change lies between -10.4% (reduction) and +10.4% (increase).
- The fifth column shows the p-value. This is a number between 0 and 1, and is a standard way of indicating the strength of significance of a result:
  - A large p-value (>0.05) indicates weak evidence to reject the null hypothesis that there has been no change relative to the comparator areas.
  - A small p-value (typically ≤0.05) indicates strong evidence to reject the null hypothesis that there has been no change relative to the comparator areas.
  - p-values very close to the cut-off (0.05) are considered to be marginal (could go either way).

- The sixth column indicates whether the change is statistically significant. If the p-value is >0.05 and confidence interval encompasses both a positive and negative change (as in the case of the change in collisions), then the conclusion is that the change is not statistically significant.
- The final column shows the (increased) sample size that would be required to achieve significance, if the estimated change remained the same. Let's assume the estimated change is -7.3%. In logged terms this is an effect of log(0.927) = -0.076, with a 95% CI of (-0.276, +0.124), so that the standard error of log(effect)) is 0.102. For this to be marginally significant (at the 5% level), the 95% CI would need to be (-0.152, 0), so the width of the CI would reduce from 0.400 to 0.152: a factor of (0.4/0.152) = 2.63. So, either the z value in the calculation of the CI would need to be 0.076/0.102 = 0.745 instead of 1.96, leading to a 54% CI (or a P value of 0.46); or the standard error of the log(effect) would need to decrease by a factor of 2.63 and hence the sample size would need be increased by a factor of 2.632 = 6.9, and therefore the sample size would need to be 6.9 x 436 which is approximately 3000. The calculation refers to the *combined* (before and after) sample size, but gives an indication of the scale of additional after data needed. This calculation is only undertaken for results which are not significant.

Change in collisions – Relative to the comparator areas, the number of collisions recorded in the residential case studies is estimated to have fallen by 0.5%[12]. However, the confidence interval is wide (-10.4% to +10.4%), and the real change could be either positive or negative.

Change in casualties – Relative to the comparator areas, the number of casualties recorded in the residential case studies is estimated to have fallen by 0.8%. However, the confidence interval is wide (-9.7% to +9.1%), and the real change could be either positive or negative.

In the case of fatal casualties, the model fit was not sufficient to draw any conclusions about the change relative to the comparator areas (i.e. there was a large discrepancy between the observed values and the values expected in the model in question). A larger sample of data is needed enable a conclusion to be drawn about the scale and direction of change.

Change in pedestrian and cycle casualties (vulnerable users) – Relative to the comparator areas, the number of pedestrian casualties recorded in the residential case studies is estimated to have fallen by 7.3%. While this appears to represent a sizeable change, the confidence interval is very wide (-24.1% to +13.2%), and the real change could be either positive or negative.

In the case of cycle casualties, the model fit was not sufficient to draw any conclusions.

Note that both of these analyses are based on fairly infrequent events (only a small subset of collisions involve either a pedestrian or cyclist) and so the quarterly observations used in the model are often quite small. A larger sample of data is needed enable a conclusion to be drawn about the scale and direction of change.

Change in child and older casualties (vulnerable users) – Relative to the comparator areas, the number of child casualties recorded in the residential case studies is estimated to have fallen by 4.1%. Again, this appears to represent a sizeable change, but the confidence interval is very wide (-23.2% to +19.7%), and the real change could be either positive or negative.

In the case of older people, the model fit was not sufficient to draw any conclusions. There are only 79 casualties involving road users over 75 years across the residential case study areas over the time period considered, and so these occur quite infrequently, making it hard to get a good fitting model. Again, a larger sample of data is needed enable a conclusion to be drawn about the scale and direction of change.

Change by road type – The results also show no significant change when disaggregated by road type (Table 5-4).

[12] Note - This isn't to say that each of the case study areas shows the same response, but that the response (relative to the comparator areas) across all the case study areas shows a 0.5% reduction.

Table 5-4 Estimated treatment effect – Change in collisions by road type

	Estimated Change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample for 95% Sig
Major strategic roads (FRC 1-3) (n = 17)	+25.3%	-51.7%	+225%	0.643	✕	303
Important local roads (FRC 4-5) (n = 401)	-12.5%	-28.9%	+7.7%	0.207	✕	968
Minor local roads (FRC 6-7) (n = 1,156)	+5.6%	-6.5%	+19.3%	0.376	✕	5673
All roads	**-0.5%**	**-10.4%**	**+10.4%**	**0.925**	✕	**688,943**

n = combined before and after sample for case study areas

The above changes (relative to the comparator areas) are all non-significant, and should not be reported as changes.

Analysis by case study area – None of the residential case studies show a significant change in collisions at an individual case study level (Table 5-5).

Table 5-5 Estimated treatment effect – Change in collisions by case study area

Case study area	Relative weight or contribution to overall result	Change in collisions relative to comparator areas	95th Lower Confidence Limit	95th Lower Confidence Limit	p-value	Stat. Sig.	Sample required for 95% signif
Walsall	0%	-72.2%	-96.6%	126.2%	0.232	✕	21
Winchester Stanmore	2%	-16.3%	-62.9%	89.0%	0.669	✕	608
Liverpool Area7	7%	41.0%	-6.2%	111.8%	0.098	✕	150
Liverpool Area2	5%	-8.9%	-46.0%	53.4%	0.725	✕	3,108
Middlesbrough	16%	-15.5%	-34.8%	9.6%	0.204	✕	565
Calderdale	5%	-1.8%	-43.1%	69.4%	0.947	✕	72,500
Nottingham	7%	7.6%	-28.7%	62.5%	0.728	✕	3,135
Brighton Phase 2	51%	0.1%	-13.2%	15.4%	0.990	✕	~20m
Chichester	7%	12.3%	-23.0%	63.6%	0.547	✕	1,176

For all case study areas the change in collisions relative to the comparator areas is insignificant, and the figures for individual areas should not be reported as changes.

There are either too few collisions to determine whether the change is significant or not (in the smaller case study areas), or there are a larger number of collisions but the change is not of sufficient magnitude to be significant (larger case study areas).

Summary – Based on the above analysis, there is insufficient evidence to reject the null hypothesis that there has been no change in collisions and casualties following the introduction of 20mph limits. In other words, there is insufficient evidence to conclude that there has been a significant change in collisions and casualties following the introduction of 20mph limits in residential areas, in the short term (based on the post implementation data available to date).

Although the absolute number of collisions, casualties, pedestrian casualties, and child casualties (per km, per year) has reduced in the residential areas, there has also been a reduction in the corresponding 30mph comparator areas. There is currently considerable variation in the data across the different case studies and time periods, and statistical analysis indicates that the real changes in the case study areas could be positive or negative.

In all cases, the p-values are large indicating a high level of probability (generally more than 50%) that the relative reductions identified in the case study areas are due to chance, and that there is no meaningful difference between the reduction in the case study and comparator areas. While a number of case studies show a greater reduction in collisions / casualties than in the corresponding comparator areas, these results are based on very small case study sample sizes. The weightings attached to these findings in the statistical model are therefore small, and little confidence can be attached to their significance.

The availability of further ‘after’ data, showing a similar trend to the data currently available, would reduce the range within which the real change is estimated to lie (represented by the 95th lower and upper confidence limits). However, the estimated change for collision and casualties is only -0.5% and -0.8% respectively, and the amount of additional data required to demonstrate that this scale of impact is statistically significant is very substantial (688,943 records for total collisions and 289,315 records for total casualties!).

This does not mean that repeating the analysis in a couple of years’ time, when more case study data is available, will not show a significant change. Collision and casualty rates are known to fluctuate from year to year. Some of the analysis is based on small subsets of the data (particularly for collisions involving pedestrians, cyclists, children and older persons), and the post implementation data currently available may not be indicative of the longer term trend.

The after data for the case study areas shows an increase in collisions in quarters 4-6 (12-18 months after implementation), which is one reason for the non-significant findings. It would be interesting to see what happens after this, when further data is available.

5.4. How have collision and casualty rates changed in city centre case study areas?

5.4.1. Overview (city centre case studies)

Winchester City Centre and Brighton Phase 1 case studies are both categorised as 'City centre and adjacent residential areas'.

As described above, both case study areas contain a higher proportion of major strategic roads and important local roads than the residential case studies, and a lower proportion of minor local roads. As a result, they have much higher collision rates per kilometre than the residential case study areas (2.45 per km/year in Brighton Phase 1, and 1.11 per km/year in Winchester City Centre, in the before period).

Collisions and casualties per year – A summary of the average number of collisions and casualties per year in the two city centre case studies is presented in Table 5-6.

Table 5-6 Average number of collisions and casualties per year in city centre case studies and corresponding comparator areas

	Case study areas			Corresponding comparator areas		
	Average number / yr - before	Average number / yr - after	% Change	Average number / yr - before	Average number / yr - after	% Change
Number of collisions						
Brighton (Phase 1) (TC-AW1)	266	217	-19%	7,902	7,867	0%
Winchester City Centre (TC-AW2)	15	16	+1%	7,647	7,816	+2%
All city centre areas	**281**	**233**	**-17%**	-	-	-
Number of casualties						
Brighton (Phase 1) (TC-AW1)	317	250	-21%	9,815	9,650	-2%
Winchester City Centre (TC-AW2)	18	17	-3%	9,510	9,565	+1%
All city centre areas	**335**	**267**	**-20%**	-	-	-

Although Brighton (Phase 1) and Winchester City Centre are based on the same comparator area, the timespans are different for each case study and hence the before and after data for the comparator areas differs.

As some comparator areas are used more than once it is not appropriate to sum the rates and compare with the aggregated results for the case study areas.

The following observations can be drawn from the table:

- Brighton (Phase 1) is the biggest case study area, and the number of collisions and casualties is much greater than elsewhere. There was a substantial reduction in the average number of collisions / casualties per year between the before and after periods (-19% for collisions, -21% for casualties). In contrast there was little change in the comparator area. However, there is considerable month-to-month variability within both datasets, and statistical modelling (presented below) is required to draw a firmer conclusion.
- The number of collisions / casualties per year in the Winchester City Centre case study area is much smaller, and more likely to be influenced by the random nature of collisions. Both the case study and comparator area show little change in the average number of collisions / casualties per year.

Statistical analysis – Table 5-7 shows the results for the statistical analysis for the two city centre case study areas. The form of the input data is described in Chapter 4. The data for the case study and comparator areas has been aggregated on a quarterly basis (i.e. a 3 month period).

Brighton Phase 1 is the only case study area where we have been able to estimate a statistically significant change in collisions, relative to the 30mph comparator area. Relative to the comparator area, the number of collisions is estimated to have fallen by 18.3%. The confidence interval is wide (-25.3% to -10.7%), but does indicate a significant reduction.

Winchester City Centre is a much smaller area. Relative to the comparator area, the number of collisions is estimated to have fallen by 1.2%, however, the confidence interval is very wide and the real change could be either positive or negative.

It should be remembered that the larger the sample size, the greater the likelihood of being able to detect a significant change in collisions and casualties. The total number of before and after collisions in Brighton Phase 1 is 2143; compared with 112 in Winchester City Centre; and 1741 across the aggregated set of residential case studies. The likelihood of being able to detect a real change in Brighton Phase 1 is therefore much greater than elsewhere.

Table 5-7 Change in collisions in city centre case studies, relative to comparator areas

	Estimated Change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample required for 95% signif
Brighton Phase 1 (n = 2143)	-18.3%	-25.3%	-10.7%	<0.001	✔	-
Winchester City Centre (n = 112)	-1.2%	-33.7%	+47.4%	0.954	✕	128,788

n = combined before and after sample for case study areas

The change in Winchester City Centre (relative to the comparator area) is not significant, and should not be reported.

5.4.2. Detailed analysis of the change (in Brighton Phase 1)

Change in collisions and casualties - Table 5-8 shows that following the introduction of the 20mph limit, central Brighton has experienced a significant reduction in overall collisions and casualties, pedestrian casualties, and casualties aged 75 or over, relative to the comparator area. See Appendix F for detail.

Table 5-8 Change in collisions and casualties in Brighton Phase 1, relative to comparator areas

	Estimated Change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample for 95% Sig
Change in collisions (n = 2143)	-18.3%	-25.3%	-10.7%	0.000	✔	-
Change in casualties (n = 2516)	-19.7%	-26.0%	-12.8%	0.000	✔	-
Change in pedestrian casualties (n = 619)	-29.4%	-40.3%	-16.4%	0.000	✔	-
Change in cycling casualties[13] (n = 601)	5.0%	-10.7%	23.5%	0.556	✕	6,496
Change in under 16yrs casualties (n = 93)	-17.0%	-40.0%	14.9%	0.261	✕	505
Change in over 75yrs casualties (n = 133)	-50.9%	-66.7%	-27.7%	0.000	✔	-

n = combined before and after sample for case study areas

The change in cycle casualties and child casualties (relative to the comparator areas) are all non-significant, and should not be reported.

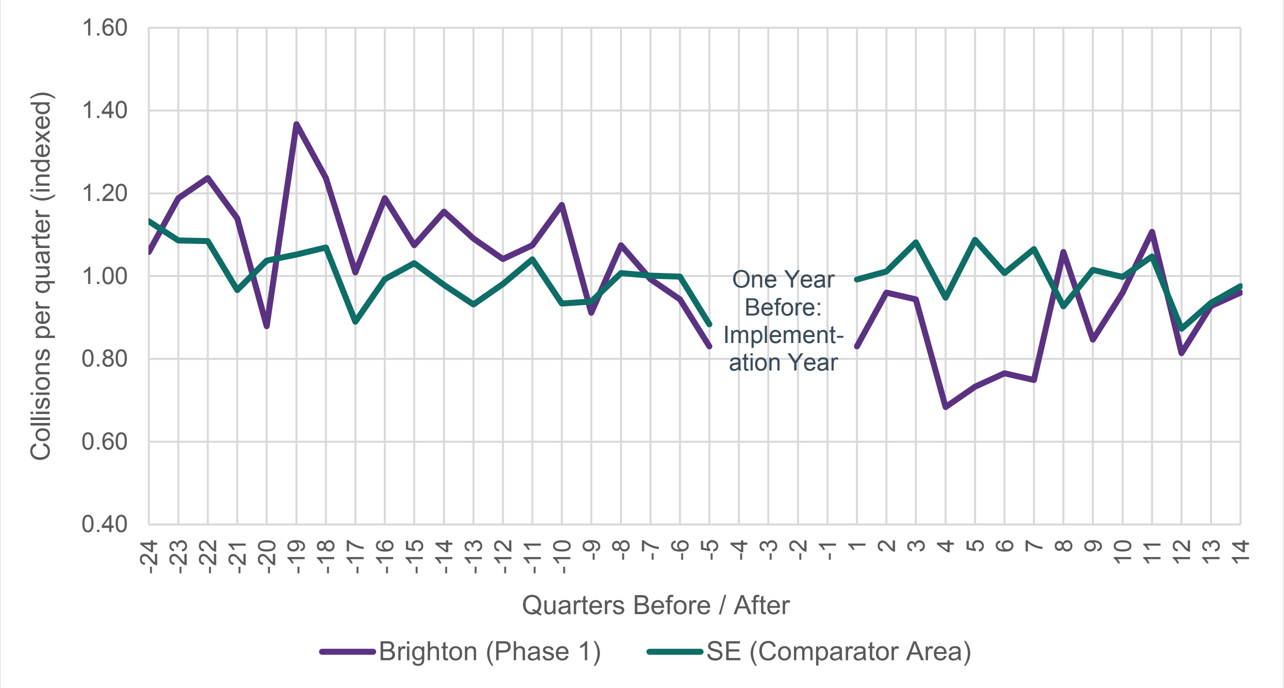
The 'estimated change' has been calculated by the statistical model, based on quarterly data for the case study and comparator areas. It therefore differs from the change that might be inferred from Table 5-5, which is based on the average number of collisions / casualties per year.

[13] Cycle count data provide by the Council suggests there has been a 28% in cycling across the wider city (not just the Phase 1 area) since 2008.

In absolute terms, the number of collisions per km of road per year fell from 2.448 to 2.021 between the before and after periods, corresponding to a 17.4% reduction.

Relevance of comparator trend - To understand what is driving these findings, Figure 5-2 shows the collision trend in Brighton over time against the trend in the comparator area (other Urban City and Town locations in the South East).

Figure 5-2 Quarterly indexed collisions for Brighton Phase 1 case study and comparator area



The data is indexed to the average value of each dataset to allow the trend to be observed without the comparison being obscured by the fact that the volume of collisions in comparator areas is much higher than in the case study areas.

The graph shows that the statistical results are a product of a general downward trend in collisions in Brighton (Phase 1) and a more stable trend in the comparator area.

It is interesting to note that the case study area collisions already appeared to be on a downwards trend even prior to the introduction of the 20mph speed limits[14], suggesting other factors have influenced the trend. The number of collisions dropped further during the second year following implementation (quarters 4 to 7), but then increased. Further data would be required to determine the long term trend.

5.4.3. Role of influencing factors (in Brighton Phase 1)

The above section shows that there has been a significant reduction in overall collisions, overall casualties, pedestrian casualties, and casualties aged 75 or over. To understand what is driving these changes, this section examines the role of influencing factors, including:

- road type;
- potential factors identified in the theory of change logic maps (or intermediate outcomes), including change in speed, smoother and more consistent driving, and driver awareness of risks and hazards; and
- external factors such as change in traffic flow, wider policy, the presence of major road works, and reporting processes.

Change by road type – Further analysis has also been conducted on the road types within the Brighton Phase 1 area - major strategic roads (FRC 1-3), important local roads (FRC 4-5), and minor local roads (FRC 6-7).

The role out of new 20mph (signed only) limits in Brighton Phase 1 included higher flow major strategic roads and important local distributor roads, as well minor local roads. Elsewhere, new 20mph limits have

[14] The potential reasons for this were discussed with Brighton City Council, but no clear factors were identified.

typically been implemented on minor local roads, with distributor roads largely left unchanged. As such, the minor local road category (FRC6-7) accounts for over 90% of the total road length across all case study areas, but only 74% of the road length in Brighton Phase 1. The difference can be observed in Figure 5-3 and Figure 5-4 which show the location of new 20mph limits in Brighton Phase 1 and Liverpool Area 7 respectively.

Collision rates are generally considered to be a product of road standards and level of flow. Major strategic routes have higher flow and much higher per km collision rates than less strategic routes (see Appendix tables D3 and D9 which show for each case study area the higher grade roads have higher collision rates), resulting in a much higher number and rate of collisions in Brighton Phase 1 overall and the presence of 20mph roads with a much higher density of collisions than elsewhere - see for example, the local distributor roads running east west parallel to the seafront (B2066), and the "Y" shaped roads (A23 and A270) leading north to south which are major strategic roads (Figure 5.3). These roads show a high density of collisions and have been changed to 20mph as part of the scheme. In contrast, there are no high-density collisions roads shown in Liverpool Area 7 (Figure 5-4) in large part because the higher flow roads are not part of the 20mph roll out.

Figure 5-3 Location of new 20mph limits (by road type) and collision density in Brighton Phase 1 (pre-scheme)

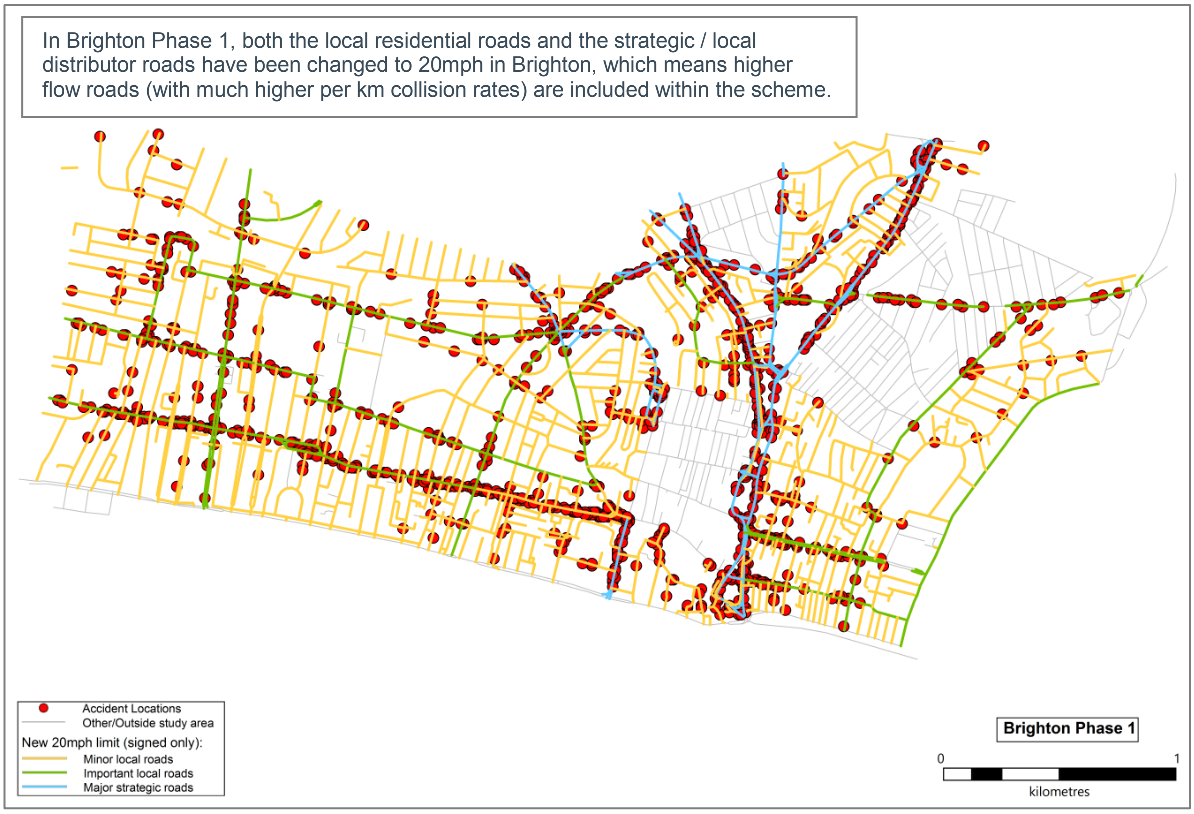
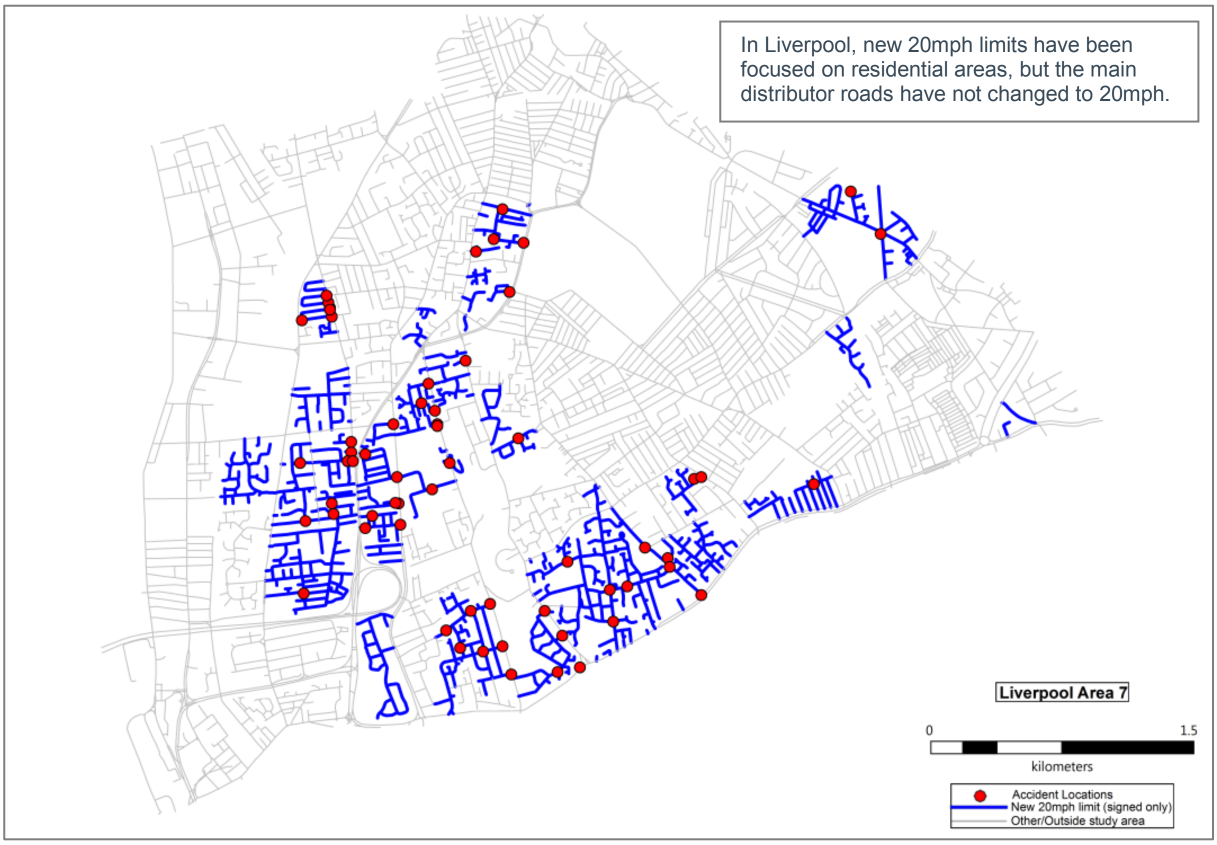


Figure 5-4 Location of new 20mph limits (by road type) and collision density in Liverpool Area 7 (pre-scheme)



Analysis by road type (Table 5-9) shows that there has been a significant reduction in collisions across all road types, but the change has been most pronounced on major strategic roads (-23.7%). As described above, these roads have higher traffic flows and much higher per km collision rates than less strategic routes, and the change on these roads contributes substantially to the overall change reported for Brighton Phase 1.

Table 5-9 Change in collisions by road type in Brighton Phase 1, relative to comparator area

	Estimated Change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample for 95% Sig
Major strategic roads (FRC 1-3)	-23.7%	-35.1%	-10.4%	9×10^{-4}	✔	-
Important local roads (FRC 4-5)	-16.1%	-28.3%	-1.8%	0.029	✔	-
Minor local roads (FRC 6-7)	-15.1%	-26.7%	-1.7%	0.029	✔	-
All roads	**-18.3%**	**-25.3%**	**-10.7%**	1×10^{-5}	✔	-

Although not as marked, the reduction in collisions on lower order roads in Brighton Phase 1 are also significant (-16.1% on important local roads, and -15% on minor local roads). This contrasts to the experience in other case study areas, comprised predominantly of minor local roads, where there has been no significant change.

Brighton Phase 1 includes the area surrounding the city centre. It is likely that many of the roads categorised as 'important local roads' and 'minor local roads' have higher flow and hence collision rates than similar grade roads in more residential areas. Although many of the minor roads are residential in nature, their proximity to the city centre makes them key distributor roads (which often include shops, services, and offices) means that they are likely to be used by through traffic as well as local residents. The potential for conflict is likely to be higher than on minor roads in more residential areas, and the potential for a reduction in collisions therefore more likely. This is supported by the collisions per km shown by case study area in

Appendix tables D3 and D9 which show that on all road types, collision rates are higher in Brighton Phase 1 than the other case study areas.

Figure G-2 (Appendix G) shows that many 'minor local roads' (FRC6-7) in Brighton (Phase 1) have average 7 day flows exceeding 2000 vehicles per day, while similarly classified roads in Walsall (Rushall) and Winchester (Stanmore) (both small-scale residential schemes) have flows well below 2000 vehicles per day. Similarly, flows on 'important local roads' in Brighton (Phase 1) are much higher than those in Walsall (Rushall) and Winchester (Stanmore). However, flows on 'important local roads' in Winchester City Centre, and on both types of roads in Brighton (Phase 2) are much closer to those in Brighton, suggesting that flow is not the only factor driving the change in Brighton (Phase 1). Similar data is not available for other case study areas, preventing a more comprehensive analysis from being undertaken.

Actual change in speed – The following evidence shows a small reduction in speed in the Brighton Phase 1 area:

- Analysis of area-wide journey time speeds (based on GPS journey speed data) shows that:
  - In the core city centre area, the median speed fell by 0.8mph, the 85th percentile speed fell by 1.5mph, and the 15th-85th percentile speed fell by 1.6mph.
  - In the adjacent residential areas (within Phase 1), the median fell by -1.0mph, the 85th percentile fell by 1.5mph, and the 15th-85th percentile speed fell by 1.9mph.
  - The biggest reduction in speed occurred on important local roads - but these roads have not experienced the biggest reduction in collisions.

