

The Bristol Twenty Miles Per Hour Limit Evaluation (BRITE) Study

Analysis of the 20mph Rollout Project

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1 Executive Summary

1.1 Background

- In July 2012, Bristol City Council voted to introduce 20mph speed limits throughout the city. This followed the completion of successful pilot schemes in South and East Bristol. The 20mph speed limit was introduced in six phases. The first area implemented on 20th January 2014 covers Central Bristol and borders the two pilot areas. The process of introducing 20mph limits across the city was completed in September 2015.
- The roll-out of the 20mph speed limits in Bristol was about more than reducing road traffic casualties, although this was one of the aims. The roll-out sought to improve health and well-being across the city, taking a holistic perspective as to how slower traffic speeds might impact on people's lives.

1.2 Aim

- To evaluate the impact of the roll-out of 20mph speed limits across the city of Bristol.

1.3 Methods

- The research took a holistic, public health approach to evaluation, using a variety of data sources to examine: changes in vehicle speeds; road traffic casualties; levels of walking and cycling; public perceptions and attitudes; and reported levels of health and wellbeing across the communities in Bristol before and after the introduction of 20mph speed limits across Bristol.

1.4 Speed

- On average, according to Automatic Traffic Count (ATC) speed data (with over 36 million vehicle observations analysed) there was a statistically significant 2.7mph decrease in vehicle speeds on roads where the 20mph speed limit was introduced, when controlling for other factors that might affect speed (areas, calendar year, time of day, season, type of road, and day of week). In the areas that stayed 30mph, there was a statistically significant negligible reduction in speed (0.04 mph)
- The largest reduction in speed was on 20mph A and B roads.
- Average speeds on 20mph roads were found to be below 24 mph in every area except for the Outer North and South areas of Bristol. On 30mph roads, average speeds are below 30mph in every area.
- Average speeds declined by a greater amount in the summer months and on weekends, where traffic volume (and congestion) is lowest.

- 94% of roads surveyed saw a reduction in average speeds. Average speed decreased on 100 roads out of 106.
- The greater reduction in speeds seen here when compared with previous studies may be due to the methodological differences in the approach taken in the BRITE Study, including analysis of individual vehicle speeds rather than daily average speeds, and inclusion of both residential and larger roads which may have a greater scope for speed reductions.

1.5 Casualties

- Annual rates of fatal, serious, and slight injuries following the introduction of the 20mph speed limits are lower than the respective pre-20mph limit rate, thus showing a reduction in the number of injuries. The estimated total number of injuries avoided across the city each year is 4.53 fatal, 11.3 serious, and 159.3 slight injuries.
- The estimated annual saving following the decrease in casualties is £15,256,309, based on Department for Transport formula for calculating the cost of road traffic casualties.
- The decrease in casualties has also benefitted some vulnerable groups. It is estimated that:
 - Two child lives will be saved every three years; 3 older adult lives will be saved every two years; and 3 pedestrian deaths will be avoided every year.
 - More than 4 child serious injuries will be avoided in just over three years; 4 older adult lives will be saved in three years; and 2 pedestrian severe injuries will be avoided every year.
 - The number of avoided slight child injuries per year is 7.68; 25.77 older adult slight injuries will be avoided each year; and 24.54 pedestrian slight injuries will be avoided each year.
- Because of the study design employed, it is not possible to state with certainty that the reductions in casualties are due to the introduction of the 20mph limits. However, the link between reduced motorised vehicle speeds and reductions in casualties has been demonstrated by studies across the world. Therefore, slower average speeds in Bristol are plausibly associated with the observed reductions in casualties. However more monitoring is needed.

1.6 Wider public health effects

- Clear majority support remains in Bristol for 20mph speed limits, with 62% supporting such limits on residential roads and 72% on busy streets.
- However, there is cynicism in Bristol about lack of enforcement of 20mph limits, a lack of compliance from “other drivers” and an increased readiness to report that it is sometimes okay to drive above the posted speed limit on residential roads.
- The number of people who walk or cycle to work in Bristol has increased between 2010 and 2015.

- More children in Bristol now walk or cycle to school following the introduction of the 20mph speed limits.

1.7 Conclusions

- This study has found statistically significant reductions in average traffic speeds of 2.7mph across the city of Bristol, following the introduction of 20mph speed limits. This is a larger reduction than seen in previous evaluations in other cities, but may reflect the study methodology.
- The study employed a more sophisticated analysis than previous studies of 20mph limits, including using individual speed data from over 36 million vehicle observations and controlling for other factors that might affect changes in traffic speeds.
- Over the period of the 20mph limit implementation, there has been a reduction in the number of fatal, serious and slight injuries from road traffic collisions, equating to estimated cost savings of over £15 million per year.
- Although there is still majority support for 20mph speed limits in Bristol, there remains concern about compliance and behaviour of other drivers.
- Walking and cycling across Bristol has increased, both among children travelling to school and adults travelling to work.
- The introduction of 20mph speed limits in Bristol offers a model for other towns and cities across the UK, who are seeking to reduce traffic speeds, cut road traffic casualties, and promote community health and well-being through road danger reduction.
- In order to assess effectiveness of 20mph speed limits, it is vital that other towns and cities follow Bristol's example, and prioritise the ongoing collection and analysis of appropriate data on vehicle speeds, road traffic casualties and wider public health impacts.