- Results from spot speeds undertaken at 47 sites with a 20mph speed limit (1 on a major strategic road, 11 on important local roads, and 35 on minor local roads) show an average reduction across the area of 1.6mph (flow-weighted) after 13months, and -1.3mph (flow-weighted) after 26 months, varying from -9.0mph (decrease) to +7.6mph (increase) on individual roads.

Table 5-10 Change in speed by road type, based on GPS journey speed data (Brighton Phase 1: core city centre + adjacent residential area)

Core city centre + adjacent residential area

New 20mph limit (signed only)	Major strategic roads			Important local roads			Minor local roads		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	20mph		30mph	20mph	
Distance of Roads	6.8kms			14.9kms			52.6kms		
Sample VKMs Observed	365,776	371,272		210,695	230,866		109,715	130,030	
Compliance	94%	55%	-39%	90%	44%	-47%	97%	72%	-25%
Median Speed (mph)	19.6	18.8	-0.7	22.4	21.0	-1.4	16.1	15.8	-0.3
85th Percentile (mph)	27.0	25.7	-1.3	28.5	26.8	-1.8	24.1	23.1	-1.0
15th - 85th percentile	19.3	17.5	-1.8	15.5	14.5	-1.0	16.2	15.0	-1.2
% Driving <20mph	51%	55%	4%	36%	44%	7%	69%	72%	3%

Adjacent residential area only

New 20mph limit (signed only)	Major strategic roads			Important local roads			Minor local roads		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	20mph		30mph	20mph	
Distance of Roads	4.3kms			14.1kms			48.8kms		
Sample VKMs Observed	205,589	209,982		188,883	208,414		81,316	97,046	
Compliance	93%	51%	-42%	90%	43%	-47%	96%	69%	-28%
Median Speed (mph)	20.6	19.8	-0.8	22.5	21.1	-1.4	16.7	16.4	0.2
85th Percentile (mph)	27.8	26.5	-1.3	28.6	26.9	-1.7	25	23.8	-1.2

15th - 85th percentile	19.2	17.4	-1.9	15.7	14.7	-1	16.5	15.1	-1.4
% Driving <20mph	47%	51%	4%	36%	43%	7%	66%	69%	3%

Core city centre only

New 20mph limit (signed only)	**Major strategic roads**			**Important local roads**			**Minor local roads**		
	Before, After, Diff			**Before, After, Diff**			**Before, After, Diff**		
Speed Limit	30mph	20mph		30mph	20mph		30mph	20mph	
Distance of Roads	2.5km			0.8km			3.8km		
Sample VKMs Observed	160,187	161,290		21,812	22,452		28,399	32,984	
Compliance	96%	61%	-35%	92%	50%	-41%	100%	81%	-19%
Median Speed (mph)	18.3	17.6	-0.7	21.7	19.9	-1.8	14.3	13.9	-0.5
85th Percentile (mph)	26.0	24.7	-1.3	27.9	25.5	-2.4	21.4	20.9	-0.5
15th - 85th percentile	19.5	17.6	-1.9	13.9	12.6	-1.2	158.2	14.7	-0.4
% Driving <20mph	56%	61%	+5%	39%	50%	+11%	79%	81%	+2%

Results from spot speeds undertaken at 47 sites (1 on a major strategic road, 11 on important local roads, and 35 on minor local roads) show an average reduction across the area of 1.6mph (flow-weighted) after 13 months, and - 1.3mph after 26 months, varying from -9.0mph (decrease) to +7.6mph (increase) on individual roads.

Whether or not the small change in speed is due to the introduction of 20mph limits, this is expected to have had a positive influence on reducing the number and severity of collisions in the case study areas, all other factors being equal.

Finch et al. (1994) and Taylor et al. (2000) show that a change in mean spot speed of 1mph can be expected to reduce injury collisions by 5-6%. In absolute terms, the number of collisions per km per year fell by 17.4% between the before and after period; more than expected given the 1.3mph reduction in average speed.

Change in driver awareness – A net proportion of non-resident drivers agreed that 20mph limits increase driver awareness of potential risks and hazards (58% agreed, 13% disagreed); but residents were more likely to disagree than agree (30% agreed, 40% disagreed)[15]. The results suggest that there are mixed views on whether 20mph limits are perceived to have had a positive influence on driving standards; and there is insufficient evidence to determine whether driver awareness has had a positive influence on reducing collisions, all other factors being equal.

Change in traffic flow – Collisions are a consequence of flow and road standard, and so a change in flow could have contributed to the reduction in flow observed during the after period.

Evidence from the GB Road Traffic Count data collected by DfT shows a 4.1% reduction in annual traffic flow on major A roads in Brighton Phase 1, comparing average annual flow six years before implementation and four years post implementation (see Appendix G.2).

Data was also collected by the local authority over a 7 day period in Jun 2013 (just prior to implementation) and Jun 2015 (just over two years post implementation). Data was collected at 15 sites on important local roads (FRC4-5) and 37 sites on minor local roads (FRC6-7). Overall the data shows an increase in flow of 2%. However, further analysis shows this comprises a reduction of -1% on important local roads, and an increase of 8% on minor local roads. (See Appendix G.1)

This evidence suggests that a reduction in traffic flow on A roads (-4%) has contributed to the large change in collisions on 'major strategic roads', but is unlikely to be the key driver of change given the scale of reduction in collisions on major strategic roads. On important local roads, the significant reduction in collisions appears to have occurred against a backdrop of little change in traffic (-1%). On minor local roads,

[15] Non-resident drivers sample = 131. Residents sample = 201.

the significant reduction in collisions appears to have occurred despite a reported 8% increase in traffic on these roads.

Wider policy – Brighton City Council was asked what other policy initiatives have been introduced in recent years, which might have resulted in a reduction in collisions and casualties, but were unable to identify any other substantial initiatives. In terms of road safety, there has been a small reduction in the road safety budget in recent years, and there is no longer a dedicated road safety team. The Council works well with the Sussex Road Safety Partnership, to reduce road casualties across Sussex.

It was acknowledged that the Council hadn't invested as much in awareness and engagement activities to support the 20mph limit introduction as other locations, citing the marketing approach in Liverpool as an example.

Major works – There were a number of significant road schemes constructed during the period used for the after analysis (May 2013 – Dec 2016). This included a major scheme at Seven Dials (major roundabout) where at least one of the arms of the roundabout was closed between March 2013 and December 2013; road works on Edward Street in 2014 (however, monitoring undertaken by the Council suggested that the traffic impact was not very significant), and major works at Brighton Station in first half of 2015. These may have disrupted the flow of traffic, resulting in lower speeds and hence a lower collision rate. However, various capital schemes were also implemented during the period used for the before analysis.

Reporting processes – The Council were not aware of any changes in the way collisions and casualties have been reported by the police in recent years.

Summary – The evidence currently available suggests that the introduction of 20mph limits on higher flow roads has contributed to the significant reduction in the number of collisions and casualties recorded within the Brighton Phase 1 area, based on 3 years of post-implementation data. However, collisions are known to fluctuate over time and further data is required to determine the longer-term impacts of the change in the speed limit.

There has been a small reduction in speeds which is expected to have had a positive influence on safety outcomes, but there is mixed evidence on whether drivers in Brighton are now more aware of hazards and risks, and whether this has influenced the number of collisions in the after period. A reduction in traffic flow on A roads has contributed to the larger reduction in collisions on 'major strategic roads', but is unlikely to be the key driver of change given the scale of reduction in collisions on major strategic roads. Changes in traffic flow do not appear to have contributed to the significant reduction in collisions on 'important local roads' and 'minor local roads'.

It is interesting to note that the number of collisions dropped during the second year following implementation (quarters 4 to 7), but then increased in Year 3. It would be interesting to see what happens in Years 4 and 5, and how this affects the long-term trend.

5.5. Change in contributory factors

5.5.1. All case studies

Section 5.2.2 earlier in this report outlined the most commonly occurring contributory factors in the case study areas and how these relate to the most common factors in GB overall. It also identified contributory factors that could have some relationship with speed. This section considers how the frequency of contributory factors has changed. Table 5-11 compares the occurrence of contributory factors in the before and after periods, across all case study areas. The factors identified earlier as being most likely to be affected by speed changes are highlighted. **It should be remembered that not all collisions are included in the contributory factors database, and the allocation of factors is largely based on professional judgement. The findings should be treated with caution due to the limitations of the dataset, and further evidence is required to draw firmer conclusions.**

Table 5-11 Contributory factors associated with before and after collisions – all case study areas

Contributory Factor	Before		After		Percentage Point Difference	Stat. Sig.
	Collisions where factor identified	% of all collisions with CFs	Collisions where factor identified	% of all collisions with CFs		
Failed to look properly	528	37%	369	42%	**+5%**	✔
Ped - Failed to look properly	248	17%	138	16%	**-1%**	✕
Failed to judge other person's speed	219	15%	166	19%	**+4%**	✔
Poor turn or manoeuvre	171	12%	103	12%	**0%**	✕
Careless/Reckless/In a hurry	162	11%	154	18%	**+7%**	✔
Ped - Careless/Reckless/In a hurry	98	7%	48	5%	**-2%**	✔
Slippery road (due to weather)	87	6%	18	2%	**-4%**	✔
Loss of control	80	6%	47	5%	**-1%**	✕
Disobeyed Stop sign/markings	77	5%	17	2%	**-3%**	✔
Stationary or parked vehicles	75	5%	30	3%	**-2%**	✔

**Factors most likely to be affected by a change in speed limit are highlighted in pink.*
Sample size: 1447 before; 898 after.

Both highlighted and non-highlighted factors show percentage point changes in frequency. This demonstrates the difficulty in analysing what impact, if any, has occurred due to the introduction of 20mph.

The following driver-related factors, expected to be less prevalent in 20mph limits, have actually increased:

- Failed to look properly (+5%, a significant increase from 37% to 42%); and
- Failed to judge other person's speed (+4%, a significant increase from 15% to 19%).

Concerns that reducing the speed limit to 20mph may make pedestrians more complacent are not validated, with pedestrian-related factors showing no significant change or a small decrease in frequency:

- Ped - Failed to look properly (no significant change); and
- Ped - Careless/Reckless/In a hurry (-2%, a small significant reduction from 7% to 5%).

However, the data does support concerns that lowering the limit may increase driver frustration and distraction, with a significant increase in the proportion of collisions categorised as ‘careless / reckless / in a hurry’:

- Careless/Reckless/In a hurry (+7%, a significant increase from 11% to 18%).

Driver frustration and distraction may also explain the increase in ‘failed to look properly’ and ‘failed to judge other person’s speed’ incidents.

5.5.2. Predominantly residential case study areas

Comparison of contributory factors associated with before and after collisions in residential case study areas shows no significant change in the prevalence of the top 10 contributory factors.

The frequency with which the various factors identified in Table 5-12 changes in the after period varies from -7% to +5%, and broadly reflects the trend for all case study areas. However, the size of the dataset is relatively small (based on 670 collisions in the before period, and 398 collisions in the after period). This results in a high level of uncertainty about whether the data is indicative of a real increase or decrease in prevalence of these factors, or whether the changes are simply due to the random nature of collisions. **The findings should be treated with caution due to the limitations of the dataset, and further evidence is required to draw firmer conclusions.**

Table 5-12 Contributory factors associated with before and after collisions – Predominantly residential case study areas

Contributory Factor	Before		After		Percentage Point Difference	Stat. Sig.
	Collisions where factor identified	% of all collisions with CFs	Collisions where factor identified	% of all collisions with CFs		
Failed to look properly	252	38%	166	42%	+4%	✕
Ped - Failed to look properly	103	15%	55	14%	-1%	✕
Failed to judge other person's speed	95	14%	75	19%	+5%	✕
Poor turn or manoeuvre	80	12%	44	11%	-1%	✕
Careless/Reckless/In a hurry	82	12%	68	17%	+5%	✕
Ped - Careless/Reckless/In a hurry	46	7%	21	5%	-2%	✕
Slippery road (due to weather)	57	9%	9	2%	-7%	✕
Loss of control	50	7%	25	6%	-1%	✕
Disobeyed Stop sign/markings	38	6%	9	2%	-4%	✕
Stationary or parked vehicles	52	8%	22	6%	-2%	✕

**Factors most likely to be affected by a change in speed limit are highlighted in pink.*

Sample size: 670 before; 398 after.

5.5.3. Brighton Phase 1 only

The only significant change to collisions across all the case study areas occurred in Brighton Phase 1, and therefore a separate analysis of the contributory factors in just Brighton Phase 1 may help demonstrate why this scheme has been successful. Table 5-13 shows the top ten most common contributory factors for Brighton Phase 1 only, before and after the introduction of 20mph signed only. **Again, the findings should be treated with caution due to the limitations of the dataset, and further evidence is required to draw firmer conclusions.**

The data for Brighton Phase 1 shows no significant change in the prevalence of the top 10 contributory factors.

The frequency with which the various factors identified in Table 5-13 changes in the after period varies from -3% to +8%, and broadly reflects the trend for all case study areas. However, the size of the dataset is relatively small (based on 705 collisions in the before period, and 440 collisions in the after period). This results in a high level of uncertainty about whether the data is indicative of a real increase or decrease in prevalence of these factors, or whether the changes are simply due to the random nature of collisions.

Table 5-13 Contributory factors associated with before and after collisions – Brighton Phase 1

Contributory Factor	Before		After		Percentage Point Difference	Stat. Sig.
	Collisions where factor identified	% of all collisions with CFs	Collisions where factor identified	% of all collisions with CFs		
Failed to look properly	261	37%	191	42%	+5%	✕
Ped - Failed to look properly	136	19%	78	17%	-2%	✕
Failed to judge other person's speed	112	16%	88	19%	+3%	✕
Poor turn or manoeuvre	89	12%	55	12%	0%	✕
Careless/Reckless/In a hurry	77	11%	85	19%	+8%	✕
Ped - Careless/Reckless/In a hurry	48	7%	24	5%	-2%	✕
Slippery road (due to weather)	25	4%	8	2%	-2%	✕
Loss of control	25	4%	22	5%	+1%	✕
Disobeyed Stop sign/markings	39	5%	8	2%	-3%	✕
Stationary or parked vehicles	23	3%	8	2%	-1%	✕

**Factors most likely to be affected by a change in speed limit are highlighted in pink.*

Sample size: 705 before; 440 after.

5.6. Change in traffic flow

As highlighted above, collisions are a consequence of flow and road standard, and so a change in flow could have contributed to the reduction in collisions observed during the after period.

Evidence from the GB Road Traffic Count data collected by DfT shows that across the nine case study areas with count sites on major roads[16], average annual traffic flow <u>increased</u> by 1.8% across all case study areas with data and by 2.4% across all residential areas with data, comparing flows six years before implementation and up to five years post implementation (see Appendix G.2). The analysis does not take into account whether the roads in question have a 20mph limit, and is intended to provide an indication of the background trend in traffic on major A roads in these case study areas. There is no evidence to determine whether this trend also applies to other roads in the case study areas.

The number of count sites at individual case study areas varies substantially, and is particularly low for some case study areas. However, the following findings are based on a substantial number of count sites and gives an indication of the variation in trends between individual case studies:

- Liverpool Area 7 (54 sites, all on non-20mph limit roads) = +0.5%;
- Middlesbrough (35 sites, all on non-20mph limit roads) = +4.4%;
- Brighton Phase 1 (25 sites, all on 20mph limit roads) = -4.1%.

[16] The dataset does not include count sites in the Walsall (Rushall) and Winchester City Centre case study areas. Portsmouth was excluded from this analysis.

5.7. Key findings

What has been the change in residential areas?

- The comparator analysis indicates that there is insufficient evidence to conclude that there has been a significant change in collisions and casualties following the introduction of 20mph limits in residential areas, in the short term (based on the post implementation data available to date). Although the absolute number of collisions and casualties (per km, per year) has reduced in the residential areas, there has also been a reduction in the corresponding 30mph comparator areas.
- Collision and casualty rates are known to fluctuate from year to year. Some of the analysis is based on small subsets of the data (particularly for collisions involving pedestrians, cyclists, children and older persons), and the post implementation data currently available may not be indicative of the longer term trend. Repeating the analysis in a couple of years' time, when more case study data is available, may (or may not) show a significant change.

What has been the change in city centre areas?

- The comparator analysis shows that Brighton Phase 1 is the only case study area where the change in collisions and casualties, relative to the 30mph comparator area is significant. The results show a significant reduction in overall collisions (-18%), overall casualties (-19%), pedestrian casualties (-29%), and casualties aged 75 or over (-51%). However, there is no evidence to indicate a significant change in casualties involving cyclists and under 16s, at this time.
- The changes appear to be a reflection of the city characteristics; and the blanket implementation of 20mph limits across all roads within the scheme area, including higher flow A and B roads which have typically been excluded from the residential case study schemes. There has been a significant reduction in collisions across all road types, but the change has been most pronounced on major strategic roads.

6. Impact on neighbouring roads

6.1. Introduction

In addition to considering the impact that 20mph signed only has had on roads that have experienced a change in speed limit, it is also worth considering the impact on the neighbouring roads that have not experienced a change in speed limit. It is possible that the change in speed limits could have had wider impacts, which this analysis aims to identify.

The focus of this analysis is on 30mph roads surrounding the 20mph limit schemes, that have remained 30mph. The methodology remains the same as that used for the 20mph analysis. 30mph roads in the vicinity of the case study areas have been entered into a statistical model along with comparator area roads (30mph roads in the comparator areas) to control for background changes in collision rates. An overall impact has been determined using a negative binomial generalised linear model, and individual case study outputs have been considered to understand if individual case study areas are performing differently.

6.2. What impact is observed on 30mph roads?

Collisions per year – A summary of the average number of collisions per year on 30mph roads in the case study and comparator areas is first presented.

Table 6-1 Average number of collisions per year on 30mph roads surrounding the case study areas, compared with corresponding comparator areas

	Surrounding 30mph roads			Corresponding comparator areas		
	Average number / yr - before	Average number / yr - after	% Change	Average number / yr - before	Average number / yr - after	% Change
Walsall (Rushall) (R-SM1)	0	1	82%	4689	4376	-7%
Winchester (Stanmore) (R-SM2)	10	12	27%	7657	7743	1%
Liverpool (7) (R-AW1a)	170	138	-19%	6027	3983	-34%
Liverpool (2) (R-AW1b)	89	87	-3%	5641	3625	-36%
Middlesbrough (R-AW2)	2	1	-33%	1179	1037	-12%
Nottingham (Bestwood) (R-AW4)	33	42	25%	1259	1280	2%
Brighton (Phase 2) (R-AW5)	89	94	6%	7837	7903	1%
Chichester (R-AW7)	29	27	-8%	7819	7869	1%
Brighton (Phase 1) (TC-AW1)	5	3	-38%	7902	7867	0%
Winchester City Centre (TC-AW2)	2	3	73%	7647	7816	2%
All areas	**429**	**408**	**-5%**	**-**	**-**	**-**

As some comparator areas are used more than once it is not appropriate to sum the rates and compare with the aggregated results for the case study areas.

Similar observations can be drawn to those in previous sections:

- There is considerable variability between the case study areas, in terms of the percentage change between the before and after periods, which is not surprising given the small sample sizes and the random nature of collisions.
- The comparator areas are much larger than the case study areas, and consequently there is generally less variability between the different comparator areas.
- The comparator areas for Liverpool Area 7 and Area 2 again stand out as showing a substantial reduction in collisions between the before and after periods. (The comparator data is the same as that presented in Table 28, Section 10.2.1).
- In some case study areas (e.g. Brighton Phase 1) there are very few 30mph roads remaining, resulting in a very small number of collisions on these types of roads.

Statistical analysis – Table 6-2 shows the results of the statistical analysis comparing the change in collision on 30mph roads in case study and comparator areas. It shows a significant increase in collisions observed on neighbouring 30mph roads in the case study areas, of 17.5%, relative to the 30mph comparator areas and based on the data available to date.

Table 6-2 Estimated impact on surrounding 30mph roads – Change in collisions

	Estimated change	95th Lower Confidence Limit	95th Higher Confidence Limit	p-value	Stat. Sig.	Sample for 95% Sig
Relative change in collisions in case study areas	17.5%	9.0%	26.7%	2×10^{-5}	✔	702

When this result is separated into the individual case study area impacts, as shown in Table 6-3, it is apparent that the only case study areas that show significant results are the two Liverpool case study areas. These both show a statistically significance increase in collisions in the case study area relative to the North West comparator area.

Table 6-3 Estimated impact on 30mph roads – Change in collisions – by Case Study Area

Case Study Area	Relative weight or contribution to overall result	Estimated change	95th Lower Confidence Limit	95th Lower Confidence Limit	Stat. Sig.
Walsall	0%	95%	-73%	1283%	✘
Winchester Stanmore	3%	26%	-21%	100%	✘
Liverpool Area7	35%	23%	8%	39%	✔
Liverpool Area2	16%	51%	26%	82%	✔
Middlesbrough	1%	-24%	-72%	109%	✘
Nottingham	9%	23%	-4%	57%	✘
Brighton Phase 2	27%	5%	-9%	21%	✘
Chichester	8%	-8%	-30%	19%	✘
Brighton Phase 1	1%	-38%	-70%	31%	✘
Winchester City Centre	1%	69%	-37%	354%	✘

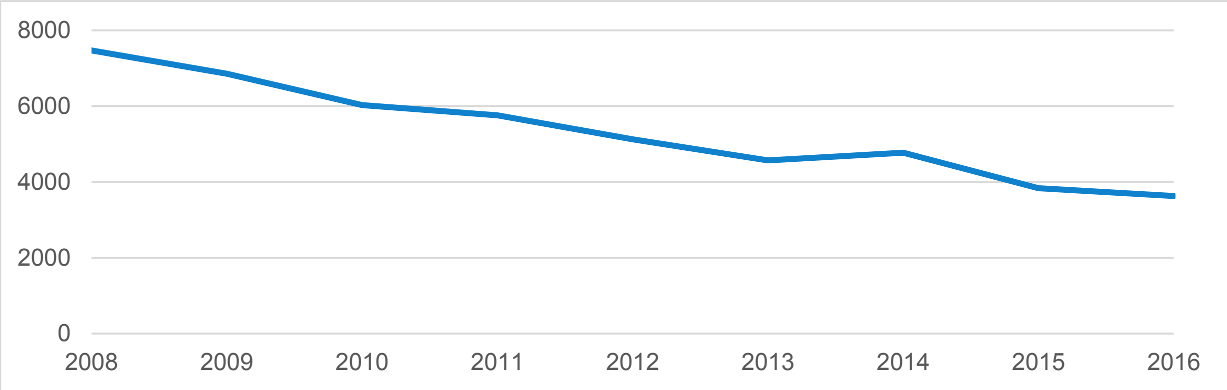
For all case study areas, except Liverpool Area 7 and Area 2, and the change in collisions relative to the comparator areas is insignificant, and the figures for individual areas should not be reported.

It appears that the cause of this increase is heavily influenced by the north-west comparator area having a large decrease in collisions over time (see Figure E-3, Appendix E), rather than because there has been an increase in the number of collisions in Liverpool. The number of collisions per month has actually decreased in both Liverpool Case Study areas between the before and after periods, just not as much as in the comparator area.

Trend in collisions on 30mph roads in the north-west comparator area

The STATS19 data for the north-west comparator area shows a steady decline in the number of collisions on 30 mph roads since at least 2008. This is in contrast to the trend recorded in the other comparator areas, where the data suggests there has been little overall change or a small increase or decrease over the same time period.

Number of collisions per annum in the north-west comparator area, based on STATS19 data



Much of the north-west comparator area is focused on Greater Manchester, alongside roads in Liverpool which still have a 30mph limit in place. A discussion with Transport for Greater Manchester identified two key factors which may have contributed to the STATS19 data trend.

Firstly, a number of public counters at police stations have been closed, making it difficult for members of the public to report collisions which have not been attended by the police. Some stations have also reduced or stopped facilities which enable the public to report collisions by phone. This may have resulted in a reduction in recorded collisions (captured in the STATS19 data), which exceeds the actual reduction in collisions on 30mph roads. In other words, the actual number of collisions per annum may not have declined as such as the STATS19 data suggests.

Secondly, there are significant congestion issues in Manchester, and the city was recently named the second most congested area in the UK after London[17]. Over the period of the analysis, there have been a substantial road works in place associated with the implementation of various transport schemes (MetroLink, bus priority measures, etc), which have contributed to the congestion and believed to have kept speeds down. Given the known relationship between traffic speed and number of collisions, this may have contributed to the substantial reduction in collisions per annum observed in the north-west.

Liverpool is also believed to be affected by increasing congestion, which may have impacted speeds and collisions on larger/arterial 30mph roads; again contributing to the substantial reduction in collisions per annum observed in the north-west.

6.3. Key findings

In this section, looking at the collision impact on neighbouring roads that have remained at the 30mph speed limit, it has been found that:

- There is a statistically significant increase in collisions on 30mph roads across all case study areas when compared to their comparator areas.
- However, sensitivity analysis shows that this increase is entirely driven by large increases in the two Liverpool case study areas only, relative to the comparator areas.
- Further examination of this shows that both the Liverpool areas have recorded a reduction in collisions, but not as substantial as the reduction recorded in the North-West comparator area. It is the relative reduction in the comparator area against the case study areas that results in the statistical model pointing towards a positive treatment effect in the two Liverpool case studies.
- It is not currently clear why the north-west comparator area would have a substantially greater reduction in collisions over time than the other comparator areas. However, discussion with Transport for Greater

[17] TomTom Traffic Index ranks 390 cities from 48 countries around the world.

Manchester identified two factors which may have contributed to the trend. Firstly, the closure of public counters and phone lines at some police stations, making it more difficult for public to report collisions which have not been attended by the police. Secondly, increasing levels of congestion, partly linked to roadworks associated with development and construction sites, which may have reduced speeds and collisions on 30mph roads.

7. Summary and conclusions

7.1. Introduction

This document reports on the analysis of safety outcomes on new 20mph limits (signed only) roads, in the case study areas selected for this research. Separate comparator areas have been selected for each case study scheme to control for background trends in collisions and other factors such as traffic growth, economic trends, weather, etc. The results from other areas of analysis are reported separately, and are brought together in the overarching Technical Report for the study.

7.2. How have collision and casualty rates changed in residential case studies?

The comparator analysis indicates that there is insufficient evidence to conclude that there has been a significant change in collisions and casualties following the introduction of 20mph limits in residential areas, in the short term (based on the post implementation data available to date.

Although the absolute number of collisions and casualties (per km, per year) has reduced in the residential areas, there has also been a reduction in the corresponding 30mph comparator areas. The analysis indicates a high level of probability (generally more than 50%) that the relative reductions identified in the case study areas are due to chance, and that there is no meaningful difference between the reduction in the case study and comparator areas, at this stage.

Collision and casualty rates are known to fluctuate from year to year. Some of the analysis is based on small subsets of the data (particularly for collisions involving pedestrians, cyclists, children and older persons), and the post implementation data currently available may not be indicative of the longer term trend. Repeating the analysis in a couple of years' time, when more case study data is available may (or may not) show a significant change.

7.3. How have collision and casualty rates changed in city centre case studies?

The comparator analysis shows that Brighton Phase 1 is the only case study area where the change in collisions and casualties, relative to the 30mph comparator area is significant. The results show a significant reduction in overall collisions (-18%), overall casualties (-19%), pedestrian casualties (-29%), and casualties aged 75 or over (-51%). However, there is no evidence to indicate a significant change in casualties involving cyclists and under 16s, at this time.

The changes in Brighton Phase 1 appear to be a reflection of the city characteristics; and the blanket implementation of 20mph limits across all roads within the scheme area, including A and B roads which have typically been excluded from the residential case study schemes.

However, collisions within Brighton were on a downward trend prior to the introduction of the 20mph limits, and the reduced speed limit is expected to be just one of the factors driving the reduction in collisions. There has been a small reduction in speeds which is expected to have had a positive influence on safety outcomes, but there is insufficient evidence to determine whether drivers in Brighton are now more aware of hazards and risks, and whether this has influenced the number of collisions in the after period. A reduction in traffic flow on A roads has contributed to the large reduction in collisions on 'major strategic roads', but is unlikely to be the key driver of change. Changes in traffic flow do not appear to have contributed to the significant reduction in collisions on 'important local roads' and 'minor local roads'.

7.4. Has there been a change in collision contributory factors?

The most common contributory factors include a mix of those more likely and less likely to be affected by changes in speed. Both types of factors show percentage point changes in frequency, demonstrating the difficulty in analysing what impact, if any, has occurred due to the introduction of 20mph.

Concerns that reducing the speed limit to 20mph may make pedestrians more complacent are not validated by the contributory factors data, with pedestrian-related factors (‘pedestrian failed to look properly’, and ‘pedestrian careless / reckless / in a hurry’) showing no significant change or a small decrease in frequency. However, further evidence is required to draw a firmer conclusion.

There is some evidence from the contributory factors data to support concerns that lowering the limit may increase driver frustration and distraction, with a significant increase in the proportion of collisions categorised as ‘careless / reckless / in a hurry’. However, limitations with the dataset used means that further evidence is required to draw a firmer conclusion.

7.5. Have the new 20mph limits resulted in any collision migration (or savings) to nearby roads?

Collision migration (or savings) may occur as a result of positive or negative changes in speed compliance or driver attention when leaving the 20mph road. Analysis of area-wide journey speeds shows no evidence to suggest that drivers are going faster than previously when leaving the new 20mph limit areas. However, driver attention may be higher than previously (due to increased awareness of hazards when driving through the 20mph limit), leading to fewer collisions on surrounding roads; or lower than previously (due to increased levels of frustration), leading to more collisions on surrounding roads.

Further safety analysis was therefore undertaken to examine any impact on 30mph roads surrounding the 20mph limit schemes; using the same methodology as that for the 20mph analysis. Hence, 30mph roads in the vicinity of the case study areas were entered into a statistical model along with comparator area roads (30mph roads in similar non-case study areas) to control for background changes in collision rates.

This analysis shows no evidence of collision migration in most of the case study areas. However, there is some evidence of collision migration on the 30 mph roads surrounding the Liverpool case study areas. In both areas, the number of collisions per month decreased between the before and after periods; just not as much as in the north-west comparator area, where a substantial decline has been recorded. The reasons for the decline in the comparator area are unclear[18], leading to uncertainty about whether there has been a slower decrease in collisions in the Liverpool case studies as a result of drivers speeding up and/or driving less safely when leaving the 20mph limit.

[18] However, discussions with Transport for Greater Manchester identified two factors which may have contributed to the trend. Firstly, the closure of public counters and phone lines at some police stations, making it more difficult for public to report collisions which have not been attended by the police. Secondly, increasing levels of congestion, partly linked to roadworks associated with development and construction sites, which may have reduced speeds and collisions on 30mph roads.

Appendices

Appendix A. Bibliography

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Appendix B. Likelihood of being able to detect a significant safety effect

B.1. Introduction

It is useful to be able to estimate the likelihood of obtaining a significant result (i.e. a significant change in the level of collisions in the after period compared with the before period) for any specified true value of α and any specified sample size (e.g. total number of collisions in the overall data set). Intuitively, we know that the more data we have, the more chance there is of obtaining a significant result, if there has been a real change; also that, the larger the amount of the real change, the more chance there is of obtaining a significant result.

To do this exactly would be challenging, but following simple model provides a useful approximation.

B.2. Power calculation

Let the total number of collisions, over all sites, be denoted by Y_B in the before periods and by Y_A in the after periods. Then, if the total number of site-years in the before and after periods are the same, we would test the null hypothesis that there has been no change (H_0: α = 1) by use of the test statistic $d = Y_A - Y_B$ and for a significance level of 5%, we would conclude there has been a significant reduction in the rate of accidents if $d < d^*$ where the probability, under H_0 of observing that $d < d^*$ is 0.05.

Since Y_A and Y_B are independent Poisson random variables (in which the variance is equal to the mean), then so long as the numbers are reasonably large, we can approximate the Poisson by a Normal distribution. So the distribution of d is Normal with a mean of zero and a variance of $2m$ where m is the mean number of accidents in either the before or after period. From this, it follows that the criterion we would use to determine whether there has been a significant reduction in accidents from before to after would be to say there has been a significant reduction if $d < d^*$ where $d^* = -1.645\sqrt{2m}$.

Now, if there has been a real reduction ($\alpha < 1$), then the test statistic d will have a Normal distribution with a mean of $m(\alpha - 1)$ and variance $m(\alpha + 1)$. So, the power of the test is then the probability that we get a significant result ($d < d^*$), given that d is Normally distribution with a mean of $m(\alpha - 1)$ and variance $m(\alpha + 1)$. This probability is given by:

$$\Phi\left(\frac{d^* - m(\alpha - 1)}{\sqrt{m(\alpha + 1)}}\right)$$

where Φ is the (cumulative) distribution function of the Unit Normal.

So, for example, suppose that the number of accidents is 100 or so in each of the two periods, then the test would be to reject the null hypothesis if the difference in accidents between after and before periods $d = Y_A - Y_B$ is less than $d^* = -1.645\sqrt{2m}$ = -23.3. If the true value of α is 0.8 (a 20% reduction in accident rate) then the distribution of d is Normal with a mean of -20 and a variance of 180.

So the probability that we observe $d < d^*$ is $\Phi\left(\frac{-23.3-(-20)}{\sqrt{180}}\right) = \Phi\left(\frac{-3.3}{\sqrt{180}}\right) = \Phi(-0.246) = 0.403$.

So there is a 40% chance of coming to the "correct" decision (that is, concluding that there has been a significant reduction when there really has been a reduction of 20%).

Some simple code (given below) has been written in R to repeat this calculation for the more general case of different sample sizes in before and after periods, and for various values of α.

```
mu1 <- 3024; mu2 <- 900; alpha <- 1.0; sig <- 0.05; T1 <- 1; T2 <- mu2/mu1
sigmad0 <- sqrt((mu1/(T1*T1))+(mu2/(T2*T2)))
```

```
dstar <- qnorm(1-sig)*sigmad0
avd <- (1-alpha)*mu1/T1
sigmad1 <- sqrt((mu1/(T1*T1))+(alpha*mu2/(T2*T2)))
power <- 1-pnorm((dstar-avd)/sigmad1)
alpha; mu1; mu2; power
```

The results for the power are in the table below. The calculations assume the before sample size for the case study areas ($\boldsymbol{m_1}$) is 3024, and various values of m2 (the sample size in the after period) are considered.

Table B-1 Probability of detecting a significant safety change (where the before sample = 3024, and the after sample = 100-900)

m_2 (After sample size for case study areas)	α = 1 (0% change)	α = 0.9 (10% change)	α = 0.8 (20% change)	α = 0.7 (30% change)	α = 0.6 (40% change)
100	0.05	0.24	0.64	0.94	0.998
200	0.05	0.39	0.88	0.998	>0.998
300	0.05	0.50	0.97	>0.998	>0.998
400	0.05	0.60	0.99	>0.998	>0.998
500	0.05	0.67	>0.99	>0.998	>0.998
600	0.05	0.73	>0.99	>0.998	>0.998
700	0.05	0.78	>0.99	>0.998	>0.998
800	0.05	0.82	>0.99	>0.998	>0.998
900	0.05	0.85	>0.99	>0.998	>0.998

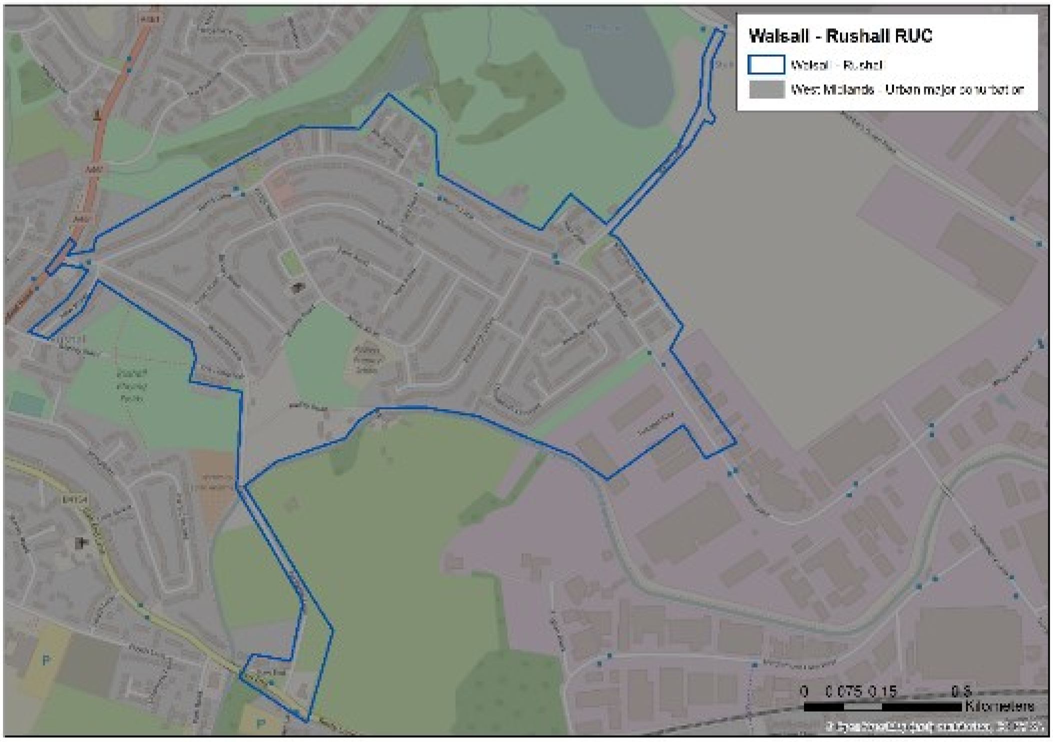
So, if the real change has been a reduction of 10% in accidents (α = 0.9), and we have approximately 900 collisions in each of the after period (m_2 = 900), then there is an 85% chance of obtaining a significant result at the 5% significance level. As expected we can see that, for any given α, the power increases as the sample size m increases; and, for any given sample size m, the power increases as the value of α decreases.

A lot of simplifying assumptions have been made in the above calculations. A set of simulation exercises have been carried out, using a more realistic representation of the data from a set of sites. Whilst it is not possible to reduce this to a simple formula, the results have shown reasonably close agreement with those from the simplified procedure above. Hence, we can have confidence that the results in the table above give a good indication of the likely power to be obtained in a variety of circumstances.

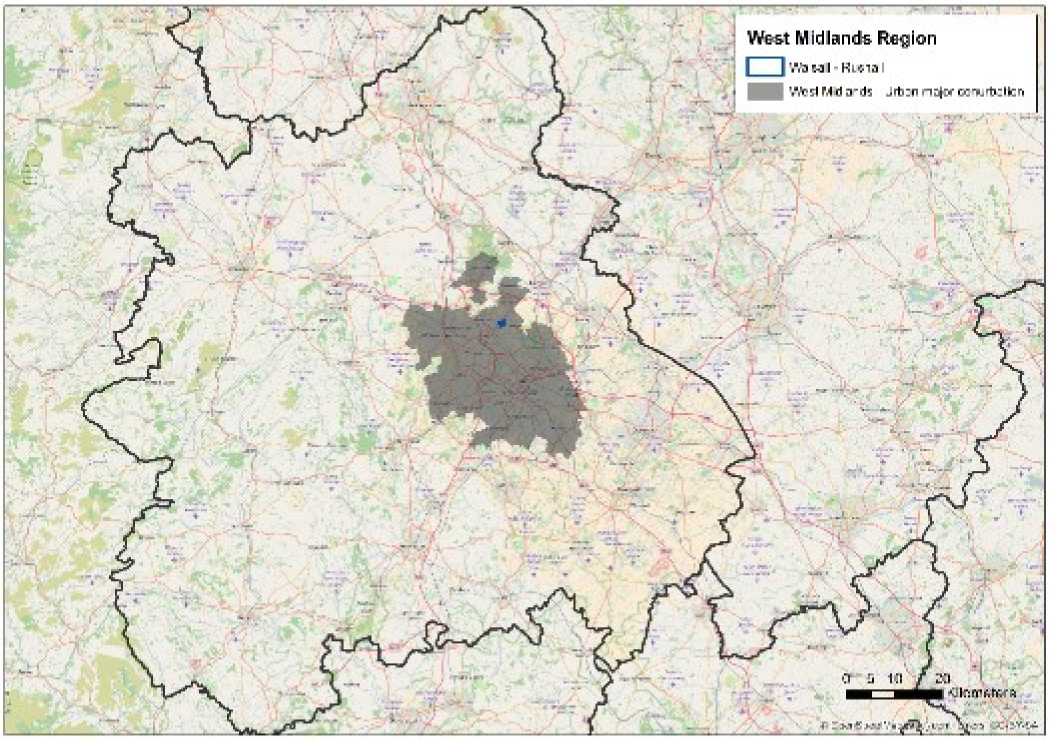
Appendix C. Case study specific data

C.1. Walsall - Rushall (R-SM1)

Rural-Urban Classification for Walsall (Rushall) - Urban Major Conurbation (0.5km^2)

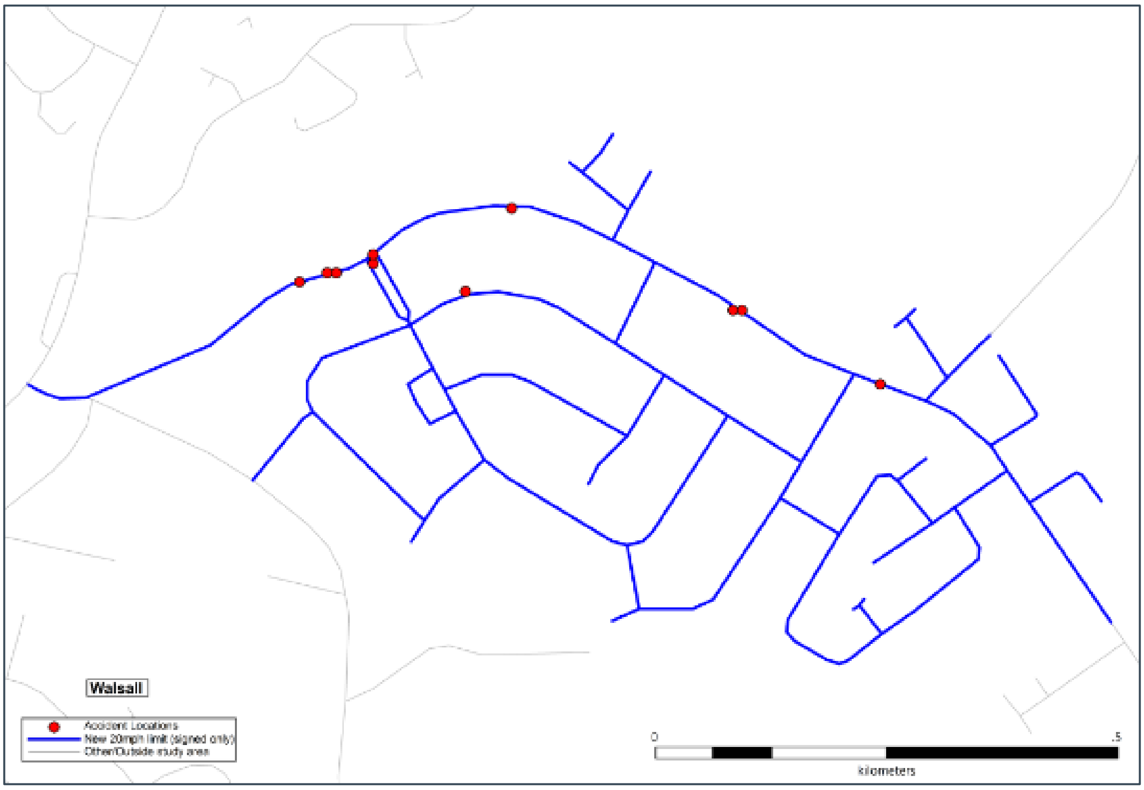


Comparator area - Other Urban Major Conurbation areas in the West Midlands (872km^2)



Location of collisions on new 20mph (signed-only) roads in Walsall (Rushall)

Before period (6 years)



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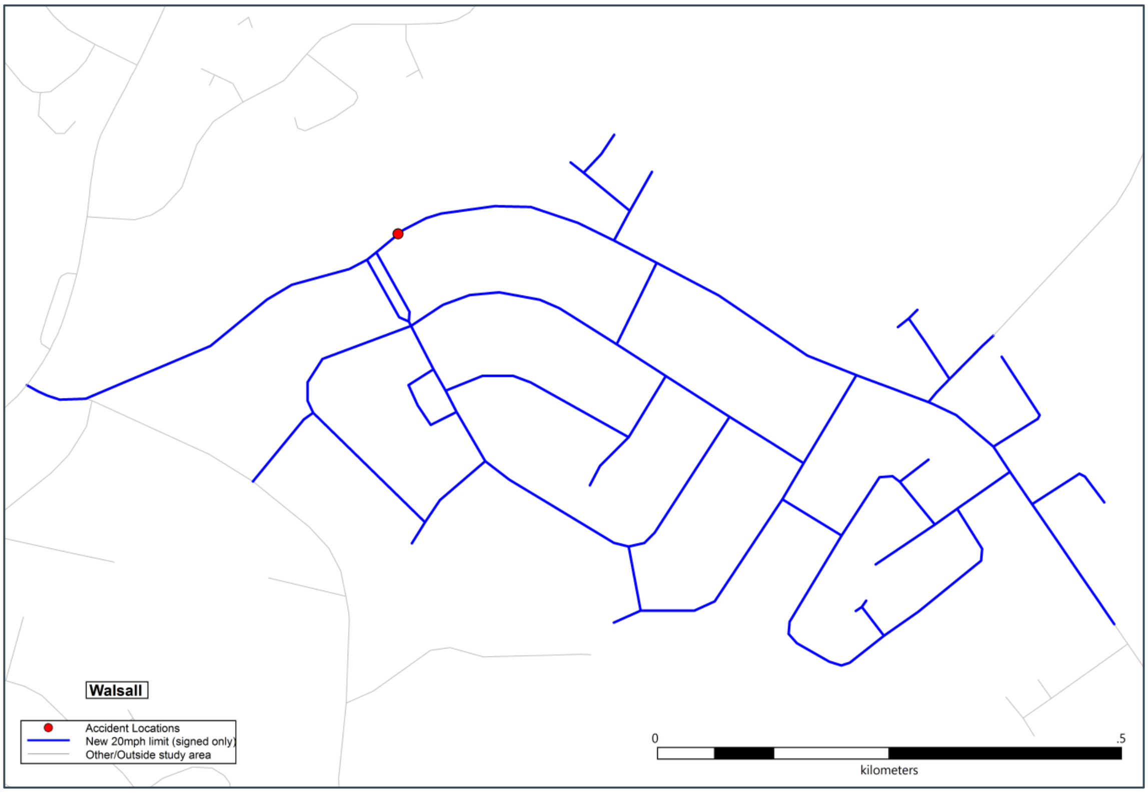
After period (33 months)



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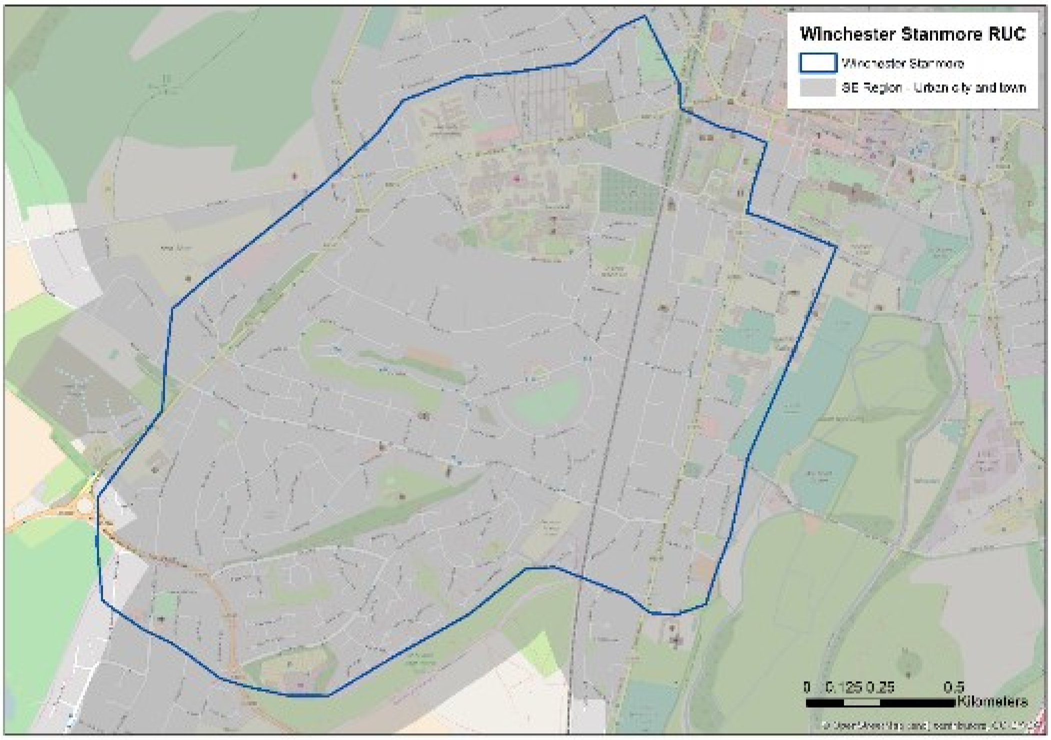
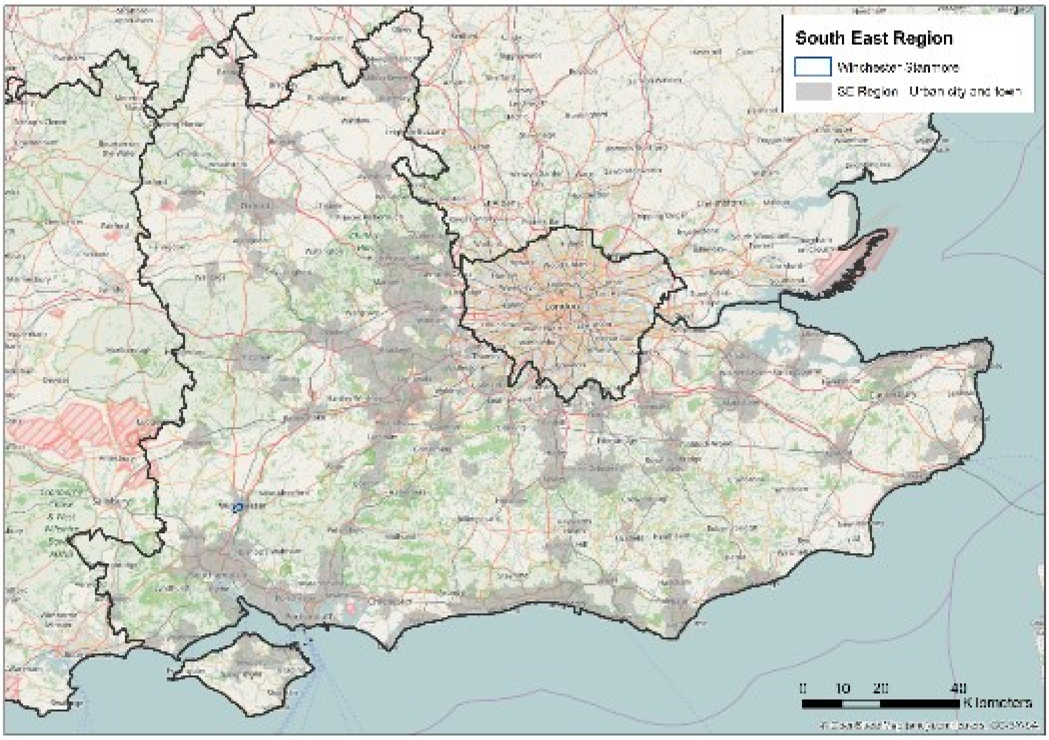
C.2. Winchester - Stanmore (R-SM2)

Rural-Urban Classification for Winchester (Stanmore) - Urban City and Town (3.6km^2)

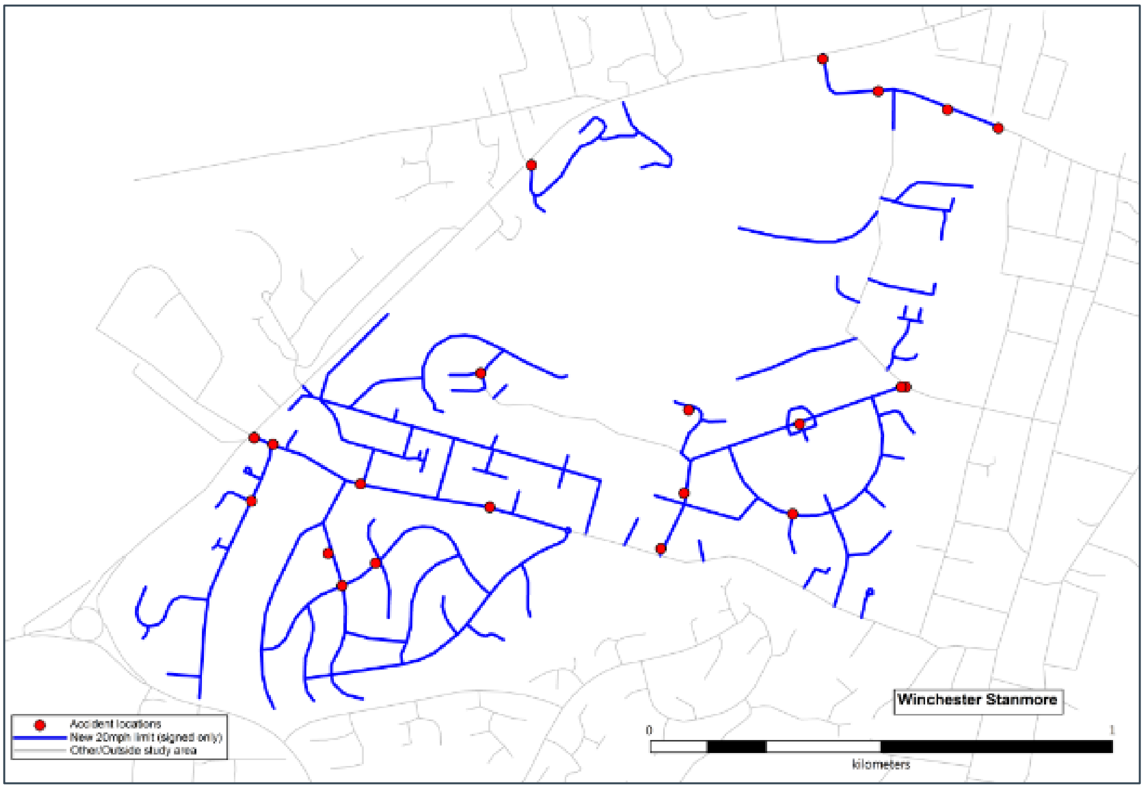


Comparator area - Other Urban City and Town in the South East (4,301km^2)



Location of collisions on new 20mph (signed-only) roads in Winchester (Stanmore)

Before period (6 years)



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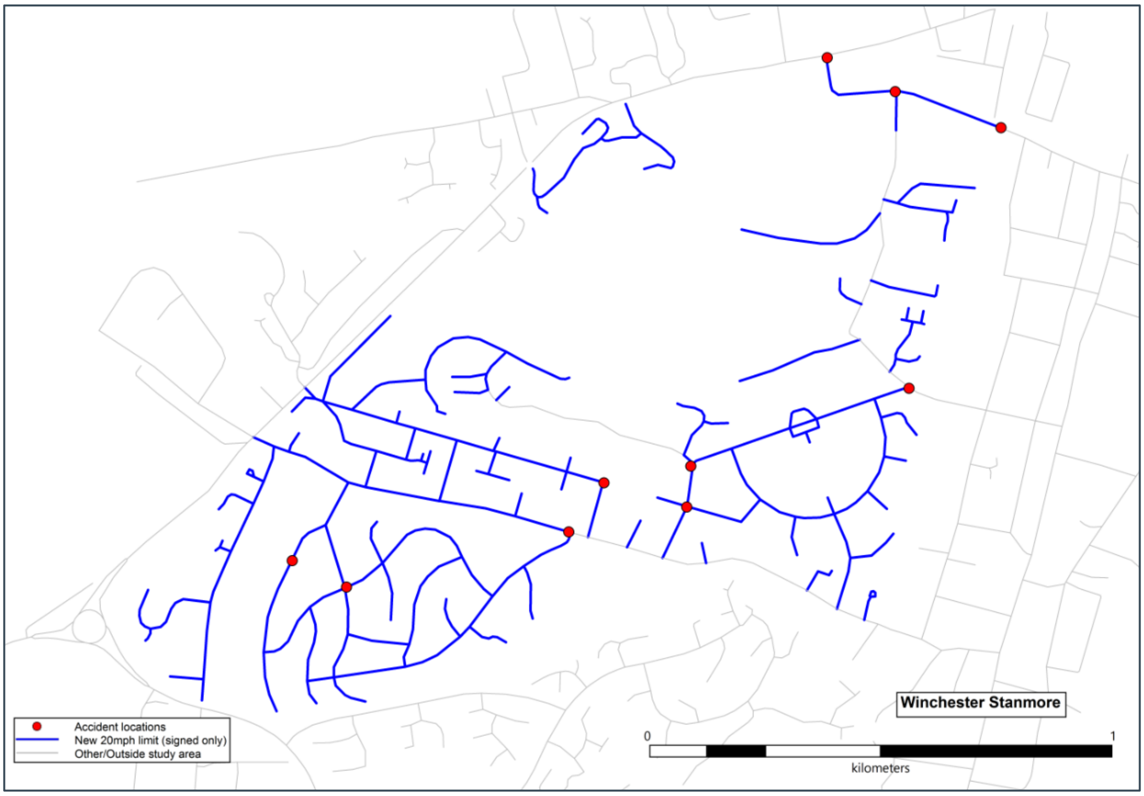
After period (29 months)