2 Introduction and Background

2.1 Introduction

This project aimed to evaluate the impact of the roll-out of 20mph speed limits across the city of Bristol. The research took a holistic, public health approach to evaluation, using a variety of data sources to examine; changes in vehicle speeds; road traffic casualties; levels of walking and cycling; public perceptions and attitudes; and reported levels of health and wellbeing across communities in Bristol.

2.2 Road traffic casualties and the role of speed

In 2016, 1,792 people were killed on the road in Great Britain, over 24,000 were seriously injured and more than 155,000 received slight injuries.⁽¹⁾ Although the number killed in 2016 represented an increase of 4% compared to the year before, the latest Department for Transport statistical release emphasises that the change (an increase of 62 fatalities) was not statistically significant and could be due to natural fluctuation. Indeed, since 2010, there has been little change in the annual number of road traffic fatalities. This period of plateau follows consistent falls in fatalities in previous decades. Compared to 2011, fatalities are down 6%. However, when it comes to serious injuries, annual numbers have increased by 4% in that time. Meanwhile, slight injuries in 2016 are down by 13% compared to 2011.⁽¹⁾

The relationship between traffic speed and risk of crashes and associated deaths and injuries on the road is well established. Particularly important are speeds between 20mph and 30mph, especially in residential areas where there are larger numbers of vulnerable road users, including pedestrians and cyclists. A 2011 study into pedestrian fatality risk associated with car impact speed concluded that there was a strong association between fatality risk and impact speed, when comparing risks at speeds between 50-30kph (31mph-18.6mph).⁽²⁾

2.3 Measures to reduce traffic speeds to 20mph

Historically in the United Kingdom, 20mph zones have been introduced to slow vehicle traffic and reduce road traffic collisions (RTCs) and associated non-intentional injuries. 20mph zones use traffic-calming measures, such as speed humps, to reduce vehicle speed across a length of road and are self-enforcing because in theory it is hard to exceed 20mph when driving through them. Such 20mph zones have been demonstrated to reduce road traffic collisions and associated deaths and injuries. A 1996 review of the impact of the introduction of two hundred 20mph zones found reductions in child pedestrian accidents of 70%, child cyclist accidents by 48%, and overall accidents by around 60%. Significantly, there was a 6.2% reduction in collisions for each 1 mph reduction in vehicle speed.⁽³⁾ A more recent controlled interrupted time series analysis of 20mph zones in London found a 42% reduction in road traffic casualties, with no evidence that casualties increased on nearby roads outside the intervention areas.⁽⁴⁾

Default 30kph (18.6mph) speed limits in residential areas is a key aspect of the Safe Systems approach to road safety promoted by the World Health Organization (WHO), World Bank and Organisation for Economic Co-operation and Development (OECD), in which the road system allows for human error while reducing the risk of death or serious injury.⁽⁵⁾

In response to the road danger reduction approach promoted by the Safe Systems approach, signs-only 20mph speed limits are increasingly being introduced by local authorities in England as a means of reducing road traffic casualties and improving residential quality of life. Signs-only 20mph speed limits have signs placed on poles and painted on the road surface indicating the speed limit. They do not usually feature traffic calming and do not therefore enforce drivers to reduce their speed to 20mph or below. An obvious advantage of signs-only 20mph speed limits is that because they do not usually involve costly traffic calming measures, a far larger number of streets can be covered than with more expensive 20mph zones. The Road Traffic Regulation Act (Amendment) Order 1999, which gave local authorities more control over the introduction of 20mph zones and limits, suggests that 20mph limits are appropriate for roads where average speeds are already below 24mph.(6)

Bristol is not alone in introducing 20mph speed limits across most roads in the city. Cities such as Portsmouth, Liverpool, Manchester, Edinburgh, Newcastle, Oxford, Sheffield, Birmingham and a number of London Boroughs have implemented 20mph speed limits. Play England, the Local Government Information Unit, and the BMA are just some of those organisations and agencies that support 20mph as routine across residential roads. The National Institute for Health and Care Excellence (NICE) has also issued guidance to local authorities advising on the implementation of 20mph speed limits.(7)

The current move towards lower speed limits is only in part powered by the injury prevention agenda. Also significant is the desire to tackle obesity through the promotion of physical activity in the form of walking, cycling and active play. There is recognition that in many societies, an “obesogenic” (obesity-causing) environment, of which road traffic is a contributory factor, dissuades the population from engaging in healthy behaviours. In the UK, policy reports on obesity have called for reductions in speed limits.(8) The perceived wider equity outcomes from lower speed limits means that the policy also intersects with the sustainability agenda, which seeks to promote sustainable forms of travel.