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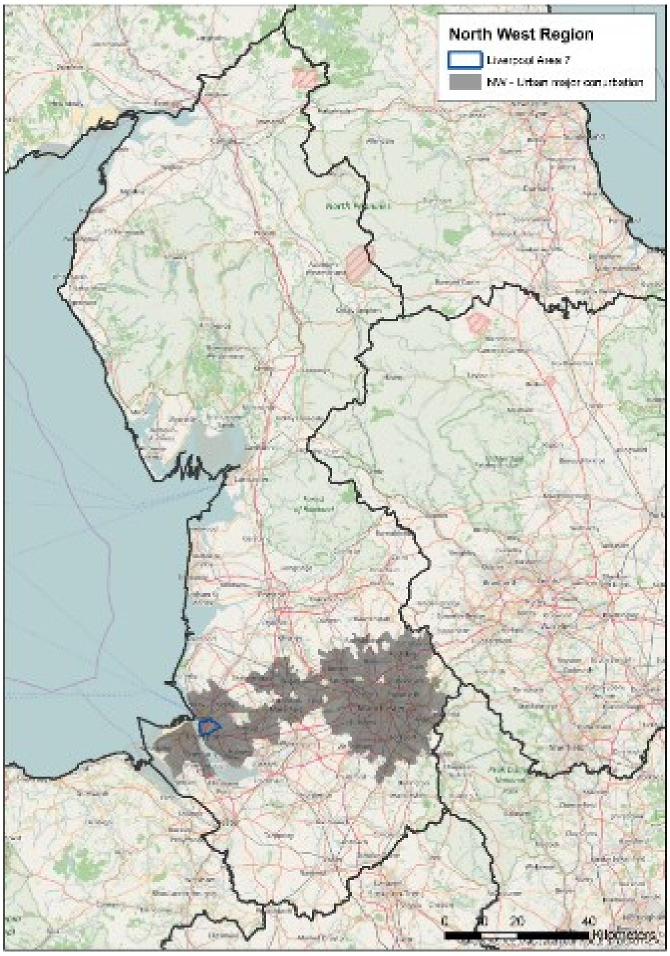
C.3. Liverpool (Area 7) – Adj. to City Centre (R-AW1a)

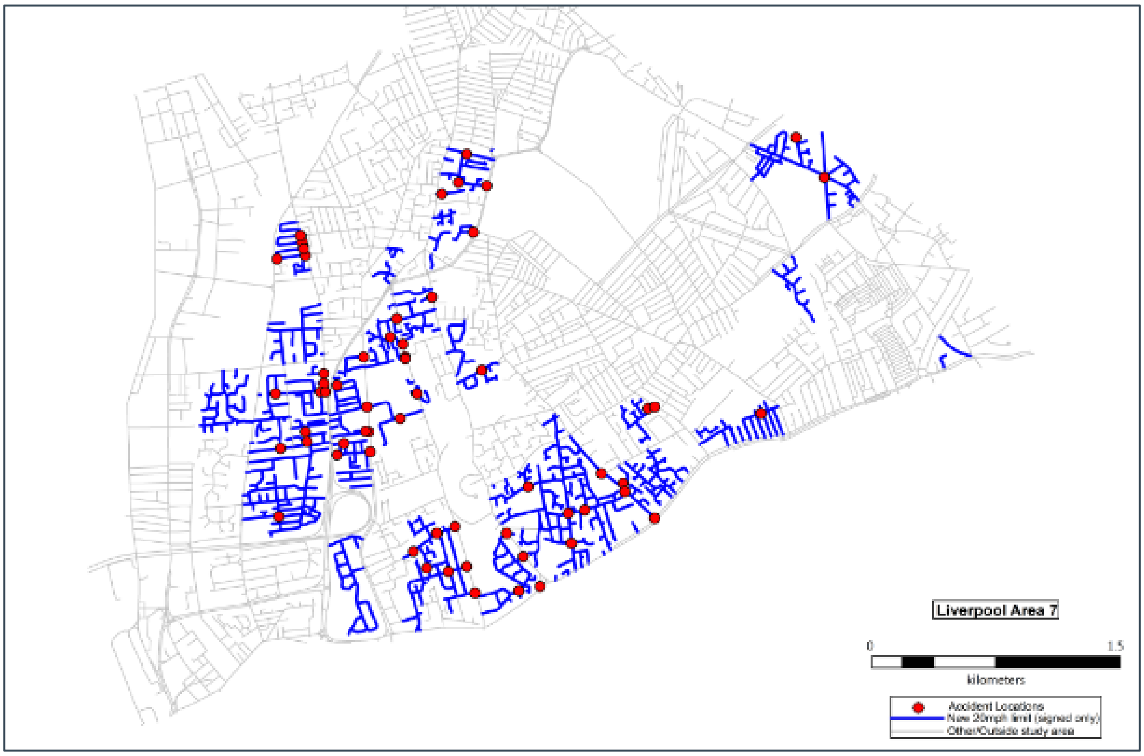
Rural-Urban Classification for Liverpool (Area 7) - Urban Major Conurbation (15.8km²)

Comparator area - Other Urban Major Conurbation areas in the North West (1,609km²)



Location of collisions on new 20mph (signed-only) roads in Liverpool (Area 7)

Before period (6 years)



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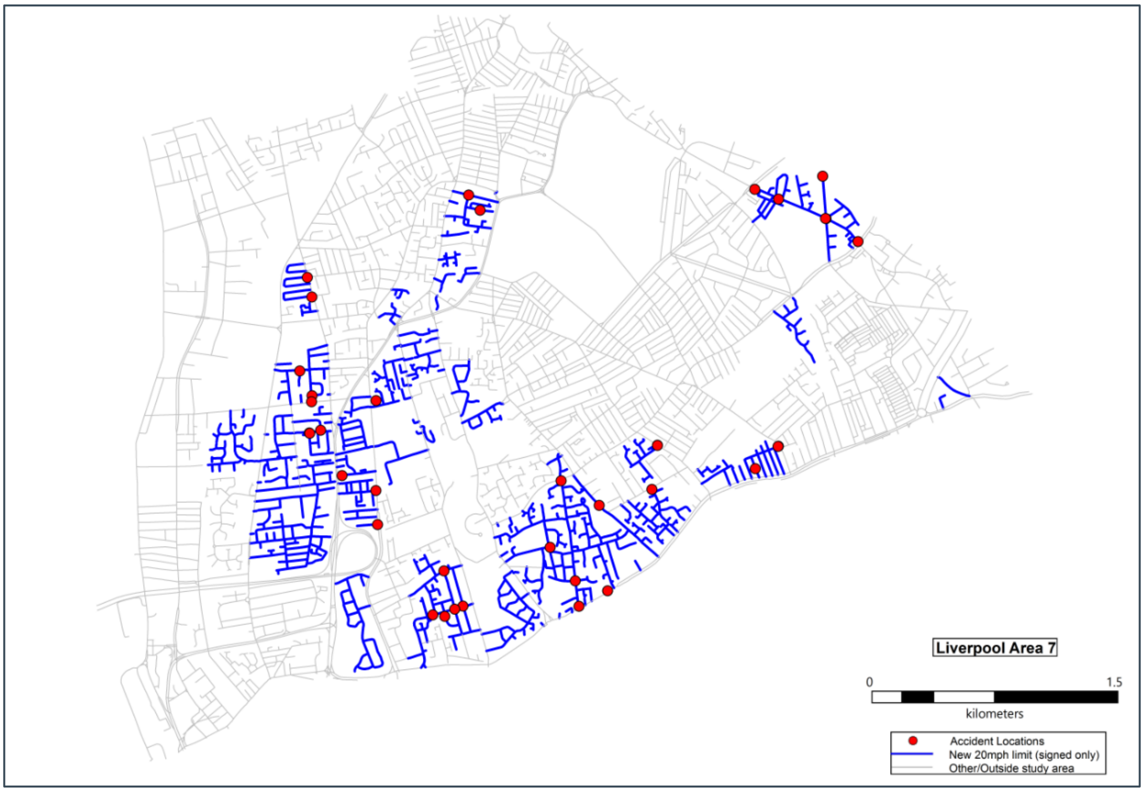
After period (32 months)



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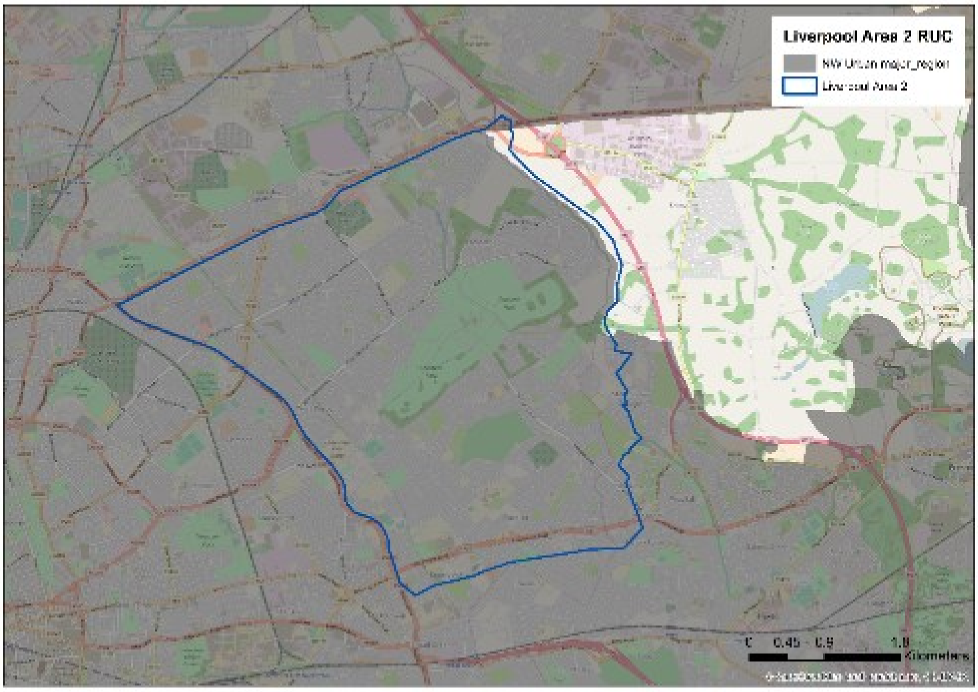
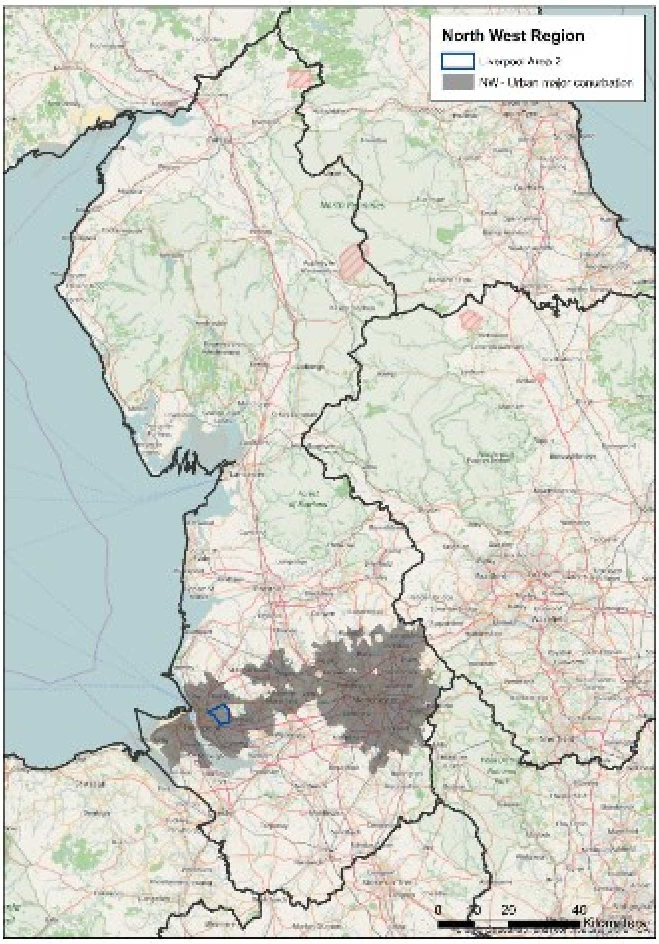
C.4. Liverpool (Area 2) – NE of City Centre (R-AW1b)

Rural-Urban Classification for Liverpool (Area 2) - Urban Major Conurbation (19.3km²)

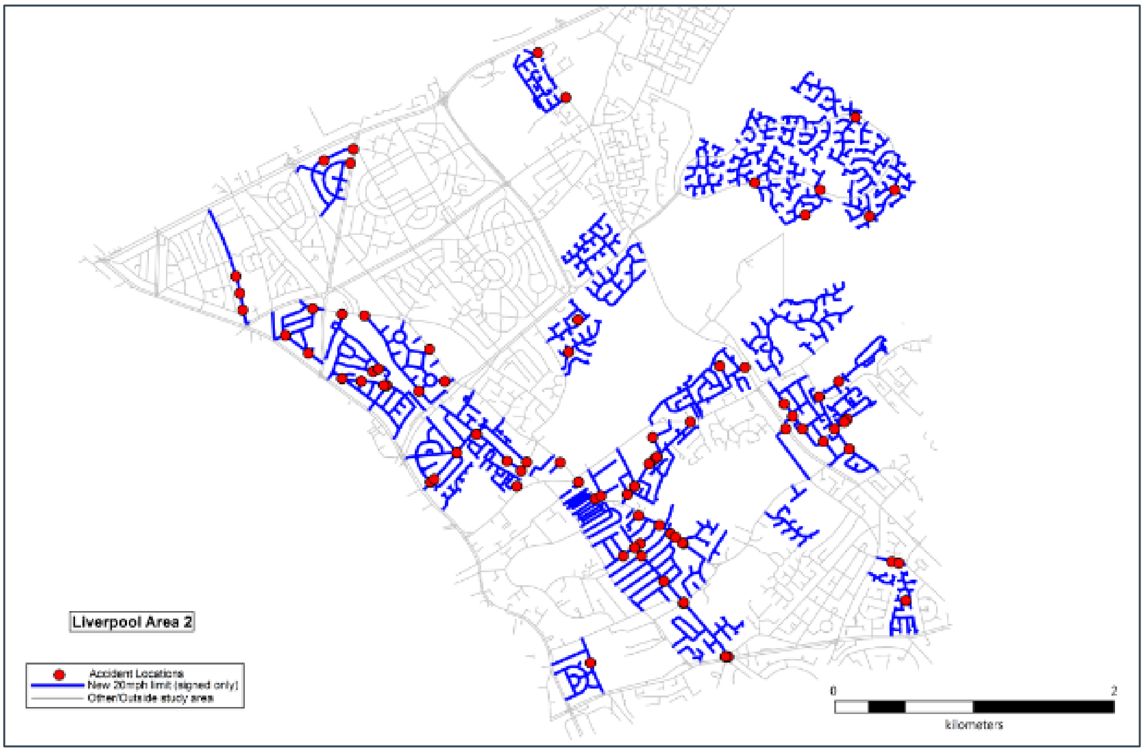


Comparator area - Other Urban Major Conurbation areas in the North West (1,600km²)



Location of collisions on new 20mph (signed-only) roads in Liverpool (Area 2)

Before period (6 years)



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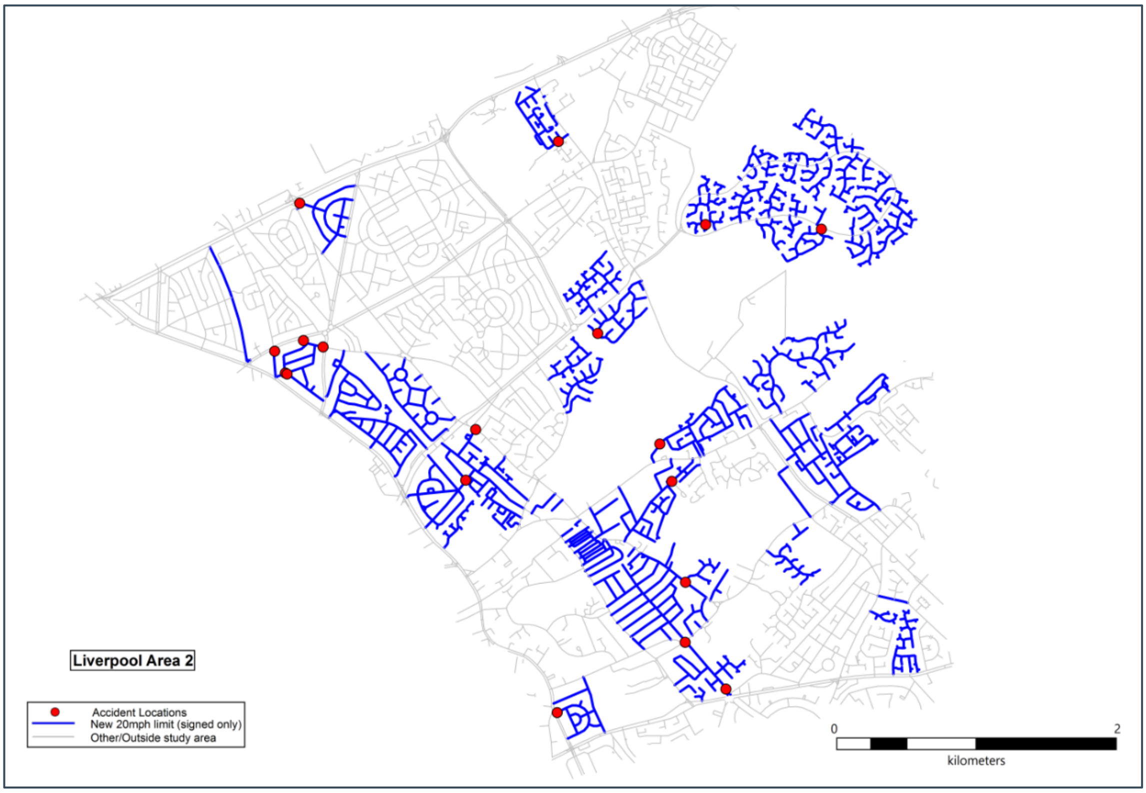
After period (23 months)



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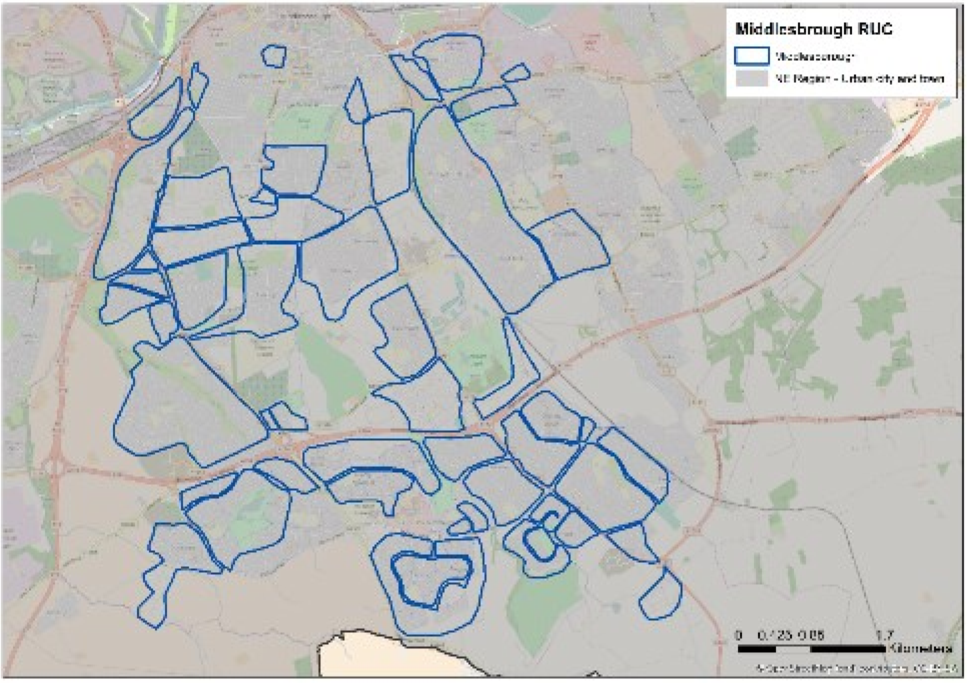
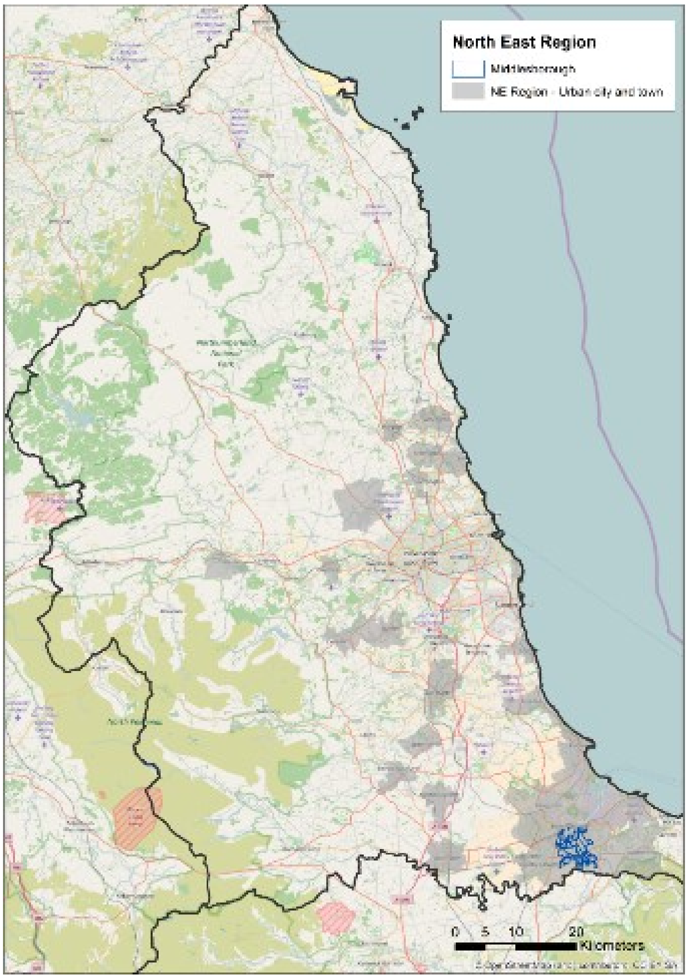
C.5. Middlesbrough – Phase 1 and 2 (R-AW2)

Rural-Urban Classification for Middlesbrough - Urban City and Town (18.6km^2)

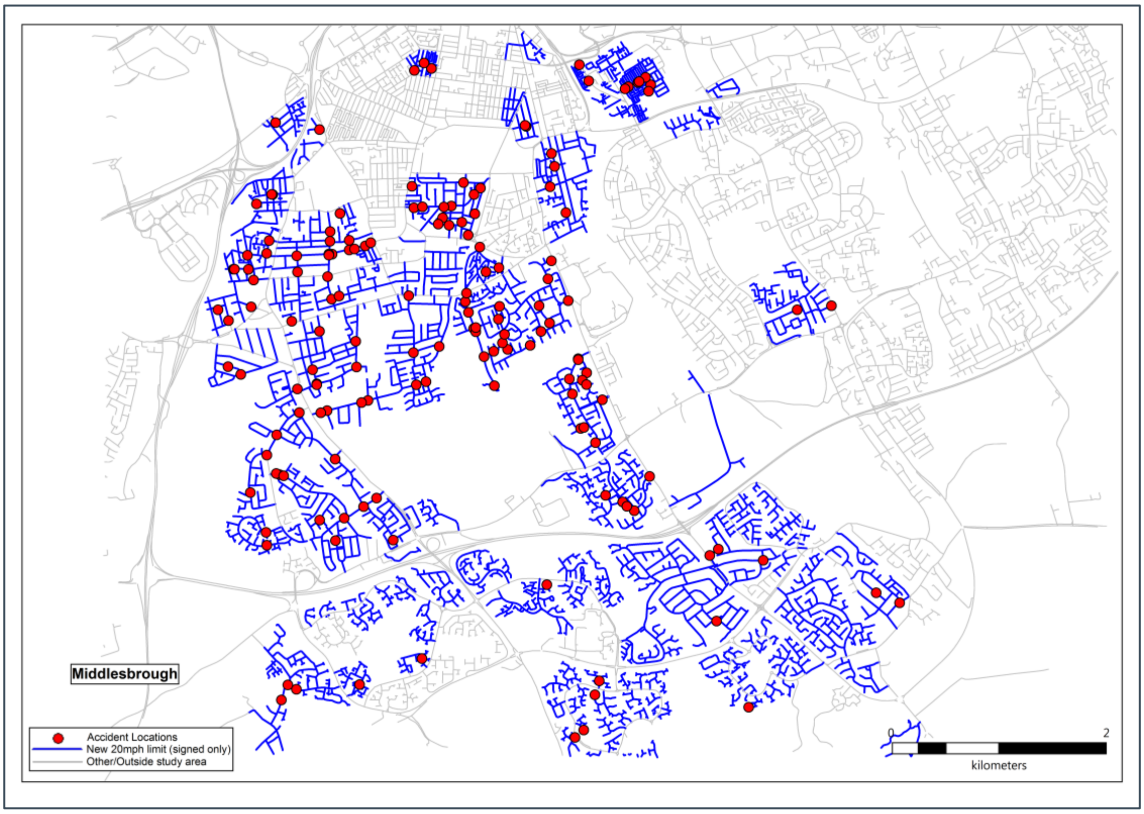


Comparator area - Other Urban City and Town in the North East (737km^2)



Location of collisions on new 20mph (signed-only) roads in Middlesbrough

Before period (6 years)



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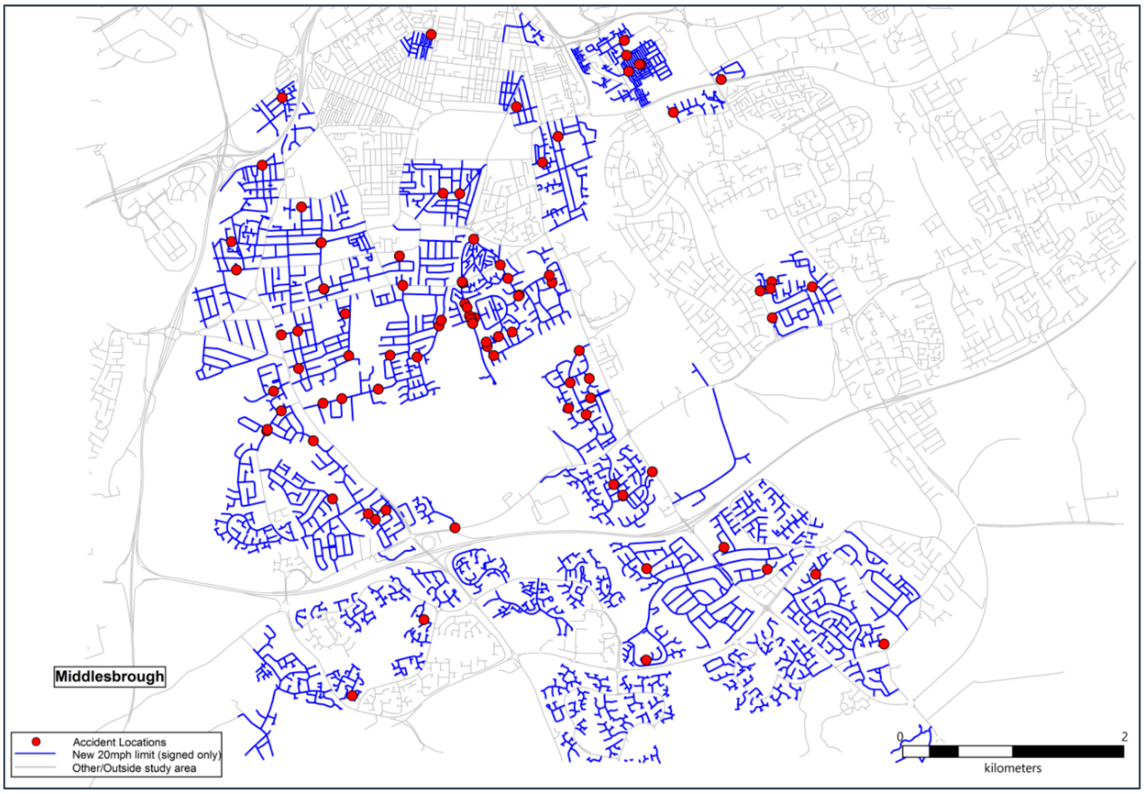
After period (42 months)



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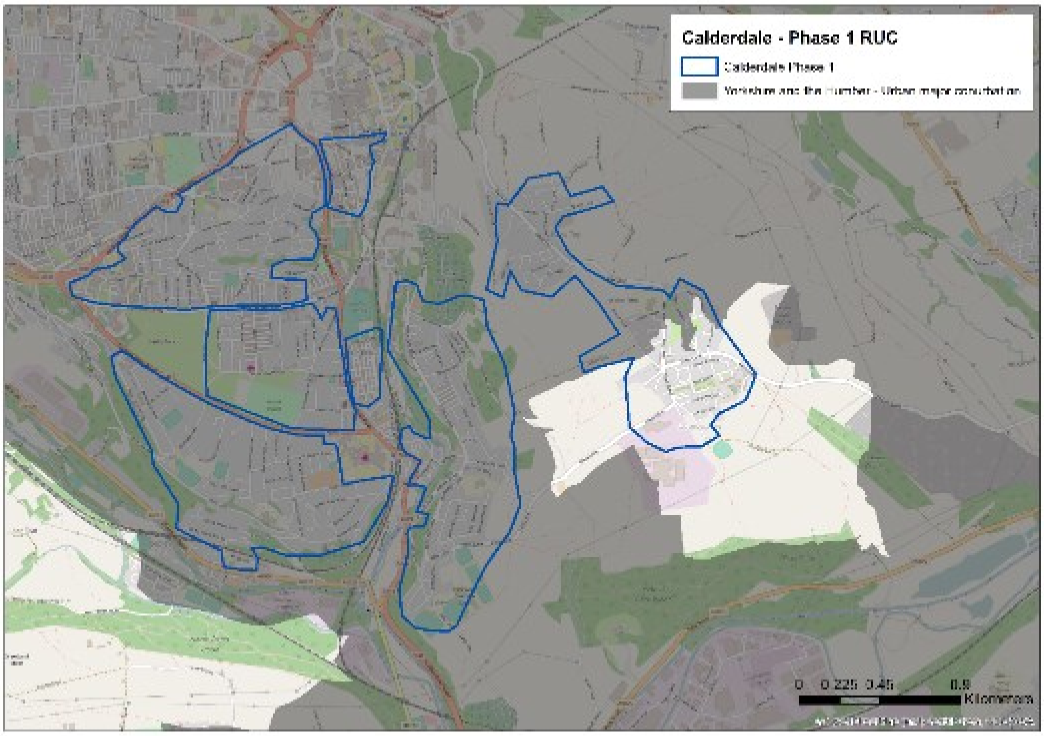
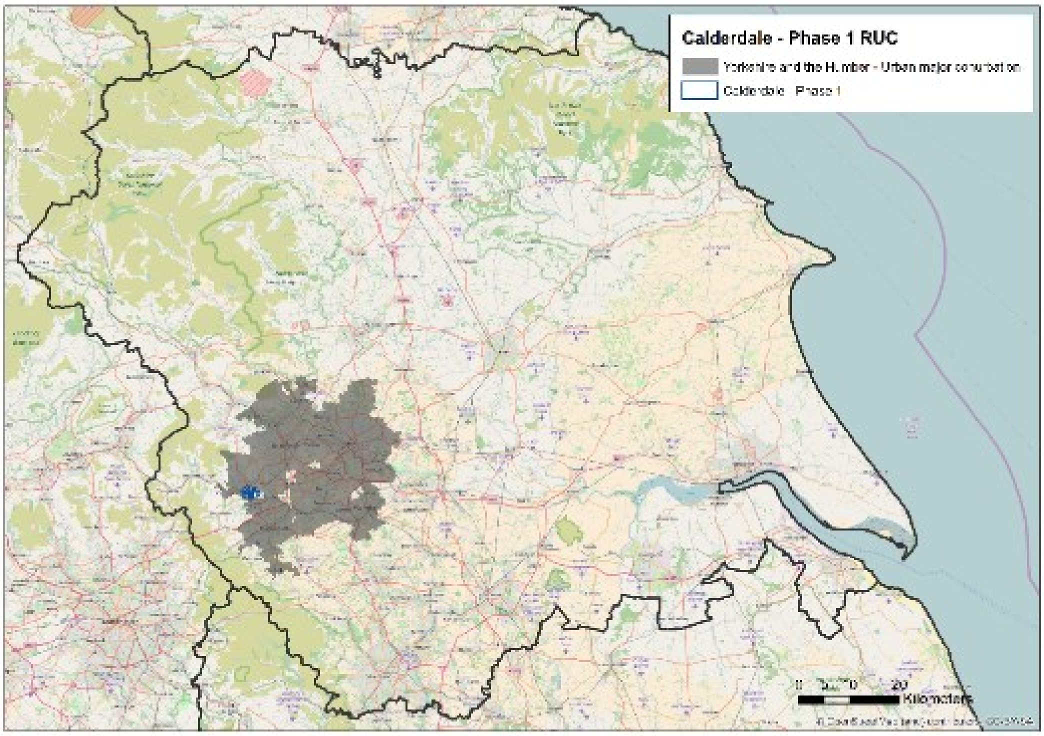
C.6. Calderdale – Phase 1 (R-AW3)

Rural-Urban Classification for Calderdale - Urban Major Conurbation (4.2km²)

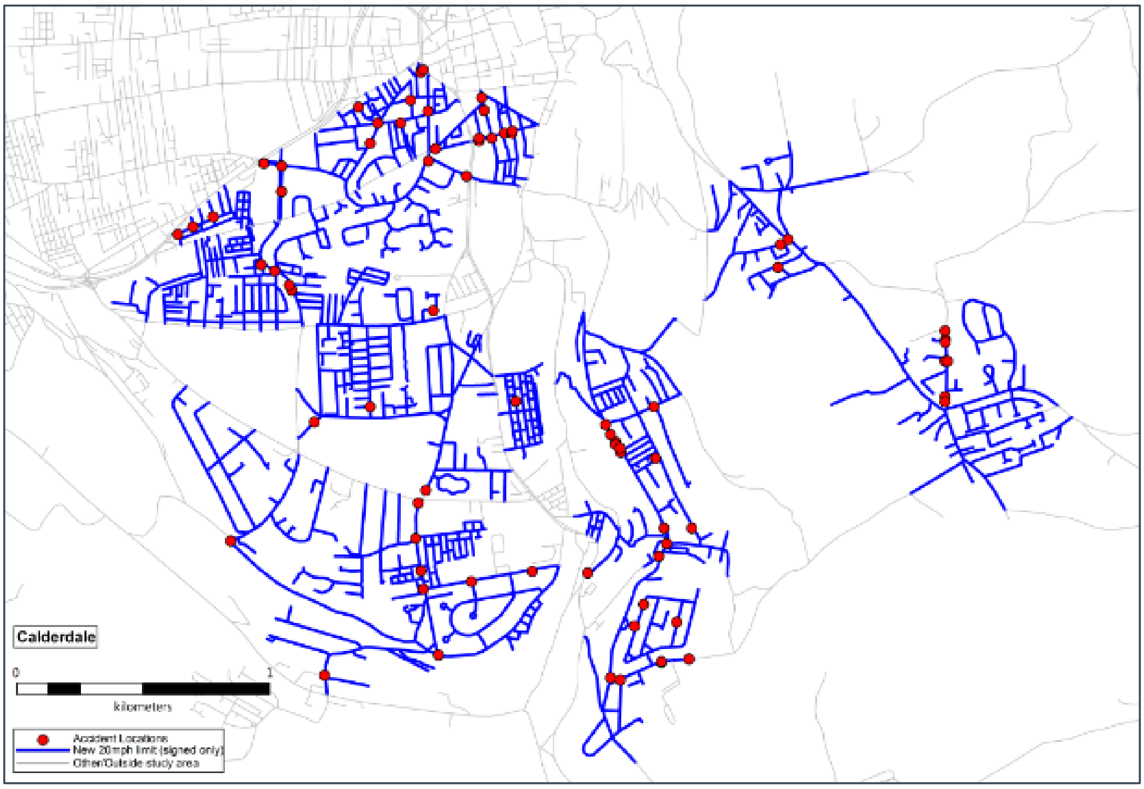


Comparator area - Other Urban Major Conurbation areas in Yorkshire and the Humber (830km²)



Location of collisions on new 20mph (signed-only) roads in Calderdale (Phase 1)

Before period (6 years)



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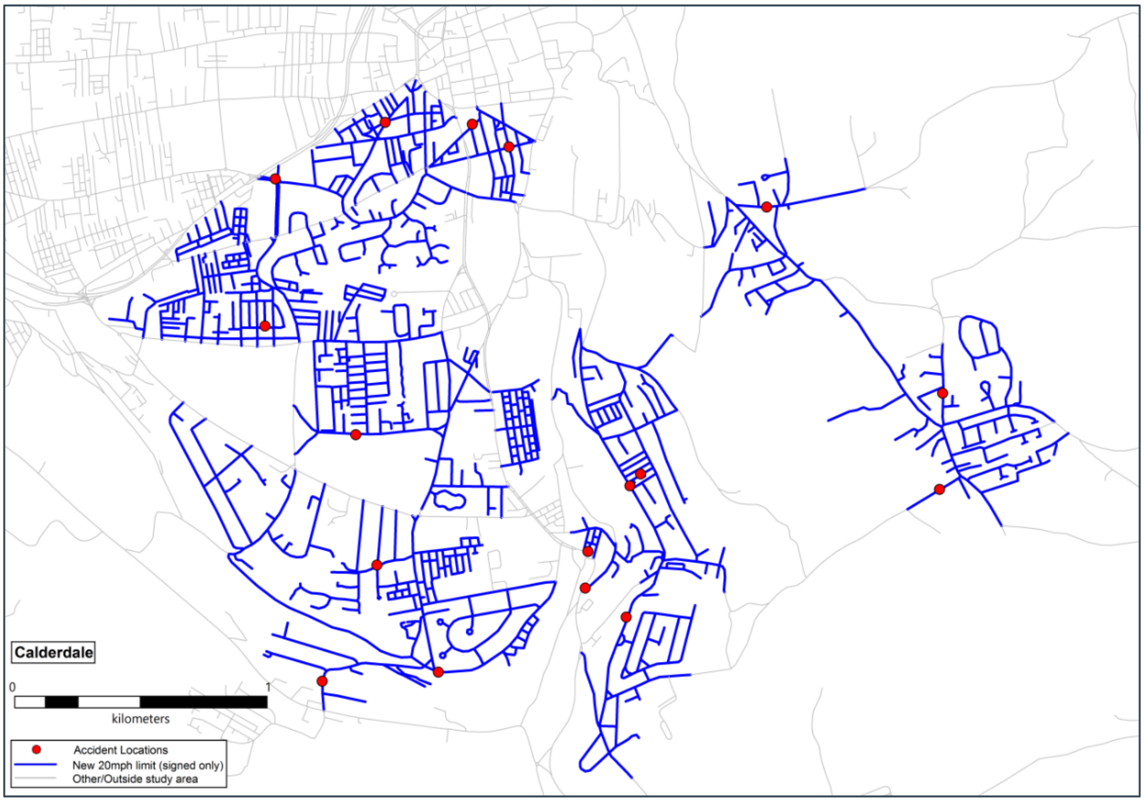
After period (17 months)



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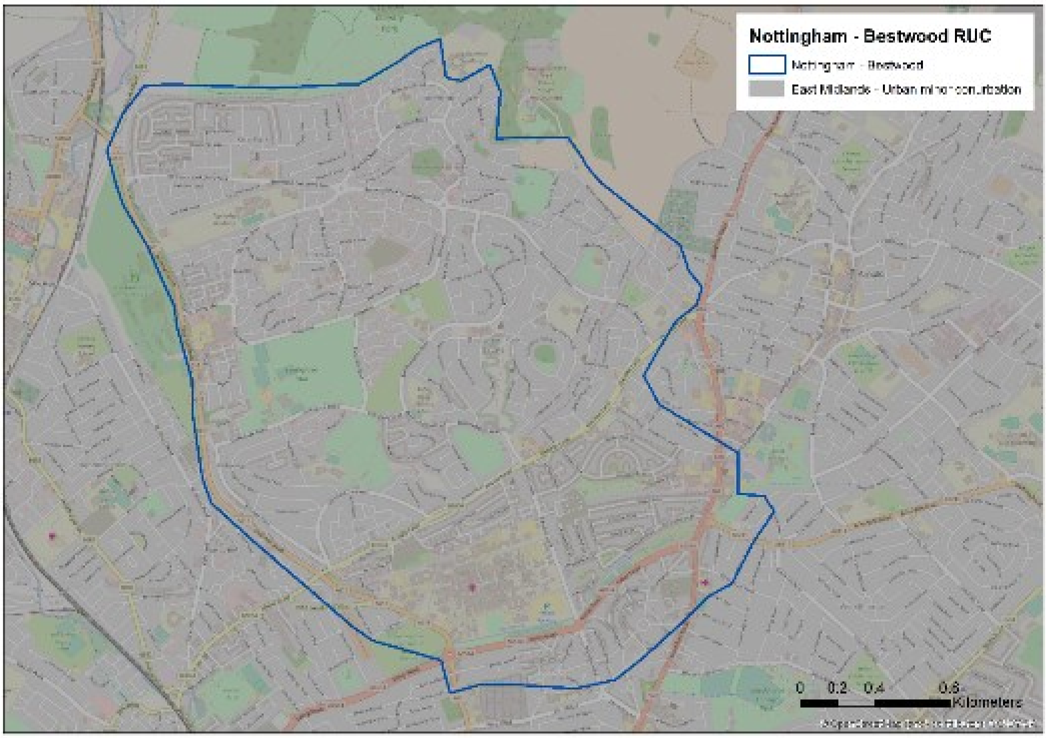
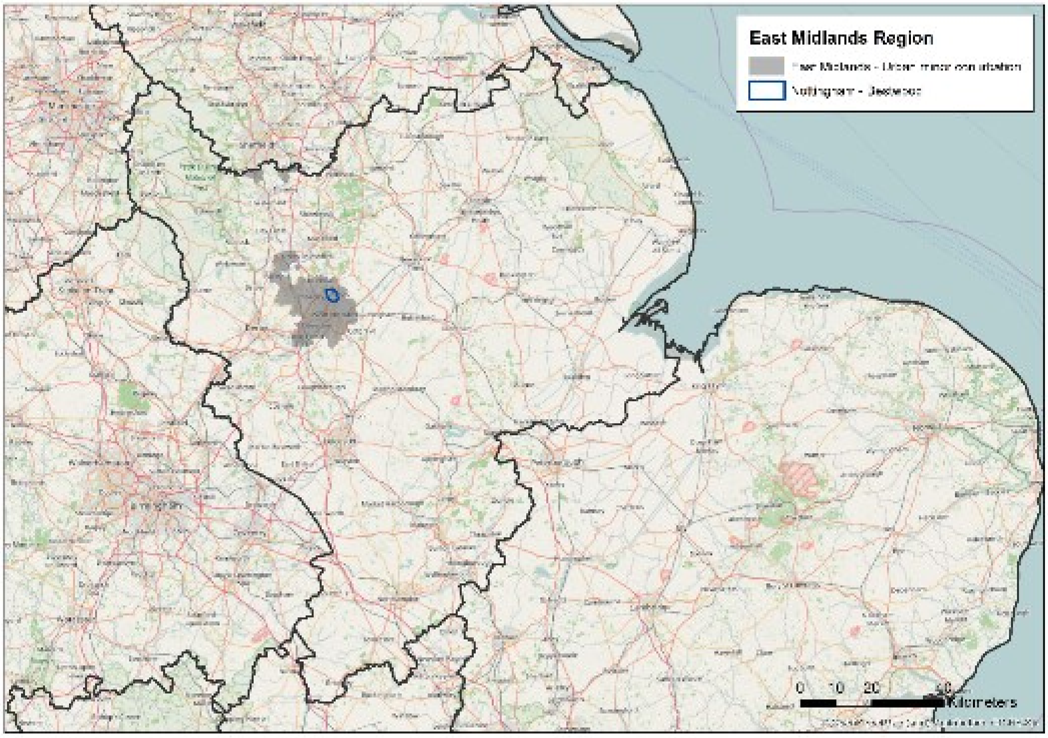
C.7. Nottingham – Bestwood (R-AW4)

Rural-Urban Classification for Nottingham (Bestwood) - Urban Minor Conurbation (7.9km²)



Comparator area - Other Urban Minor Conurbation areas in the East Midlands (358km²)



Location of collisions on new 20mph (signed-only) roads in Nottingham (Bestwood)

Before period (6 years)

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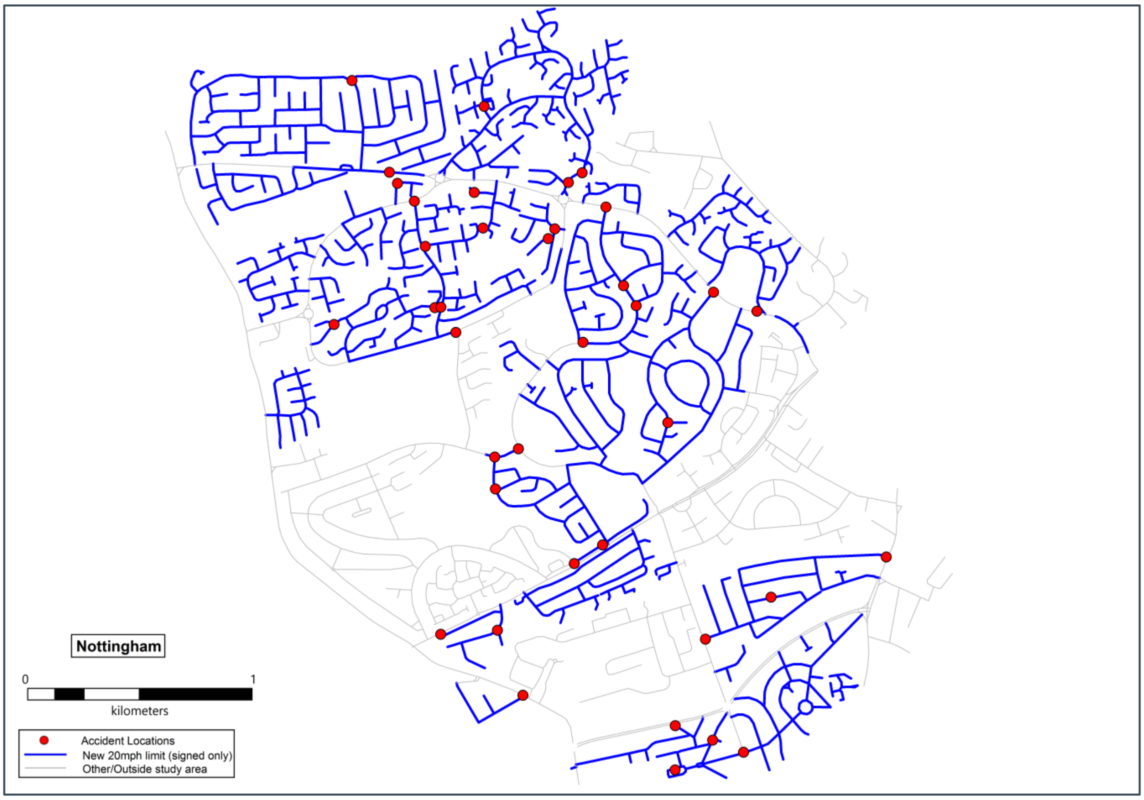
After period (32 months)



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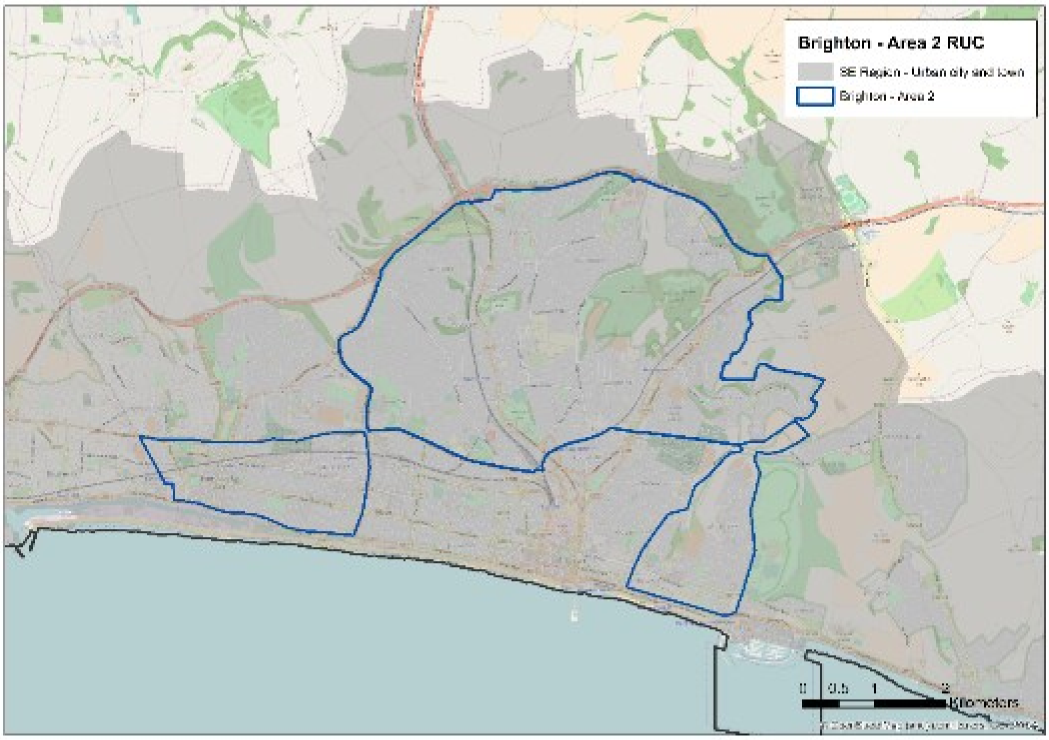
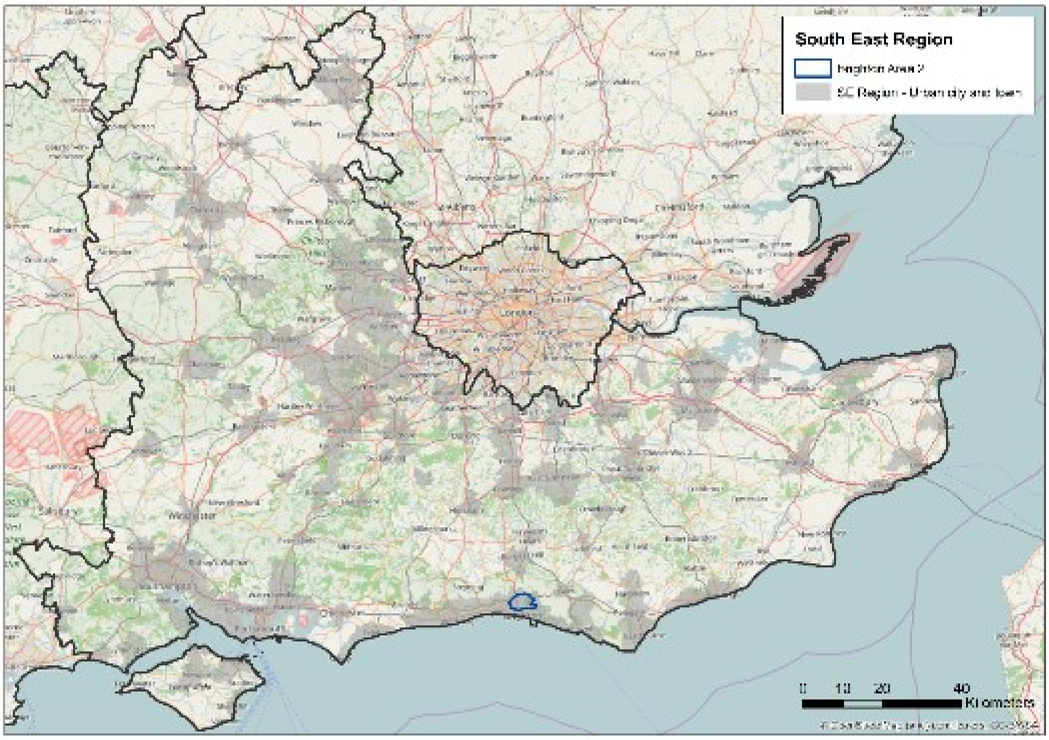
C.8. Brighton – Phase 2 (R-AW5)

Rural-Urban Classification for Brighton (Phase 2) - Urban City and Town (24.9km²)

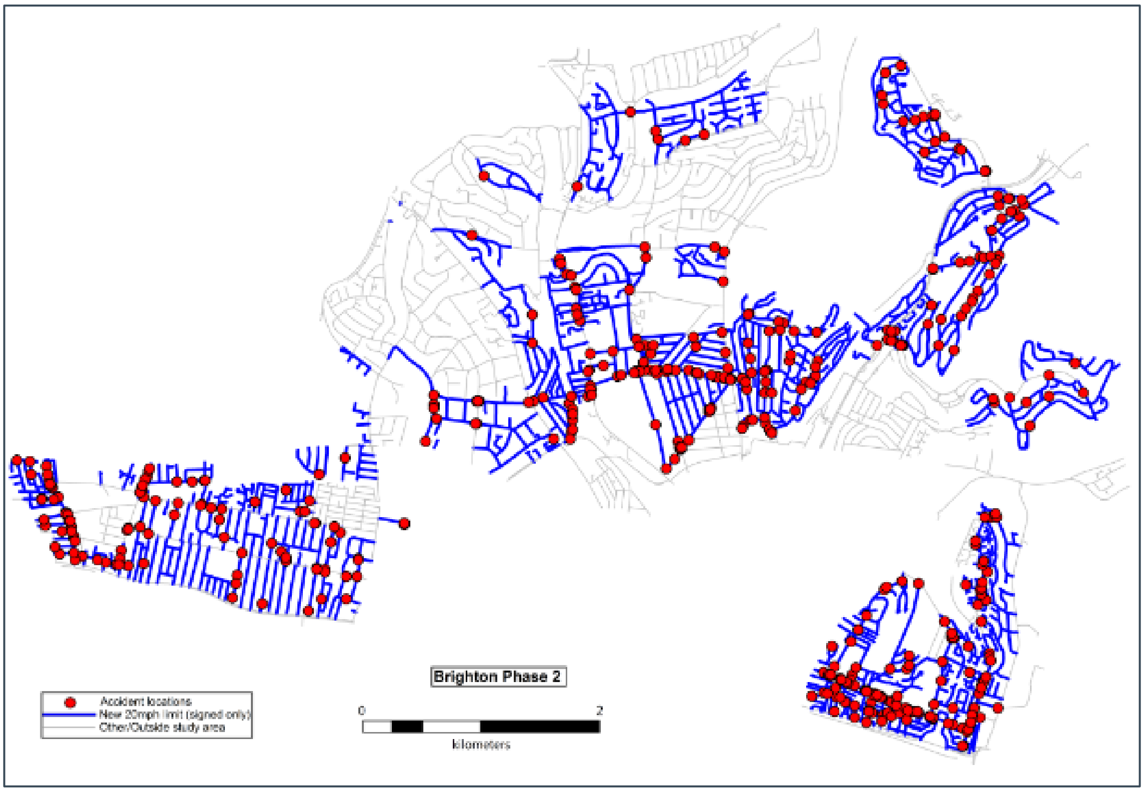


Comparator area - Other Urban City and Town in the South East (4,263km²)



Location of collisions on new 20mph (signed-only) roads in Brighton (Phase 2)

Before period (6 years)



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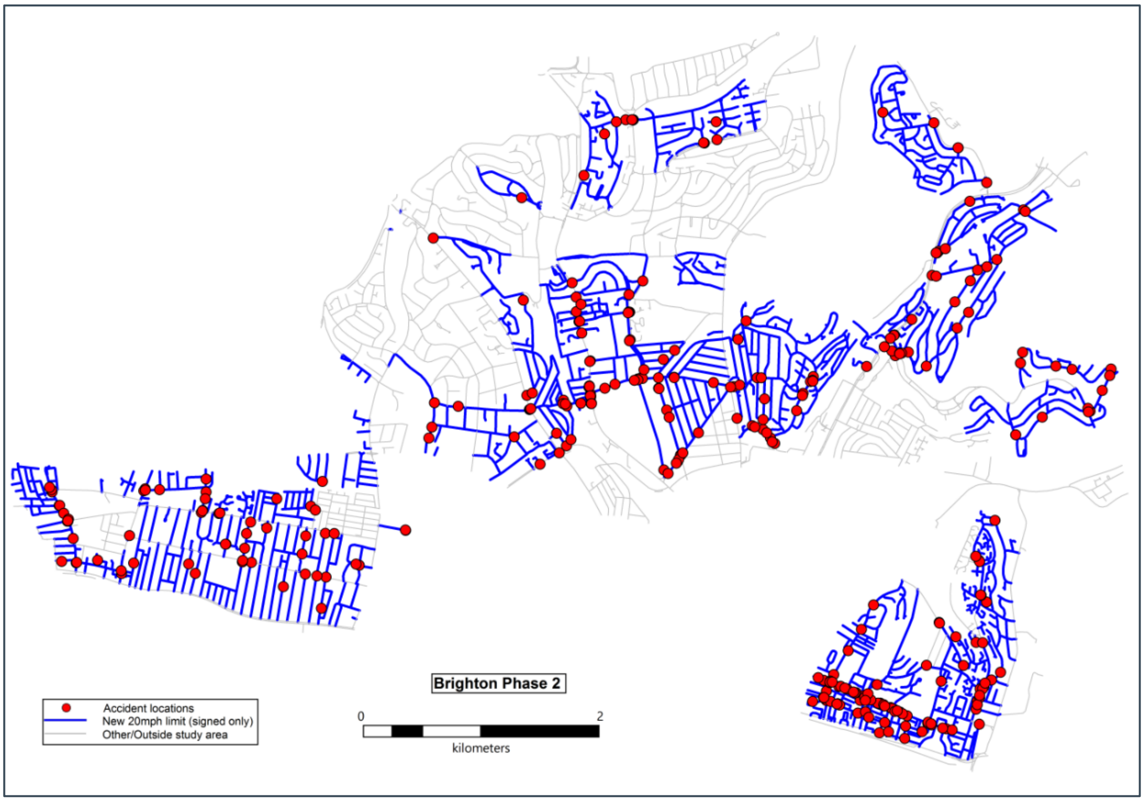
After period (30 months)



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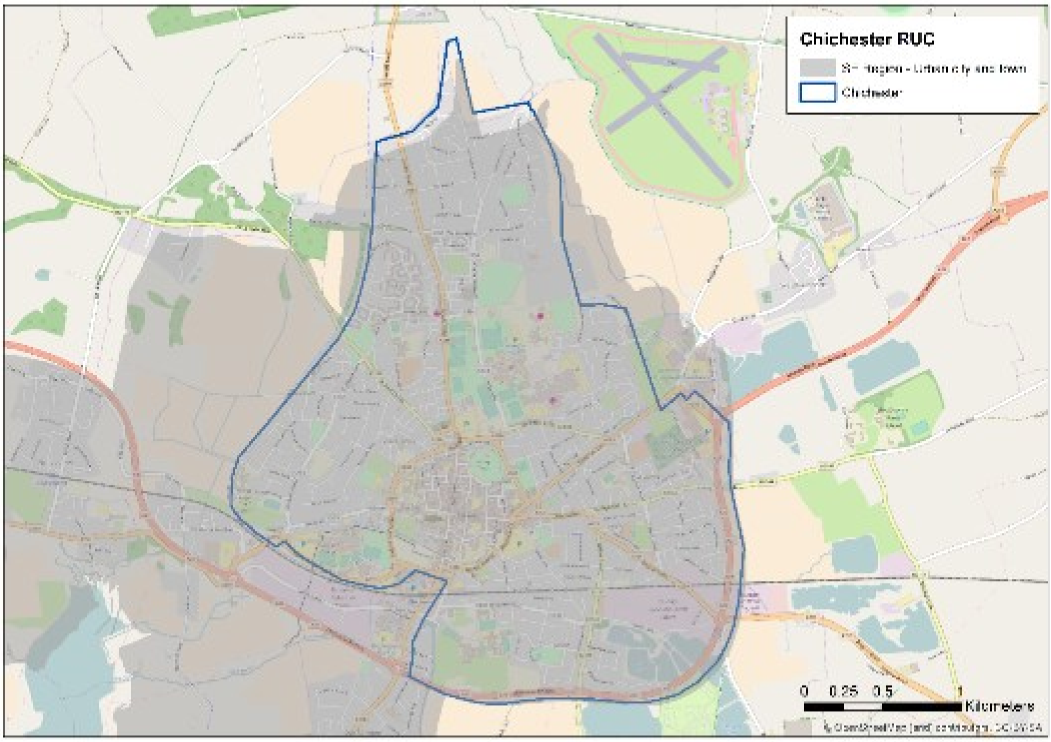
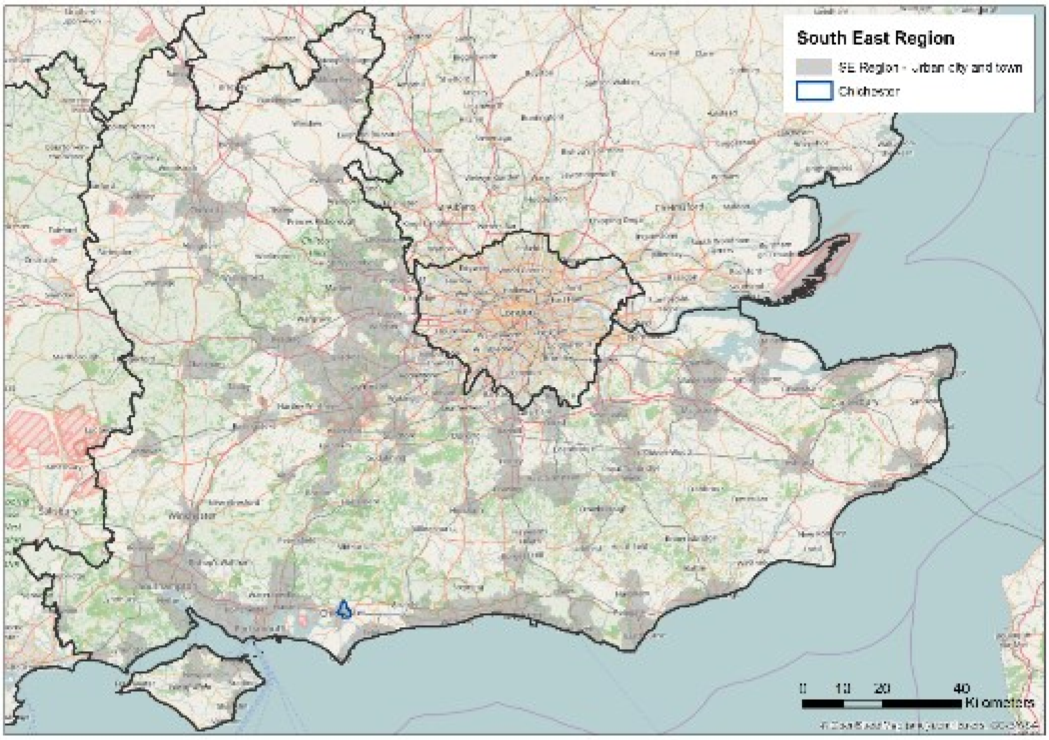
C.9. Chichester (R-AW)

Rural-Urban Classification for Chichester - Urban City and Town (7.6km²)

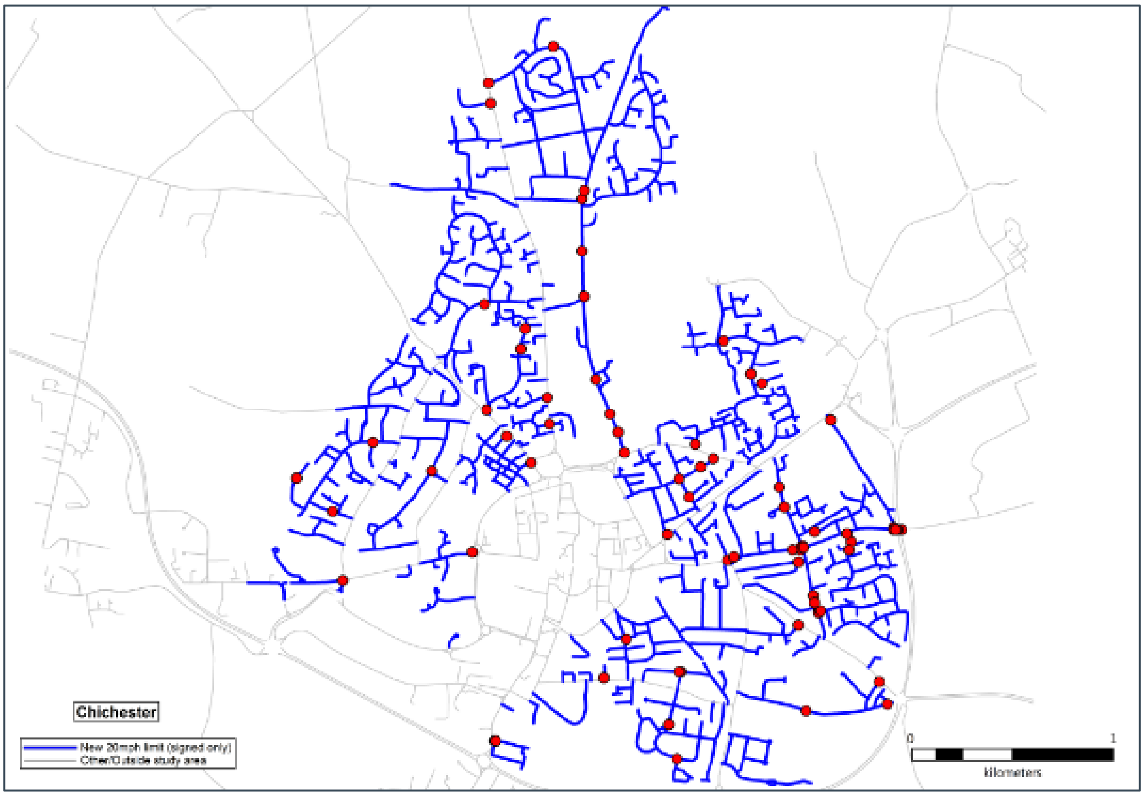


Comparator area - Other Urban City and Town in the South East (4,300km²)



Location of collisions on new 20mph (signed-only) roads in Chichester

Before period (6 years)



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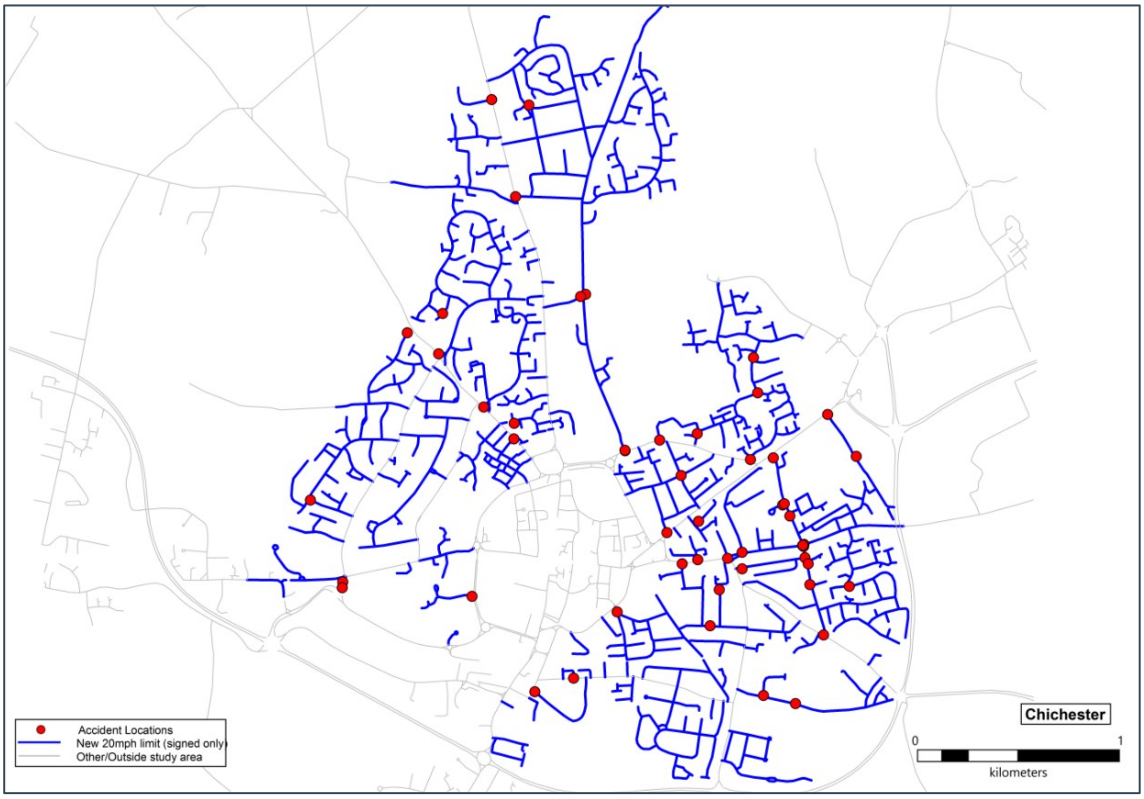
After period (41 months)



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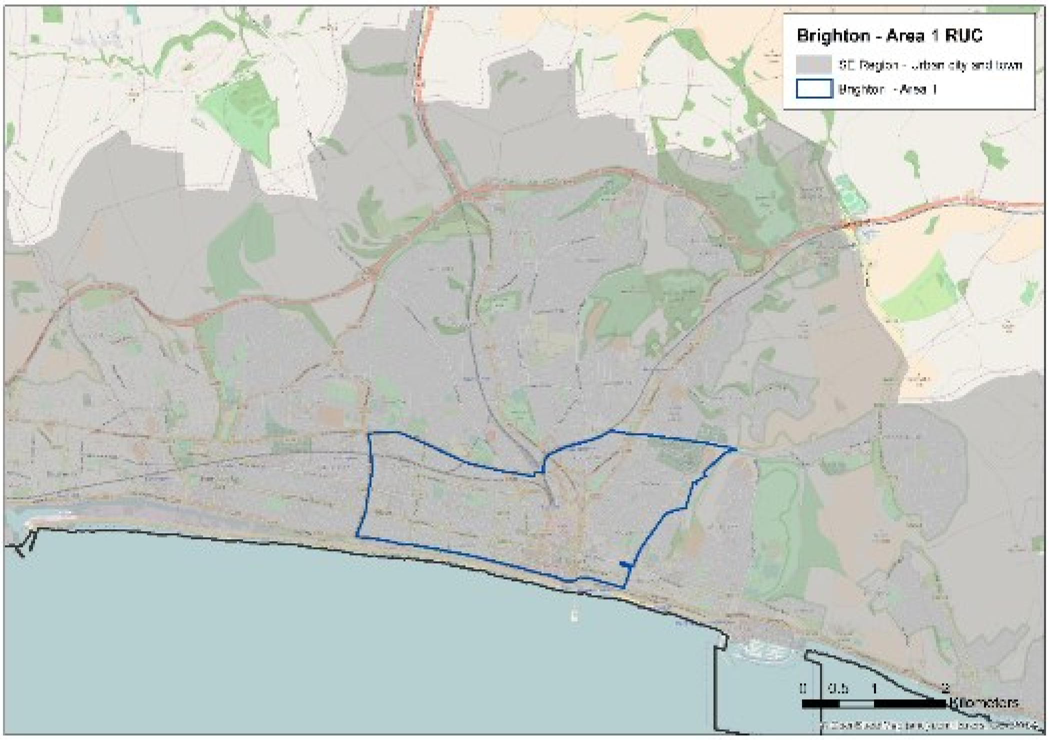
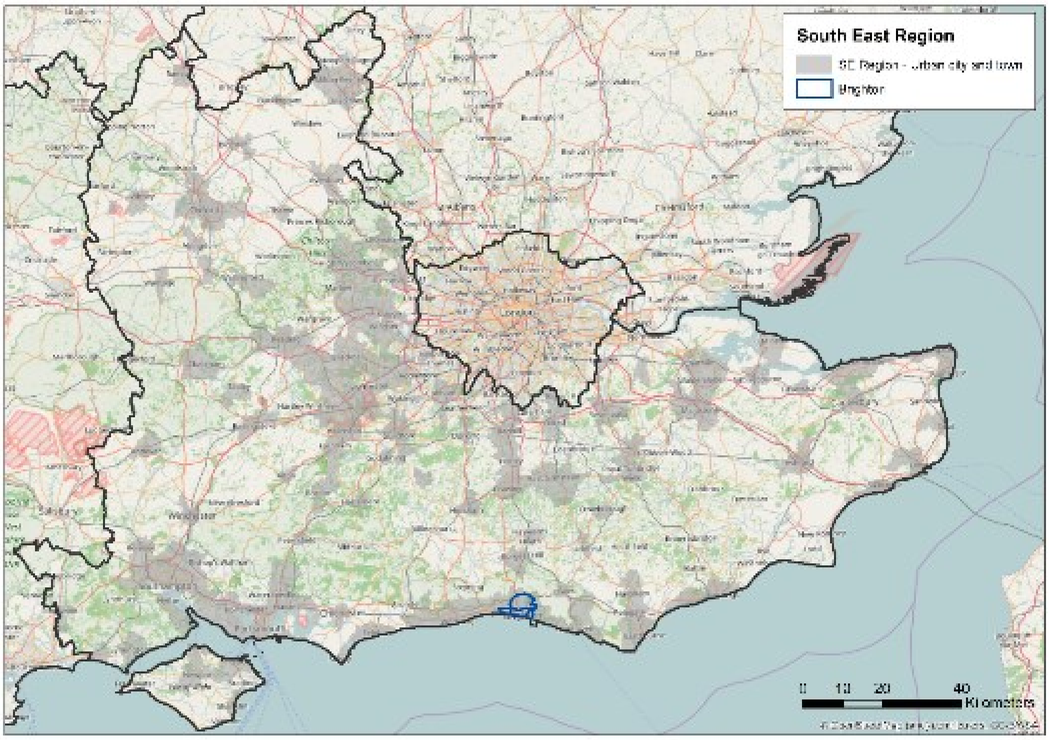
C.10. Brighton Phase 1 – City Centre and Adjacent (TC-AW1)

Rural-Urban Classification for Brighton (Phase 1) - Urban City and Town (7.0km^2)

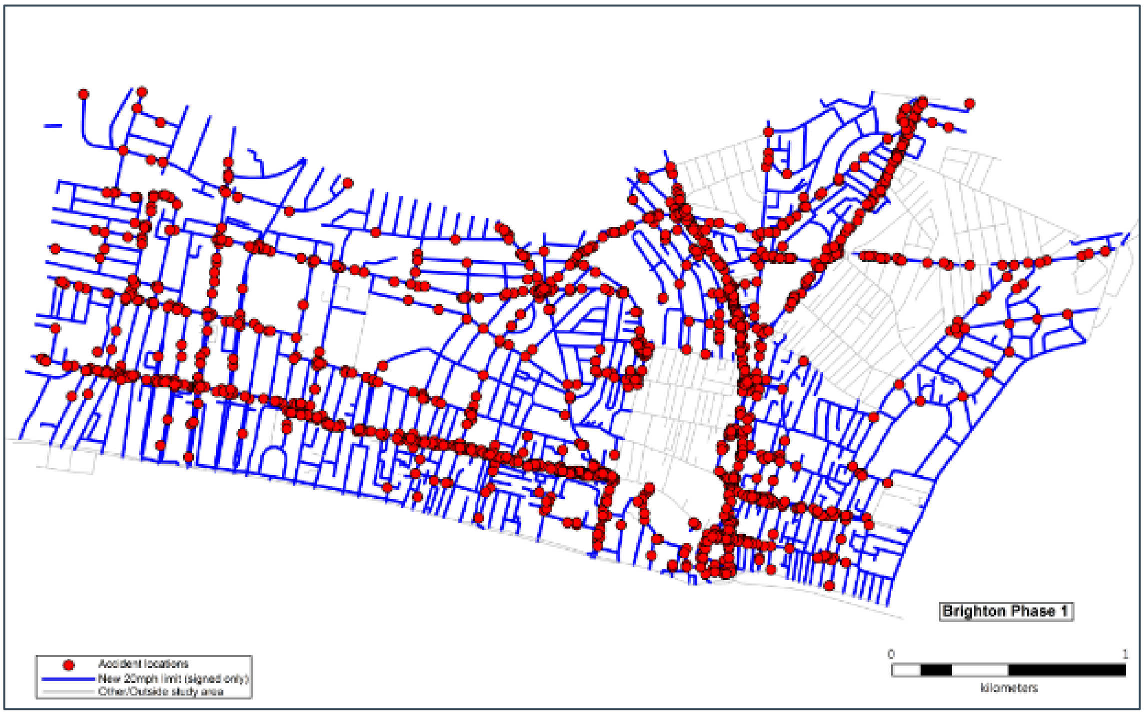


Comparator area - Other Urban City and Town in the South East (4,302km^2)



Location of collisions on new 20mph (signed-only) roads in Brighton (Phase 1)

Before period (6 years)



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After period (44 months)

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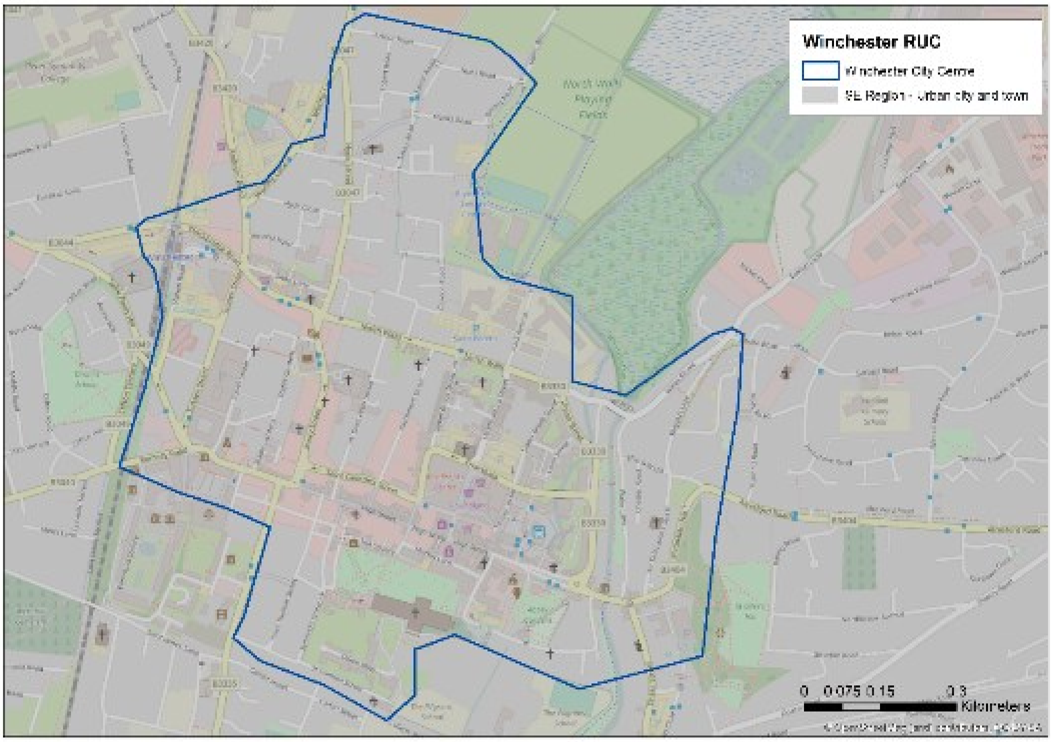
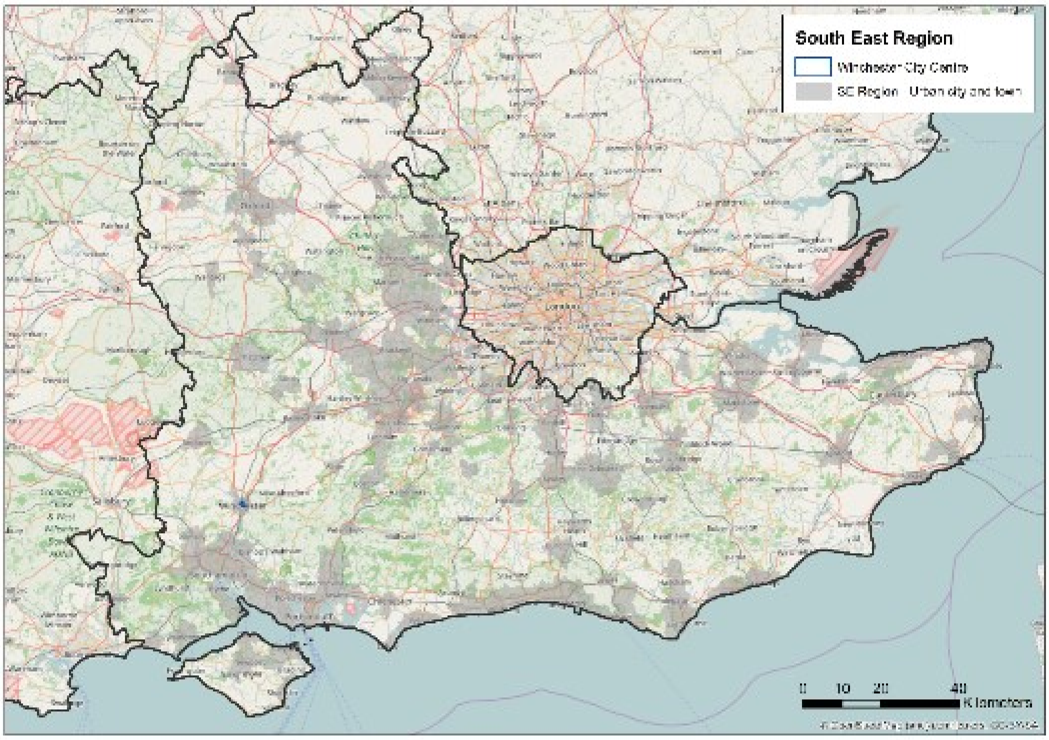
C.11. Winchester City Centre (TC-AW2)

Rural-Urban Classification for Winchester City Centre - Urban City and Town (1.0km^2)



Comparator area - Other Urban City and Town in the South East (4,303km^2)



Location of collisions on new 20mph (signed-only) roads in Winchester City Centre

Before period (6 years)

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After period (27 months)

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Appendix D. Case study area data

D.1. Introduction

This appendix presents before and after collision and casualty statistics for the case study areas, including:

- the number and rate (per road km per year) of collisions and casualties;
- the breakdown by road type, to understand the relationship between road type and collision rates; and
- the main contributory factors, in order to see whether the types of collisions that have occurred are likely to have been affected by slower speeds.

D.2. Before period

The data for the before period represents collisions (and casualties) that have occurred prior to the introduction of 20mph.

D.2.1. Collisions and casualties in 20mph limit areas

The table below shows the number and rate of collisions found in the aggregated case study areas, across the full five-year before periods. Note that the first before year is excluded from the analysis and thus the table shows the collision data for years 2 to 6 prior to the introduction of the 20mph limits.

Table D-1 Collisions/casualties for all case study areas – 5-year before period

Collisions and casualties	Aggregated number	% of casualties	Rate per km of road per year
Road length (kms)	882.48		-
All collisions	2393	-	0.542
All casualties	2903	100%	0.658
Fatal casualties	3	0%	0.001
Serious casualties	374	13%	0.085
Slight casualties	2527	87%	0.573
Cyclists injured	482	17%	0.109
Pedestrians injured	709	24%	0.161
Under 11s injured	165	6%	0.037
11-16s injured	195	7%	0.044
Over 75s injured	148	5%	0.034

D.2.2. Collisions and casualties in each case study area

The table below shows the disaggregated collision data by case study area for the before period. In general, there is a relationship between the distance of affected roads, and the number of collisions observed.

Brighton Phase 1 appears to have a larger number of collisions and casualties per km per year, than elsewhere. The area represents 12% of the case study area total road length but 56% of all collisions and 55% of all casualties. Winchester also shows a high number of collisions and casualties when the length of road is considered.

Table D-2 Number of collisions / casualties for each case study area – 5-year before period

Collisions and casualties	Walsall	Winchester Stanmore	Liverpool Area 7	Liverpool Area 2	Middles-brough	Calderdale	Nottingham	Brighton Phase 2	Chichester	**All Residential**	Brighton Phase 1	Winchester City Centre	**All City Centre**
Road length (kms)	5.8 (1%)	14.3 (2%)	53.0 (6%)	83.8 (9%)	227.1 (26%)	73.8 (8%)	64.9 (7%)	170.2 (19%)	66.6 (8%)	**759.5 (86%)**	109.1 (12%)	13.9 (2%)	**123.0 (14%)**
All collisions	7	21	73	83	142	67	64	460	64	**981**	1335	77	**1412**
All casualties	12	25	115	118	171	93	79	538	76	**1227**	1587	89	**1676**
Fatal casualties	0	0	0	0	2	0	0	1	0	**3**	0	0	**0**
Serious casualties	3	3	10	15	21	13	17	79	5	**166**	193	15	**208**
Slight casualties	9	22	105	104	148	80	62	458	71	**1059**	1394	74	**1468**
Cyclists injured	0	2	10	10	19	11	10	73	22	**157**	315	10	**325**
Pedestrians injured	0	6	19	22	51	20	26	124	5	**273**	399	37	**436**
Under 11s injured	0	0	9	13	27	8	13	37	3	**110**	51	4	**55**
11-16s injured	2	4	7	9	31	7	8	55	7	**130**	62	3	**65**
Over 75s injured	1	0	1	3	5	2	1	28	3	**44**	94	10	**104**

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The table below adjusts the total collisions and casualties for the road length in each case study area and for the number of years observed (five-year before period) to show the collision and casualty rate per road km and per year for each area. This shows that for most areas, the collision rate per road km and per year is between 0.125 and 0.294, but the rates are considerably higher in:

- Winchester City Centre (1.105) and Brighton Phase 1 (2.448).

Both these case studies involve implementing 20mph limits on key strategic roads through the city centre where flows are higher.

The table also shows differences in users involved in collisions. For example, Brighton Phase 1 and Winchester seem to have a higher incidence of cyclists and pedestrians injured in collisions. These differences between case study areas are likely to be down to a number of factors, such as the availability of cycling/pedestrian facilities, the uptake of cycling/walking in the area among many other contextual factors.

Table D-3 Collision and casualty rates per km of road per year, in each case study area – 5-year before period

Number	Walsall	Winchester Stanmore	Liverpool Area 7	Liverpool Area 2	Middles-brough	Calderdale	Nottingham	Brighton Phase 2	Chichester	All Residential	Brighton Phase 1	Winchester City Centre	All City Centre
All collisions	0.241	0.294	0.276	0.198	0.125	0.182	0.197	0.541	0.192	**0.258**	2.448	1.105	**2.296**
All casualties	0.414	0.350	0.434	0.282	0.151	0.252	0.243	0.632	0.228	**0.323**	2.911	1.277	**2.725**
Fatal casualties	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001	0.000	**0.001**	0.000	0.000	**0.000**
Serious casualties	0.103	0.042	0.038	0.036	0.018	0.035	0.052	0.093	0.015	**0.044**	0.354	0.215	**0.338**
Slight casualties	0.310	0.308	0.396	0.248	0.130	0.217	0.191	0.538	0.213	**0.279**	2.557	1.062	**2.387**
Cyclists injured	0.000	0.028	0.038	0.024	0.017	0.030	0.031	0.086	0.066	**0.041**	0.578	0.143	**0.528**
Pedestrians injured	0.000	0.084	0.072	0.053	0.045	0.054	0.080	0.146	0.015	**0.072**	0.732	0.531	**0.709**
Under 11s injured	0.000	0.000	0.034	0.031	0.024	0.022	0.040	0.043	0.009	**0.029**	0.094	0.057	**0.089**
11-16s injured	0.069	0.056	0.026	0.021	0.027	0.019	0.025	0.065	0.021	**0.034**	0.114	0.043	**0.106**
Over 75s injured	0.034	0.000	0.004	0.007	0.004	0.005	0.003	0.033	0.009	**0.012**	0.172	0.143	**0.169**
FRC 1-3	-	-	-	-	-	-	-	3.125	-	**-**	8.187	-	-
FRC 4-5	0.799	1.068	0.547	1.720	0.425	0.602	1.090	2.427	1.079	**-**	4.644	2.143	-
FRC 6-7	0.047	0.251	0.270	0.185	0.119	0.123	0.174	0.375	0.096	**-**	1.216	0.446	-

D.2.3. Collisions by road type

The table below shows the total number of collisions and casualties during the before period and collision/casualty rates per km by road type and per year.

The purpose of this analysis is to understand whether different classifications of road have differing collision rates. As expected (see Section 2), Table D-4 demonstrates that higher classification roads (FRC1 – 3 corresponding to larger roads) have higher collision rates per kilometre than lower road classifications. This is likely to be due to higher traffic flows on roads with higher road classifications.

Table D-4 Collisions by road type (per km of road per year) for all case study areas - 5-year before period

	Important strategic roads (FRC1-3)		Important local roads (FRC4-5)		Minor local roads (FRC6-7)	
Road length (kms)	11.0		62.1		809.2	
	Total number	**Per km per year**	**Total number**	**Per km per year**	**Total number**	**Per km per year**
All collisions	434	7.921	731	2.353	1,224	0.303
All casualties	527	9.619	876	2.820	1,497	0.370
Fatal and serious casualties	58	1.059	121	0.390	197	0.049
Slight casualties	469	8.560	755	2.431	1,300	0.321

When considering individual case study areas, it is important to note that the majority of road length considered is in the minor local road category (FRC6-7), with this category representing over 90% of road lengths included in the case study areas overall and for most individual case study areas.

Areas with relatively high proportion of important strategic and important local roads included in the case study are presented in Table D-5. This includes both areas in Brighton and Winchester where higher collision and casualty rates were identified. Important strategic roads represent almost 10% of roads included in Brighton Phase 1. Winchester is the case study area with the highest proportion of important local roads (close to 40%).

Table D-5 Road categories breakdown for areas with significant proportion of important roads

Road categories		Walsall	Calderdale	Brighton Phase 2	Chichester	Brighton Phase 1	Winchester City Centre
Total road length (km)		5.8	73.8	170.2	66.6	109.1	13.9
Important strategic roads (FRC1-3)	Total km	0	0	0.6	0	10.4	0
	Percent total km	***0***	***0***	***0.34%***	***0***	***9.52%***	***0***
Important local roads (FRC4-5)	Total km	1.5	9	12.9	6.5	17.9	5.4
	Percent total km	***25.89%***	***12.16%***	***7.60%***	***9.74%***	***16.43%***	***38.82%***
Minor local roads (FRC6-7)	Total km	4.3	64.8	156.7	60.1	80.6	8.5
	Percent total km	***74.11%***	***87.84%***	***92.06%***	***90.26%***	***73.88%***	***61.18%***

Table D-6 presents collision rates for these areas per road type (as well as the overall aggregated rate and the range of rates for the other individual case study areas). This shows that the presence of important strategic roads in the Brighton case study areas and the higher proportion of important local roads in the Winchester area can partially explain their higher collision rates. These areas also show higher collision rates for their minor local roads however, indicating that other factors influence this data.

Table D-6 Collision rates for case study areas with significant proportion of important roads

Collision rate per km per year	Overall rate	Range for other areas	Walsall	Calderdale	Brighton Phase 2	Chichester	Brighton Phase 1	Winchester City Centre
Across all road types	0.542	0.125 – 0.294	0.241	0.182	0.541	0.192	2.448	1.105
On important strategic roads (FRC1-3)	7.921	n/a	0	0	3.125	0	8.187	0
On important local roads (FRC4-5)	2.353	0.425 – 1.720	0.799	0.602	2.427	1.079	4.644	2.143
On minor local roads (FRC6-7)	0.303	0.119 – 0.270	0.047	0.123	0.375	0.096	1.216	0.446

D.3. After period

The data for the after period represents collisions (and casualties) that have occurred following the introduction of 20mph limits.

D.3.1. Collisions and casualties in 20mph limit areas

The table below shows the number and rate of collisions found in the aggregated case study areas, across the post-scheme periods.

Table D-7 Collisions/casualties for all case study areas – after period

Collisions and casualties	Aggregated number	Rate per km of road per year
Road length (kms)	882.48	-
All collisions	1437	0.475
All casualties	1677	0.557
Fatal casualties	3	0.001
Serious casualties	266	0.085
Slight casualties	1410	0.471
Cyclists injured	430	0.138
Pedestrians injured	403	0.135
Under 11s injured	88	0.031
11-16s injured	98	0.032
Over 75s injured	76	0.025

D.3.2. Collisions and casualties in each case study area

The table below shows the disaggregated collision data by case study area. As with the before data, In general, there is a relationship between the distance of affected roads, and the number of collisions observed.

Again, Brighton Phase 1 case study has a large number of collisions and casualties per km per year, than elsewhere. The area represents 12% of the case study area total road length but 56% of all collisions and 55% of all casualties, for the after period considered here. These figures have not changed since the before data.

Table D-8 Number of collisions/casualties for each case study area – after period

Collisions and casualties	Walsall	Winchester Stanmore	Liverpool Area 7	Liverpool Area 2	Middles-brough	Calderdale	Nottingham	Brighton Phase 2	Chichester	All Residential	Brighton Phase 1	Winchester City Centre	All City Centre
Road length (kms)	5.8 (1%)	14.3 (2%)	53.0 (6%)	83.8 (9%)	227.1 (26%)	73.8 (8%)	64.9 (7%)	170.2 (19%)	66.6 (8%)	**759.5 (86%)**	109.1 (12%)	13.9 (2%)	**123.0 (14%)**
All collisions	1	10	37	18	96	17	38	325	52	**594**	808	35	**843**
All casualties	1	15	49	23	115	23	41	375	67	**709**	929	39	**968**
Fatal casualties	0	0	0	0	1	0	0	0	1	**2**	1	0	**1**
Serious casualties	0	2	3	1	24	2	6	55	11	**104**	158	4	**162**
Slight casualties	1	13	46	22	92	21	35	320	55	**605**	770	35	**805**
Cyclists injured	0	1	9	6	18	1	5	75	26	**141**	286	3	**289**
Pedestrians injured	0	3	8	3	36	9	8	89	7	**163**	220	20	**240**
Under 11s injured	0	0	5	4	14	3	3	25	4	**58**	28	2	**30**
11-16s injured	0	0	3	2	21	3	1	29	7	**66**	31	1	**32**
Over 75s injured	0	1	1	1	9	1	0	22	0	**35**	39	2	**41**

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The table below adjusts the total collisions and casualties for the road length in each case study area and for the number of years observed (which varies between the case study areas for the post-scheme data) to show the collision and casualty rate per road km and per year for each area.

As in the before data, the collision and casualty rates per road km and per year are considerably higher in Winchester City Centre and Brighton Phase 1, than elsewhere.

Table D-9 Collision and casualty rates per km of road per year, in each case study area – after period

Number	Walsall	Winchester Stanmore	Liverpool Area 7	Liverpool Area 2	Middles-brough	Calderdale	Nottingham	Brighton Phase 2	Chichester	All Residential	Brighton Phase 1	Winchester City Centre	All City Centre
All collisions	0.063	0.289	0.262	0.112	0.094	0.163	0.220	0.546	0.228	**0.242**	2.021	1.116	**1.918**
All casualties	0.063	0.434	0.347	0.143	0.113	0.220	0.237	0.630	0.294	**0.291**	2.323	1.243	**2.201**
Fatal casualties	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.004	**0.001**	0.003	0.000	**0.002**
Serious casualties	0.000	0.058	0.021	0.006	0.023	0.019	0.035	0.092	0.048	**0.040**	0.395	0.128	**0.365**
Slight casualties	0.063	0.376	0.326	0.137	0.090	0.201	0.202	0.537	0.242	**0.251**	1.926	1.116	**1.834**
Cyclists injured	0.000	0.029	0.064	0.037	0.018	0.010	0.029	0.126	0.114	**0.056**	0.715	0.096	**0.645**
Pedestrians injured	0.000	0.087	0.057	0.019	0.035	0.086	0.046	0.149	0.031	**0.067**	0.550	0.638	**0.560**
Under 11s injured	0.000	0.000	0.035	0.025	0.014	0.029	0.017	0.042	0.018	**0.025**	0.070	0.064	**0.069**
11-16s injured	0.000	0.000	0.021	0.012	0.021	0.029	0.006	0.049	0.031	**0.026**	0.078	0.032	**0.072**
Over 75s injured	0.000	0.029	0.007	0.006	0.009	0.010	0.000	0.037	0.000	**0.014**	0.098	0.064	**0.094**
FRC 1-3	-	-	-	-	-	-	-	3.968	-	-	6.384	-	-
FRC 4-5	0.242	0.553	0.684	1.496	0.378	0.629	0.454	2.252	0.812	-	3.927	2.217	-
FRC 6-7	0.000	0.275	0.253	0.100	0.088	0.098	0.213	0.392	0.165	-	1.039	0.417	-

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Appendix E. Comparator area data

E.1. Introduction

This section includes an overview of the collision data in the selected comparator areas and provides more detail on the analysis undertaken to check the overall fit of the comparator areas selected to conduct this analysis.

E.2. Collisions rate in comparator areas

Each of the case study areas has been attributed a comparator area (see Section 4.3). The collisions in each comparator area for the before period are summarised below. Table E-1 shows the total collisions and casualties in each comparator area, while Table E-2 shows these as rates per kilometres.

Table E-1 Collisions and casualties in comparator areas – 5 year before period

	East Midlands	North East	North West	South East	West Midlands	Yorkshire
Road length (kms)	2,691.8	3,876.9	14,980.9	21,437.5	9,073.8	6,961.0
All collisions	6,294	5,893	28,206	38,284	23,448	15,712
All casualties	7,977	8,096	39,031	47,622	32,114	22,023

Table E-2 Collision and casualty rates per km per year in comparator areas – 5 year before period

	East Midlands	North East	North West	South East	West Midlands	Yorkshire
Road length (kms)	2,691.8	3,876.9	14,980.9	21,437.5	9,073.8	6,961.0
All collisions	0.468	0.304	0.402	0.357	0.517	0.451
All casualties	0.593	0.418	0.559	0.444	0.708	0.633

Table E-2 shows that the collisions rates per kilometre vary between 0.418 collisions per kilometre of road in the North East to 0.708 collisions per year per kilometre of road in the West Midlands. The casualty rates follow the collision rates in terms of relative scale.

This compares to an overall collision rate of 0.542 per km per year for the case study areas, ranging from 0.125 in the Middlesbrough case study area to 2.448 in Brighton Phase 1 (see Table D-1 and Table D-3).

E.3. Trend in comparator areas

Comparator trend by road type – Figure E-1 below shows the total quarterly collisions across the comparator areas, split into the road classification groups. This shows a downward trend over the before period across all road types.

Comparator versus case study trend – Figure E-2 shows total quarterly collisions across the case study areas (in blue) and across the comparator areas (in orange). Collison number have been indexed to enable a representation on the same graph due to the difference in scale between case study and comparator areas.

The graph shows that the trend in case study areas is also generally downward although there is much more variation in the case study areas as expected due to the much smaller sample size. Nevertheless, the linearised trend for the case study areas broadly parallels that for the comparator areas.

Figure E-1 Aggregated quarterly collisions in comparator areas by road type - 5 year before period

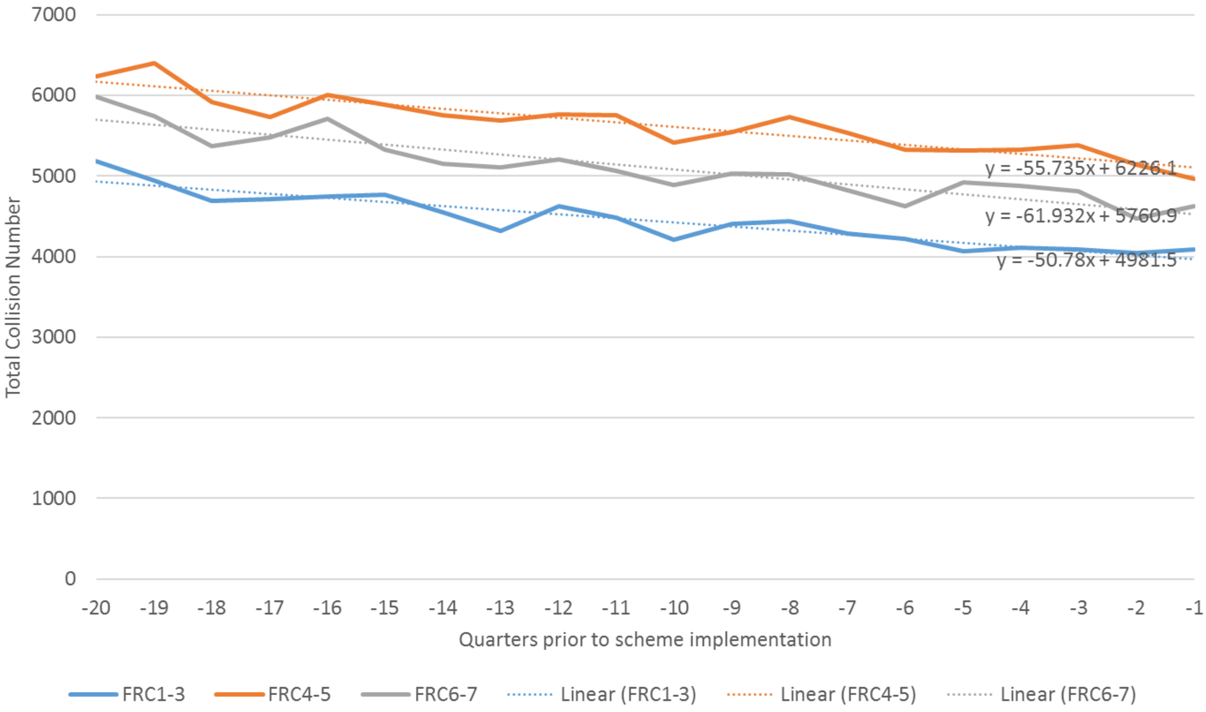
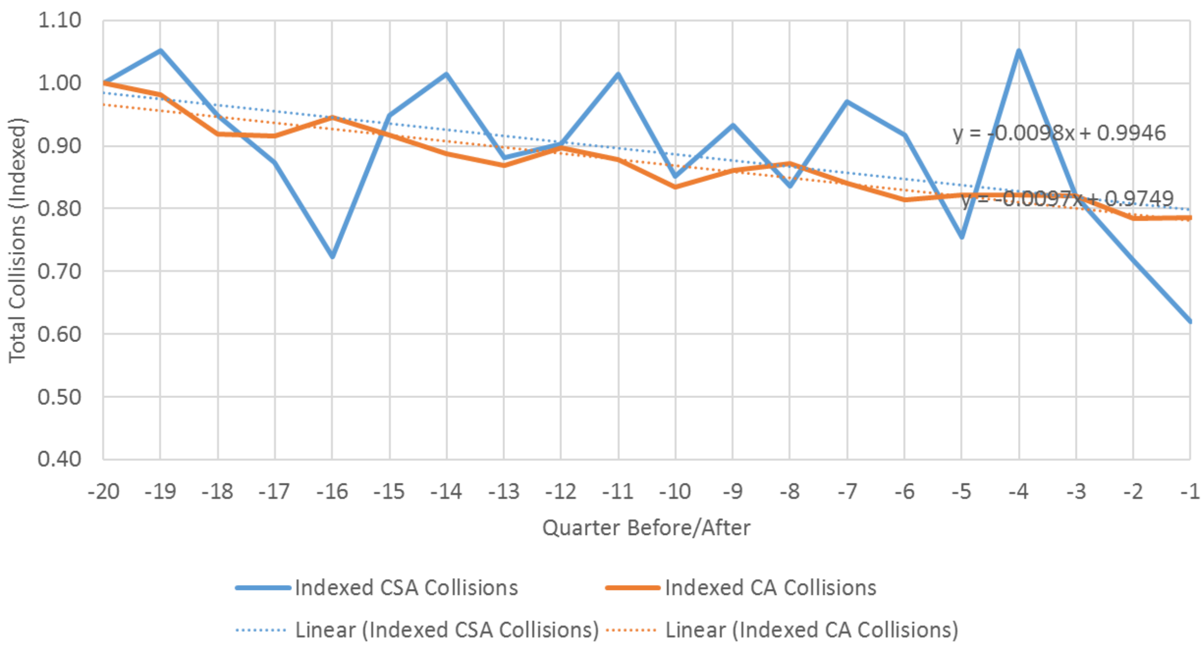
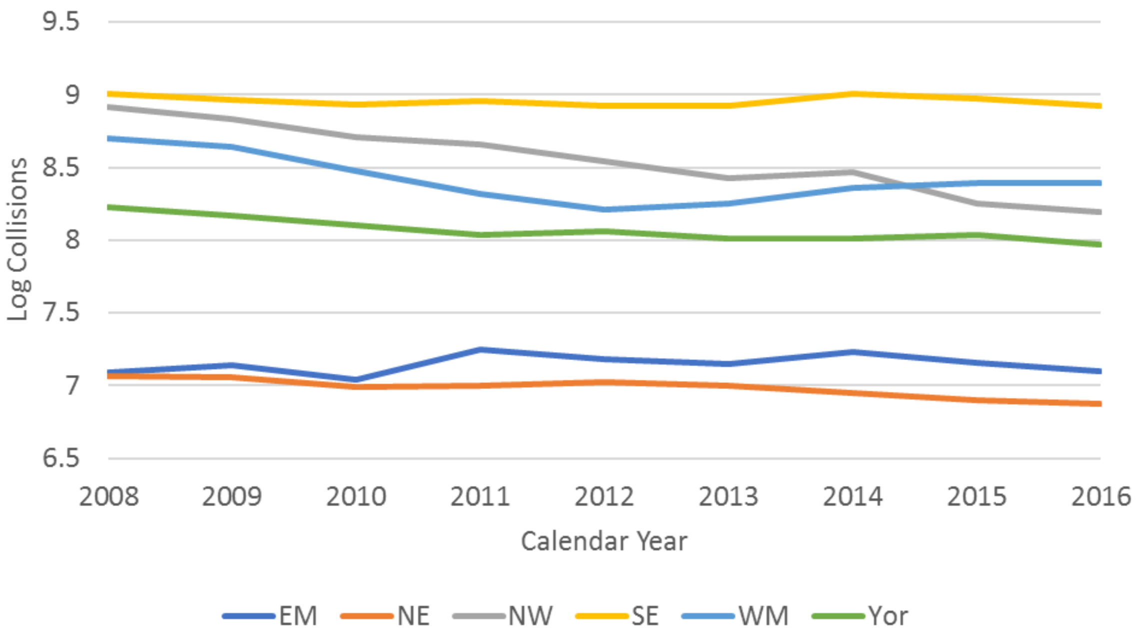


Figure E-2 Aggregated quarterly indexed collisions in case study and comparator areas - 5 year before period



Comparator area collisions by year – Figure E-3 shows the comparator area collisions on 30mph roads by year so that the trend over time can be observed. The graph is plotted on a log scale, to allow the trend to be seen without being obscured by the size of each of the comparator areas. The figure demonstrates that while most of the case study areas have seen marginal change in collisions over time, the north-west comparator area has seen a large reduction over time.

Figure E-3 30mph collisions per annum in comparator areas



E.4. Confirming comparator area fit

As noted in Section 4.3, additional analysis was undertaken by Mike Maher and the Atkins team to check that the comparator areas provide a satisfactory guide to the trend (for seasonal variation and long-term drift in the mean collision rate).

The analysis aimed to check that the variation between the observed collisions in case study areas and the expected collisions (derived from the before collisions in comparator areas) can be purely attributed to random variation (according to a Poisson distribution).

a) Initial test of fit between case study and comparator areas

The basic idea is that we can write the following model:

$$E(y_{it}) = k_i R_{it} \qquad (1)$$

Where y_{it} is the number of collisions in a case study area i in quarter t and R_{it} is the corresponding number in the comparator area in the same quarter.

The parameters k_i are scaling parameters allowing for the difference in size (in terms of numbers of collisions) between the case study area and its corresponding comparator area. The max likelihood estimates of these scaling parameters are:

$$\hat{k}_i = {\textstyle\sum_t y_{it}} \Big/ {\textstyle\sum_t R_{it}} \qquad (2)$$

So the ratio of the total collisions in the case study area to the total collisions in the comparator area. It then follows that the best estimate of the expected total number of collisions (over all sites) in quarter t is given by:

$$E_t = E\left(\textstyle\sum_i y_{it}\right) = \textstyle\sum_i \hat{k}_i R_{it} \qquad (3)$$

So we can compare the observed collision totals, by quarter, $O_t = \sum_i y_{it}$ with the expected total given by the E_t in (3), and carry out a chi-squared test to see whether the differences between the observed and expected collisions are within the limits to be expected through natural random (Poisson) variation in the collision numbers. The results are in the table below.

For the unweighted analysis, the chi-squared value is 29.3 on 19 degrees of freedom with a P value of 0.062.

While the comparator areas cannot be expected to provide a perfect predictor of what the mean collisions would be in the case study areas, the results obtained from the chi-squared tests show a remarkably small amount of over-dispersion[19].

Table E-3 Quarterly number of collisions in case study areas (observed) and in comparator areas (expected), before period

Quarter	Observed	Expected (unweighted)	Expected (weighted)
1	122	134.6	135.0
2	140	132.8	134.1
3	136	126.2	125.4
4	108	118.5	118.5
5	118	125.0	127.7
6	121	127.1	126.4
7	135	122.5	122.9

[19] In statistics, over-dispersion is the presence of greater variability (statistical dispersion) in a data set than would be expected based on a given statistical model. It would be unreasonable to expect no over-dispersion in the data.

Quarter	Observed	Expected (unweighted)	Expected (weighted)
8	131	111.4	111.9
9	141	119.3	119.4
10	112	123.8	123.8
11	96	114.0	113.1
12	132	114.6	115.0
13	109	119.0	118.1
14	143	120.9	120.3
15	107	111.8	109.9
16	110	114.0	114.8
17	120	117.3	117.7
18	121	118.2	117.3
19	103	114.2	113.9
20	88	107.6	107.7

Should the comparator areas be adjusted to reflect road types included in the case study areas?

One key characteristics that we considered adjusting for is the type of roads (FRC classification) included in each comparator area. To assess whether it would be beneficial to adjust the data in each comparator area to better represent the types of road included in each case study area, we carried out a weighted analysis where we adjusted for the respective lengths of the three road classes in the case study areas SA (d_i) and the comparator areas (D_i) by:

$$R = \frac{d_1}{D_1}R_1 + \frac{d_2}{D_2}R_2 + \frac{d_3}{D_3}R_3 \qquad (4)$$

to derive the values of the R_{it}. Then, using these alternative values in (1) – (3), we calculated the weighted expected values presented in the above table (right hand column). These values are only slightly different from the unweighted values. Using these values to test the fit between case study and comparator areas, the chi-squared value is slightly lower (indicating a slightly better fit) at 28.9 and the P value is slightly higher at 0.067.

This shows that there is little difference between the weighted and unweighted analyses and both give chi-squared values which would lead to the null hypothesis (of the Poisson model being satisfactory) at the 5% level; e.g. there is no significant evidence of “overdispersion”.

Is there a good fit between each individual case study area and its comparator area?

To assess individual case study area fit with its comparator area, we carried out separate chi-squared tests for each site. The results are presented in the table below.

All tests gave satisfactory fits (P value > 0.05) except for site 6. This is not however identified as an issue, as we would expect to see the null hypothesis rejected once on average out of every 20 tests at the 5% significance level, when the null hypotheses are true.

We note in particular that the Brighton sites (8 and 10) both give perfectly adequate results, so there is no reason here to consider omitting them.

Table E-4 Fit between each individual case study area and its comparator area

Case study area	Chi-squared	P value
1 – Walsall	13.02	0.8375
2 – Winchester	13.47	0.8138
3 – Liverpool Area 7	18.48	0.4908

Case study area	Chi-squared	P value
4 – Liverpool Area 2	26.07	0.1283
5 – Middlesbrough	13.44	0.8151
6 – Calderdale	30.75	*0.0430*
7 – Nottingham	18.21	0.5082
8 – Brighton Phase 2	18.39	0.4965
9 – Chichester	16.00	0.6573
10 – Brighton Phase 1	23.28	0.2250
11 – Winchester City Centre	24.01	0.1958

Assessing the fit using aggregated data across all case study and comparator areas

An alternative (and almost equivalent) way to proceed is to fit the model in (1) as a Poisson GLM using all data from all sites, with an 11-level site factor (to estimate the k_i) and log(R_it) as an offset.

The fitted model has a residual deviance of 236.7 (which measures the overall lack of fit between the 220 quarterly observed numbers of collisions at the 11 sites and the corresponding fitted values) on 209 degrees of freedom. This has a P value of 0.092, showing that, again, the null hypothesis of the adequacy of the Poisson model is accepted at the 5% level.

If we try to fit a Negative Binomial GLM instead, warning messages are produced indicating that there is some difficulty in estimating the additional dispersion parameter. The residual deviance is reduced – but only to 233.2. The drop from 236.7 to 233.2 is non-significant at the 5% level (a fall of 3.84 would be required), showing that the extra dispersion parameter is not justified in the model.

Summary

It would be surprising if the pure Poisson model fitted perfectly. We cannot expect the comparator area data to provide a perfect value of any case study area mean, so that the variation between the observed values and the expected values are entirely explained by the Poisson model. The results here overall are good, in that they show that there is insufficient evidence to reject the model at the 5% level.

A Negative Binomial model will be used to undertake the before and after analysis for the aggregated case study data, and estimate the treatment effect (rather than a pure Poisson model). This is now standard practice in collision modelling and will allow for “overdispersion”, without the need to rely on the assumption that a pure Poisson model is adequate.

Appendix F. Statistical output

F.1. Residential case studies only, total collisions

See Table 5-3 for summary results

Area definitions

Area 1 - Walsall

Area 2 - Winchester_Stanmore

Area 3 - Liverpool_Area7

Area 4 - Liverpool_Area2

Area 5 - Middlesborough

Area 6 - Calderdale

Area 7 - Nottingham

Area 8 - Brighton_Phase2

Area 9 – Chichester

R Output

```
> summary(fitba)


Call:

glm.nb(formula = ytot ~ farea + treat + offset(log(Rtot)), init.theta = 959244.5443,

   link = log)


Deviance Residuals:

    Min       1Q    Median       3Q       Max

-1.19131  -0.34048  -0.01107   0.28311   1.40065


Coefficients:

            Estimate Std. Error z value Pr(>|z|)

(Intercept) -8.395652   0.354012 -23.716  < 2e-16 ***

farea2       0.836660   0.399357   2.095   0.0362 *

farea3       2.470738   0.366566   6.740 1.58e-11 ***
```

```
farea4      2.551572   0.367518   6.943 3.85e-12 ***
farea5      4.601271   0.359514  12.799  < 2e-16 ***
farea6      2.935554   0.370280   7.928 2.23e-15 ***
farea7      3.834139   0.367562  10.431  < 2e-16 ***
farea8      3.953234   0.355374  11.124  < 2e-16 ***
farea9      2.030160   0.366086   5.546 2.93e-08 ***
treat      -0.004986   0.053219  -0.094   0.9254
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Negative Binomial(959244.5) family taken to be 1)

    Null deviance: 1757.5019  on 17  degrees of freedom
Residual deviance:    6.9661  on  8  degrees of freedom
AIC: 128.58

Number of Fisher Scoring iterations: 1

              Theta:  959245
          Std. Err.:  14601759
Warning while fitting theta: iteration limit reached

 2 x log-likelihood:  -106.577
```

Calculation of treatment effect and Confidence Interval

```
> estba <- as.numeric(coef(fitba)[10])
> seba <- as.numeric(sqrt(vcov(fitba)[10,10]))
> exp(estba); exp(estba-1.96*seba); exp(estba+1.96*seba)   # estimate of treatment effect and 95% CI
[1] 0.9950266
[1] 0.8964655
[1] 1.104424
```

F.2. Residential case studies only, total casualties

See Table 5-3 for summary results

R Output

```
> summary(fitba)


Call:

glm.nb(formula = ytot ~ farea + treat + offset(log(Rtot)), init.theta = 813631.6429,

    link = log)


Deviance Residuals:

     Min        1Q    Median        3Q       Max

-1.94039  -0.52168   0.02483   0.35516   1.08696


Coefficients:

             Estimate Std. Error z value Pr(>|z|)

(Intercept) -8.219871   0.277823 -29.587  < 2e-16 ***

farea2       0.717832   0.321313   2.234   0.0255 *

farea3       2.378283   0.288366   8.247  < 2e-16 ***

farea4       2.389416   0.290039   8.238  < 2e-16 ***

farea5       4.298204   0.283651  15.153  < 2e-16 ***

farea6       2.757423   0.292696   9.421  < 2e-16 ***

farea7       3.585797   0.292481  12.260  < 2e-16 ***

farea8       3.718182   0.279343  13.310  < 2e-16 ***

farea9       1.860674   0.290134   6.413 1.43e-10 ***

treat       -0.007747   0.048330  -0.160   0.8727

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


(Dispersion parameter for Negative Binomial(813631.6) family taken to be 1)


    Null deviance: 1991.901  on 17  degrees of freedom
```

Residual deviance: 10.891 on 8 degrees of freedom

AIC: 137.07

Number of Fisher Scoring iterations: 1

Theta: 813632

Std. Err.: 10656331

Warning while fitting theta: iteration limit reached

2 x log-likelihood: -115.068

>

Calculation of treatment effect and Confidence Interval

```
> estba <- as.numeric(coef(fitba)[10])

> seba <- as.numeric(sqrt(vcov(fitba)[10,10]))

> exp(estba); exp(estba-1.96*seba); exp(estba+1.96*seba)   # estimate of treatment effect and 95% CI

[1] 0.9922829

[1] 0.902601

[1] 1.090876
```

F.3. Brighton Phase 1 only, total collisions

See Table 5-8 for summary results

R Output

```
> summary(fitba)

Call:

glm(formula = ytot ~ treat + offset(log(Rtot)), family = poisson)

Deviance Residuals:

[1]  0  0

Coefficients:
```

```
            Estimate Std. Error  z value Pr(>|z|)
(Intercept) -3.39057    0.02741 -123.698  < 2e-16 ***
treat       -0.20199    0.04550   -4.439 9.03e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance:  2.0042e+01  on 1  degrees of freedom
Residual deviance: -1.6431e-13  on 0  degrees of freedom
AIC: 21.5

Number of Fisher Scoring iterations: 2
```

Calculation of treatment effect and Confidence Interval

```
> estba <- as.numeric(coef(fitba)[2])
> seba <- as.numeric(sqrt(vcov(fitba)[2,2]))
> exp(estba); exp(estba-1.96*seba); exp(estba+1.96*seba)   # estimate of treatment effect and 95% CI
[1] 0.8171002
[1] 0.7473808
[1] 0.8933235
```

F.4. Brighton Phase 1 only, total casualties

See Table 5-8 for summary results

R Output

```
> summary(fitba)

Call:
glm(formula = ytot ~ treat + offset(log(Rtot)), family = poisson)

Deviance Residuals:
[1]  0  0
```

```
Coefficients:
            Estimate Std. Error  z value Pr(>|z|)
(Intercept) -3.43405    0.02513 -136.630  < 2e-16 ***
treat       -0.21917    0.04213   -5.203 1.96e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance:  2.7597e+01  on 1  degrees of freedom
Residual deviance: -4.8850e-15  on 0  degrees of freedom
AIC: 21.817

Number of Fisher Scoring iterations: 2
```

Calculation of treatment effect and Confidence Interval

```
> estba <- as.numeric(coef(fitba)[2])
> seba <- as.numeric(sqrt(vcov(fitba)[2,2]))
> exp(estba); exp(estba-1.96*seba); exp(estba+1.96*seba)   # estimate of treatment effect and 95% CI
[1] 0.8031817
[1] 0.7395299
[1] 0.872312
```

Appendix G. Traffic flow data

G.1. Local authority count data

For most of the case study areas, the relevant local authority has undertaken before and after counts at a sample of sites on the new 20mph roads. In general, the counts have been undertaken over a 7 day period, 24 hours per day, allowing a 7 day average flow to be calculated for each site.

This data has been provided on a site by site basis for the following case study areas:

Table G-1 Count data collected for case study areas (on new 20mph roads)

ID	Case study area	No. of sites	Location of sites	Monitor-ing approach	Monitor-ing duration	Before monitoring period	After1 monitoring period	After2 monitoring period
Small-scale residential schemes								
R-SM1	Walsall (Rushall)	10	Representa-tive locations across scheme area	Pneumatic loops	7 days (24hr)	6 months pre (Sep 2013)	4 months post (Jul 2014)	30 months post (Sep 2016)
R-SM2	Winchester (Stanmore)	3	Representa-tive locations across scheme area	Speed detection radar	7 days (24hr)	15+ months pre (Aug 2009, Mar 2013)	-	17-21 months post (Nov 2015, Mar 2016)
Area-wide residential schemes								
R-AW5	Brighton (Phase 2)	46	Representati ve locations across scheme area (+ sites with complaints about speeding)	Pneumatic loops	7 days (24hr)	12 months pre (Jun 2013)	12 months post (Jun 2015)	24 months post (Jun 2016)
City centre and adjacent residential area schemes								
TC-AW1	Brighton (Phase 1)	54	Representati ve locations across scheme area (+ sites with complaints about speeding)	Pneumatic loops	7 days (24hr)	10 months pre (Jun 2012)	13 months post (May 2014)	26 months post (Jun 2015)
TC-AW2	Winchester (City Centre)	11	Representati ve locations across city	Speed detection radar	7 days (24hr)	12-30 months pre (1 site in Apr 2012, 1 in Apr 2013, 3 in Jul 2013, 6 in Sep 2013)	7-8 months post (Apr/May 2015)	-

The data provides an indication of:

- absolute flows on 20mph roads across the relevant case study areas; and
- change in flow between the before and after periods.

G.1.1. Comparison of flows across case study areas

Figures G-1 and G-2 compare flow on 'important local roads' (FRC4-5) and 'minor local roads (FRC6-7) for case study areas where detailed flow data is available.

The count sites being compared in each of the graphs have been assigned the same Functional Road Classification in the TomTom mapping file, which generally provides a good proxy for the size and strategic nature of the road. However, the graphs below shows a distinct variation between locations.

Roads classified as 'important local roads' (FRC4-5) in the two city centre-focused areas typically have a much higher flow than similarly classified roads in the small-scale residential schemes (Walsall-Rushall and Winchester-Stanmore). Brighton Phase 2, an area-wide residential scheme, also includes some 'locally important roads' with high flows.

Analysis of the data for the after period also shows a similar trend.

Figure G-1 'Before' traffic flow (7 day, 24hr average) at 20mph count sites across sample of case studies – Important local roads (FRC4-5)

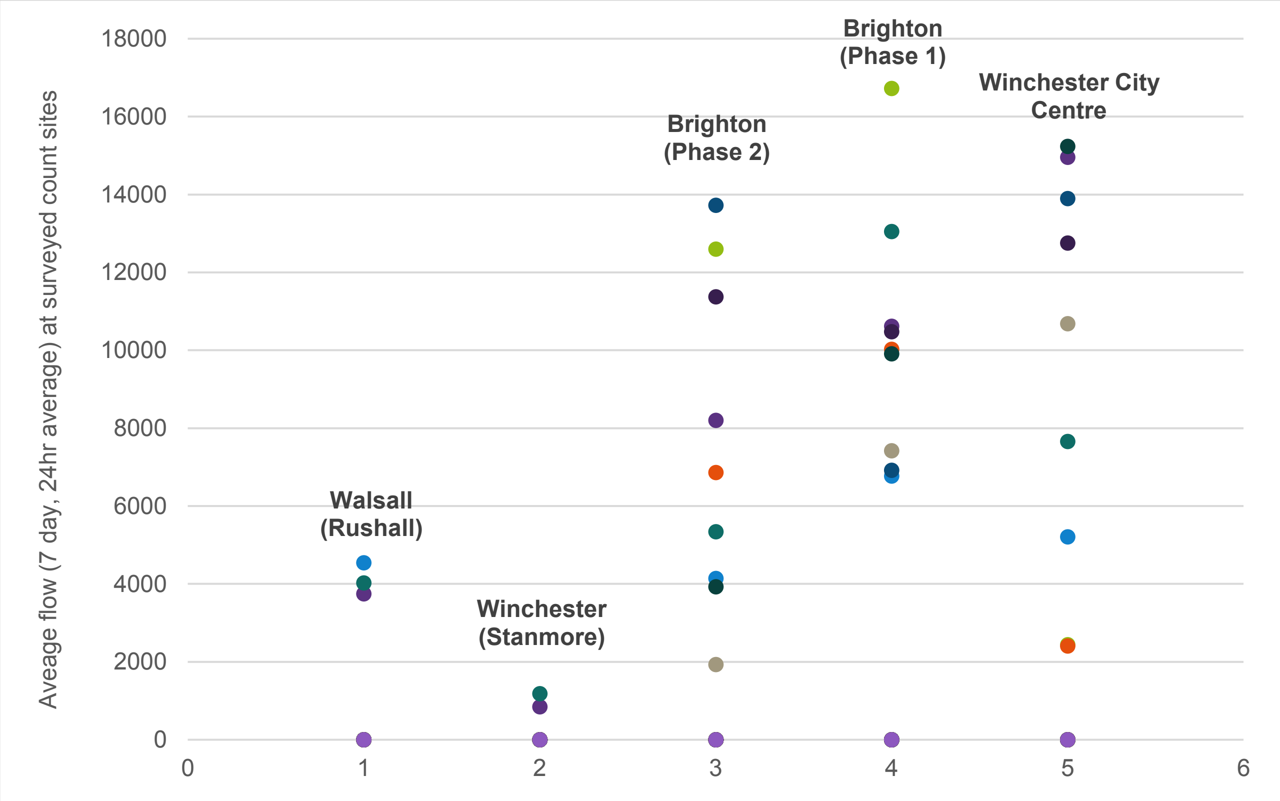


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Figure G-2 shows that flows on 'minor local roads' in Brighton Phase 1 are much higher than similar classified roads in Walsall (Rushall), Winchester (Stanmore), and in this case, Winchester City Centre.

As above, Brighton Phase 2, also includes some 'minor local roads' with comparatively high flows.

Analysis of the data for the after period also shows a similar trend.

Figure G-2 'Before' traffic flow (7 day, 24hr average) at 20mph count sites across sample of case studies – Minor local roads (FRC6-7)

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G.1.2. Change in flow between the before and after periods

Comparison of the total count across all sites in the before and after period gives an indication of any change in traffic flow following the introduction of the 20mph limit.

Table G-2 Comparison of before and after flows

ID	Case study area	No. of sites	Before	After 1 (Diff 1)	After 2 (Diff 2)
Small-scale residential schemes					
R-SM1	Walsall (Rushall)	10	17,287	-	18,590 (+8%)
R-SM2	Winchester (Stanmore)	3	3,668	-	4,476 (+22%)
Area-wide residential schemes					
R-AW5	Brighton (Phase 2)	46	115,226	114,906 (0%)	113,156 (-2%)
City centre and adjacent residential area schemes					
TC-AW1	Brighton (Phase 1)	54	247,054	-	252,537 (+2%)[A]
TC-AW2	Winchester (City Centre)	11	85,731	83,716 (-2%)	-

A. The breakdown by road type is: Major Strategic Roads (FRC1-3, 2 sites) = +3%; Important Local Roads (FRC 4-5, 15 sites) = -1%; Minor Local Roads (FRC 6-7, 37 sites) = +8%.

G.2. GB Road Traffic Count data

GB Road Traffic Count Data has also been used to determine whether there have been any major changes in flow in the case study areas, before and after implementation of the 20mph limits. The data has been downloaded from DfT's online database (https://www.dft.gov.uk/traffic-counts/). **The data relates to A roads only, so provides an indication of general trends in the case study areas rather than specifically indicating changes in flow on the 20mph roads.**

Data source

The Department for Transport (DfT) provides summary statistics of road traffic on an annual and quarterly basis. The underlying data behind these statistics is a series of national traffic counts collected by trained enumerators[20].

Data is available for each junction to junction link on the major road network (motorways and A roads) as (a) raw manual count data (b) Annual Average Daily Flows (AADF) and annual traffic data (as vehicle kilometers). Annual traffic is calculated by multiplying the AADF by the corresponding length of road and by the number of days in the year. Further information is provided for a sample of points on the minor road network (B, C and unclassified roads) but these have not been used here due to data limitations.

The AADF and traffic data for each location can either be 'counted' or 'estimated' for each year. A counted location means that a trained enumerator has completed a one day Manual Classified Count (MCC) at that location, in that year. An estimated location means that the location was not counted in that year. The frequency that each location is counted varies depending on how busy the road is.

Estimated locations use the previous year's data with an appropriate level of growth based on road type and location. Growth factors for each road type are informed by the observed count data collected across the major and minor data collection points[21].

The main benefit of using the DfT is the breadth of locations and historic data available. However, caution should be taken when using estimated traffic data as this is unlikely the reflect the impact of local changes to the extent that a bespoke data collection exercise would.

Table G-3 Summary of count point data by study area[22]

Case study area	Implementation date	Number of count sites	Data counts 6 years pre-implementation	Data counts from implementation year to 2016
Brighton Phase 1	Apr-13	25	21/150	15/100
Brighton Phase 2	Jun-14	15	35/90	12/45
Chichester	Jul-13	13	13/78	12/52
Liverpool Area 2	Jan-15	5	10/30	1/10
Liverpool Area 7	Apr-14	54	69/324	21/162
Nottingham	Apr-14	5	9/30	2/15
Winchester Stanmore	Jul-14	1	0/6	0/3
Middlesbrough	Mar 2012 – Jun 2012; Mar 2013 – Jun 2013	35	70/210	59/175
Calderdale	Jun-15	4	6/24	0/8

Analysis for table and graph stored here: P:\GBBMA\HandT\CS\Projects\5133131- Provision of 20mph Research\40 Technical\Task 3.5 Accident Analysis\8. Traffic Data\2.Flow analysis\flows\1.Case Study Flows\Filtered data

Table G-3 summarises the number of count points for each study area. The number of observed/counted

20 https://data.gov.uk/dataset/gb-road-traffic-counts

21 https://www.gov.uk/government/statistics/road-traffic-statistics-methodology-review

22 P:\GBBMA\HandT\CS\Projects\5133131- Provision of 20mph Research\40 Technical\Task 3.5 Accident Analysis\8. Traffic Data\2.Flow analysis\flows\1.Case Study Flows\Filtered data. The dataset does not include count sites in the Walsall (Rushall) and Winchester City Centre case study areas. Portsmouth was excluded from this analysis.

data locations is also provided compared to the total number of potentially observed counts (e.g. in Brighton Phase 1, there are 25 major count sites, over six years this a total of 150 potential observed counts (6*25 = 150). These columns give an indication of how much of the data for each study area has been based on observed underlying data, rather than estimated growth.

Change in annual traffic flow on major roads in case study areas

Figure G-3 and Table G-4 shows the reported change in traffic flow (annual vehicle kilometres) on major A roads in each study area. These roads may or may not have a 20mph speed limit.

The analysis is based on count locations with data for the duration of the study period (assumed to be six years pre-implementation, for consistency with the safety analysis).

The data has been compared back to a common year of 2006, for ease of comparison. For each case study area, the solid line shows the change in traffic from six years pre-implementation to 2016. A large dot on each line shows the implementation year for the case study in question. Where the implantation is spread across two years the earlier year is shown on the graph. Where the six year pre-implementation period starts after 2006, a dashed line has been used to show the change in traffic between 2006 and the start of the 'before period'. This allows all study areas to be viewed consistently.

Figure G-3 Trend in annual traffic flow (veh-kms) by case study area

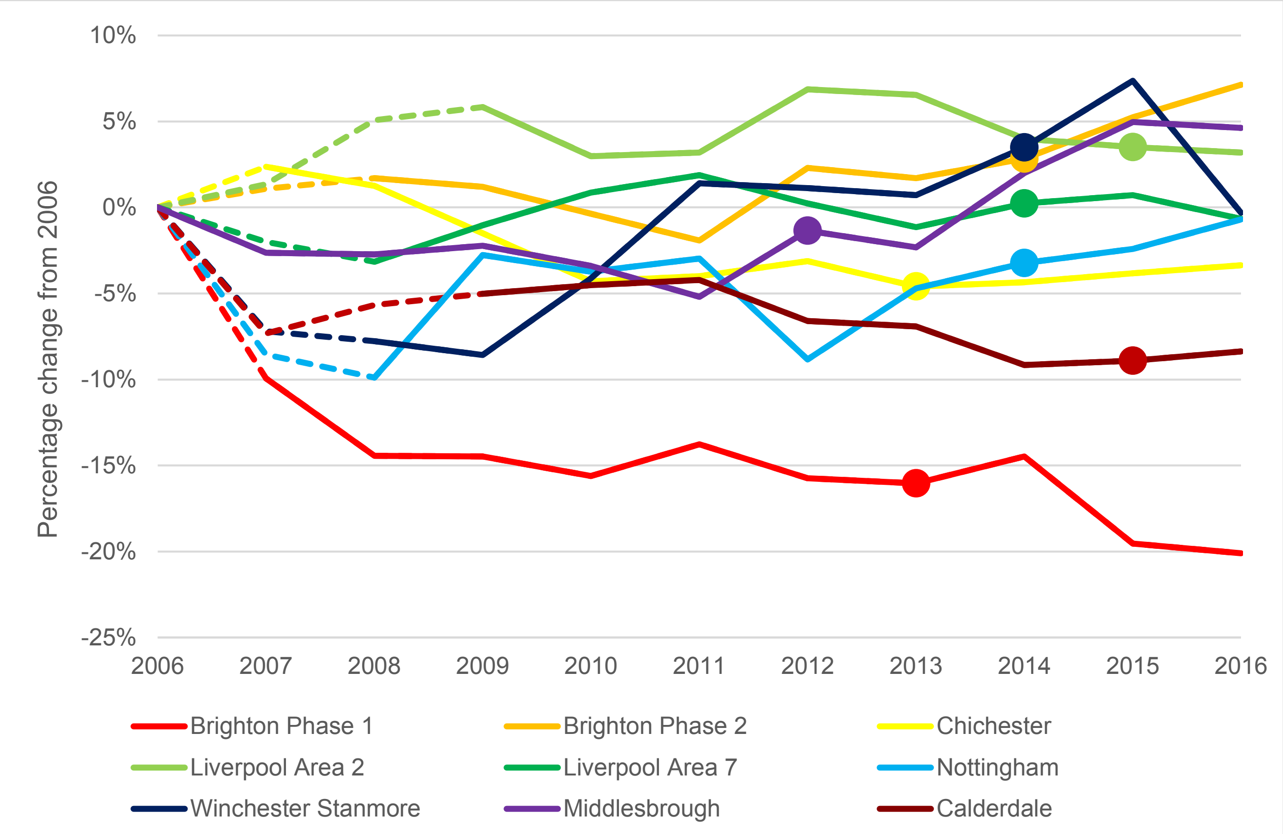

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Table G-4 Change in before and after average yearly traffic flow (veh-kms)

Case study area	Category	Before	After	% Change
Winchester (Stanmore)	Predominantly residential	6,994	7,454	6.6%
Liverpool (Area 7)	Predominantly residential	183,603	184,506	0.5%
Liverpool (Area 2)	Predominantly residential	101,222	99,724	-1.5%
Middlesbrough	Predominantly residential	464,512	484,989	4.4%
Calderdale	Predominantly residential	54,326	52,837	-2.7%

Nottingham	Predominantly residential	51,580	53,422	3.6%
Brighton Phase 2	Predominantly residential	294,167	306,714	4.3%
Chichester	Predominantly residential	102,002	99,423	-2.5%
Brighton Phase 1	City centre and adj residential areas	126,034	120,844	-4.1%
All residential areas		**1,258,404**	**1,289,068**	**2.4%**
All case study areas		**1,384,438**	**1,409,911**	**1.8%**

Key observations to note are:

- Brighton Phase 1 – The data shows a 4.1% reduction in annual traffic flow on major A roads between 2013 (implementation year) and 2016. Comparing average annual flow before and after implementation also shows a 4.1% reduction. The blanket-wide nature of 20mph implementation in Brighton Phase 1 means that these roads all have a 20mph limit.

- Middlesbrough – The data shows a 6% increase in annual traffic flow on major A roads between 2012 (the implementation year for the first phase) and 2016. Comparing average annual flow before and after implementation also shows a 4.4% increase. The nature of 20mph implementation in Middlesbrough means that none of these roads have a 20mph limit.

Appendix H. Quality assurance

H.1. Introduction

This appendix outlines some of the quality assurance measures that have been put in place to ensure that the analysis undertaken in this report has been checked and verified.

H.2. Collision matching

H.2.1. Collision matching process

Collision matching (aligning collisions to road map segments) was conducted using the FME software. To ensure the matching process was as effective as possible, a number of safeguards were put in place; namely:

- First the collisions from the DfT database were reduced to just those in the study area, to ensure no attempt was made to match irrelevant collisions.
- The *NeighborFinder* transformer (an in-built snapping algorithm) was used to snap collisions to the road network based on a buffer area around the road segments. Atkins tested a number of different buffer settings to identify the right balance between matching as many collisions as possible and maintaining confidence that the collision is snapped to the right segment. After testing different settings, it was considered 10m was an appropriate buffer to use.
- A secondary check was conducted, where possible, between the STATS19 road name and number and the road segment name and number, to ensure a match.
- Checks on the percentage of collisions matched per year and per case study area were conducted to ensure that there was no systematic bias in the results by year or area.

H.2.2. Visual check of collision matching

Once collisions had been matched to road segments, the collisions, and their respective roads were drawn on GIS maps to check visually that the matching process had provided sensible outcomes. Appendix C shows some of the maps created to check the matching process, and demonstrates that the collisions selected do visually appears to match the roads known to be 20mph.

H.2.3. Collision matching proportions

To ensure that the collision geocoding accuracy remained consistent over time in the STATS19 database, and that the collision matching algorithm worked equally effectively across all years, checks were conducted on the percentage of collisions that were matched to the road network in each case study and each calendar year. Table H-1 overleaf shows these percentages of matched collisions. It demonstrates a reasonable level of consistency from year to year in terms of the percentage of collisions that were successfully matched to the road network. This gives assurance that the process has not introduced a systematic bias.

Table H-1 Collisions matched by year in each case study area

	Walsall (Rushall) (R-SM1)	Winchester (Stanmore) (R-SM2)	Liverpool (Area 7) (R-AW1a)	Liverpool (Area 2) (R-AW1b)	Middles-brough (R-AW2)	Calderdale (Phase 1) (R-AW3)	Nottingham (Bestwood) (R-AW4)	Brighton (Phase 2) (R-AW5)	Chichester (R-AW6)	Brighton (Phase 1) (TC-AW1)	Winchester (City Centre) (TC-AW2)
2005	100%	83%	95%	96%	92%	92%	75%	82%	79%	81%	100%
2006	100%	94%	97%	97%	79%	96%	73%	79%	90%	84%	91%
2007	100%	79%	97%	96%	92%	94%	68%	78%	71%	85%	94%
2008	100%	84%	97%	92%	88%	100%	71%	86%	94%	86%	95%
2009	100%	92%	96%	95%	86%	90%	77%	83%	87%	87%	100%
2010	100%	88%	95%	92%	90%	93%	71%	91%	76%	91%	100%
2011	100%	86%	97%	94%	89%	100%	84%	89%	89%	87%	100%
2012	No Collisions	100%	96%	94%	100%	95%	91%	89%	84%	87%	100%
2013	100%	100%	98%	96%	96%	100%	95%	95%	99%	96%	100%
2014	100%	82%	94%	93%	97%	93%	94%	98%	96%	95%	100%
2015	100%	95%	95%	89%	97%	88%	95%	94%	99%	98%	100%
2016	100%	95%	96%	89%	100%	100%	89%	98%	99%	98%	100%

H.3. Checks on the comparator area collision trends

To provide a high-level check that the comparator area collision trend over time has been calculated correctly, SQL queries of the STATS19 database were conducted to summarise total collisions by year. This provided assurance that the high level trends such as those observed in the north-west comparator area (large reduction over time) are present in the data, and not caused by errors in the data processing and snapping processes.

H.4. Other checks

While not explicit checks, other outputs from this study provide assurance that the analytical processes have been sound, for example:

- The pre and post scheme collision rates calculated in Appendix D show consistency in the order of magnitude reported in each case study area. This provides reassurance that the process for calculating the figures has been applied consistently.
- The statistical analysis results are internally consistent, with the case study area results clearly feeding into the all case study area results and shaping that finding.
- Appropriate version control and spreadsheet best practice has been used throughout the data processing
- R Statistics coding has been supported by Mike Maher
- FME has been used for much of the data processing, which provides an auditable trail of the data manipulation process.

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