2.4 Evidence for 20mph speed limits

The evidence on the effectiveness of 20mph speed limits is growing. An early evaluation of 20mph limits in Scotland found a considerable drop in the number of recorded collisions per year, and a significant reduction in serious and fatal collisions.(9) A 2015 systematic review of the effectiveness of 20mph speed limits found evidence that introducing these lower speed limits reduce collisions and injuries, vehicle speed and volume, as well as improving perceptions of safety among the local population.(4) A number of local authority-led evaluations have taken place. Portsmouth, the first city in the UK to introduce a 20mph across most of the city, undertook an evaluation and reported a 22% reduction in casualties, with an average speed reduction of 1.4mph.(10) Bristol City Council evaluated the impact of introducing 20mph speed limits in two pilot areas of the city, reporting small but important reductions in average daytime vehicle speeds, an increase in walking and cycling, and strengthening public support.(11) In Bath and North East Somerset (BANES) a recent review of their 20mph limit intervention found an overall reduction in average speeds of 1.3mph, with some reductions in road traffic collisions.(12)

Nonetheless, most of the evidence from studies on 20mph limits to date is cross-sectional, has relatively short follow-up periods, and is potentially confounded by a range of factors. In addition, other potential wider benefits of 20mph limits, including improved levels of wellbeing and community cohesion among residents, have not routinely been researched.

One issue of discussion regarding 20mph speed limits is the possible impact on air quality. There are many factors which impact upon air pollution levels on a daily and annual basis and it is difficult to

quickly and easily separate the influence of these from the impact of measures such as the introduction of 20mph limits. How drivers respond to 20mph limits, whether they are enforced effectively, whether the number of vehicle trips changes and the driving styles on a particular road are also likely to be important in the overall air pollution impact of this measure.

A number of studies have been conducted into the effects that 20mph limits have on air pollution. Overall, a smoothing of driving style and cutting out of the acceleration phase from 20mph to 30mph is considered to be beneficial for emissions of harmful pollutants. A study from Berlin concluded that the introduction of 30kph limits (18.6mph) resulted in an up to 30% reduction in particulate emissions and 15% reduction in traffic related nitrogen oxides (NOx) emissions but enforcement of the limit and smoothing of flow with traffic light coordination was thought to play an important role.(13) A 2013 study conducted in London, backed up with real-world monitoring, showed the impacts of 20mph speed limits to be mixed but with particular air quality benefits being seen for particulate and NOx emissions from diesel vehicles.(14)

Overall, the evidence suggests that 20mph limits are likely to result in negligible impacts upon air pollution. The Draft NICE Guidance on outdoor air quality suggested that 20mph limits should be considered as an air quality improvement measure but the evidence supporting it was found to be weak. Evidence of a worsening of air pollution from this measure appears to be limited, with several studies highlighting potential air pollution improvements in certain circumstances. Wider benefits from 20mph limits include increases in walking and cycling, reductions in noise, and a range of co-benefits including reductions in casualties and severity of those which do occur as well as proportionately larger positive impacts for poorer communities which otherwise suffer from higher levels of road traffic pollution. Therefore, it is considered that 20mph limits should be seen a positive measure for both safety, encouragement of modal shift and air pollution.

2.5 Bristol 20mph speed limit roll out

In July 2012, Bristol City Council voted to introduce 20mph limits throughout the city. This followed the completion of successful pilot schemes in South and East Bristol. The lower speed limit was introduced in six phases. The first area implemented on 20th January 2014 covers Central Bristol and borders the two pilot areas. The process of introducing 20mph limits across the city was completed in September 2015. See Appendix A for maps of the phase areas and speed limit distribution across Bristol following introduction of the 20mph limits.

20mph speed limit installation dates	
Speed Order Limits	Operative date
1020- Inner South Bristol area pilot	19/05/10
1038 – Inner East Bristol area pilot	22/10/10
1401 – Phase 1 (Central area)	20/01/14
1416 – Phase 2 (Inner South Area)	11/07/14
1436 – Phase 3 (Henleaze etc)	29/09/14
1502 – Phase 4 (East Area)	27/03/15
1518 – Phase 5 (Outer North Area)	19/06/15
1538 – Phase 6 (North Area)	23/09/15

The 20mph speed limit is a sign-only scheme with social marketing support (the use of marketing to achieve social change), and does not involve the introduction of any physical traffic calming measures such as speed humps. 20mph is now the new legal limit in Bristol for all motorised vehicles on most roads except those selected to retain a 30mph limit such as through-routes. Speed limits on dual carriageways and 40mph and 50mph roads were not altered.

The roll-out of the 20mph speed limit in Bristol was about more than reducing road traffic casualties, although this was one of the aims. The roll-out sought to improve health and well-being across the city, taking a holistic perspective as to how slower traffic speeds might impact on people's lives.

The extension of 20mph limits has three main aims:

- Road danger reduction – the Cycling City and Active Bristol initiatives have already achieved significant change with their emphasis on shared roads and as a result more people walking and cycling around the city. A lower speed limit will make the streets safer for all road users, reducing the risk and the severity of collisions.
- Making Bristol healthier – with lower road speeds, walking, cycling and outdoor play are more attractive options, all of which have a positive impact on health and the community. As well as increasing physical activity, these pursuits offer a greater opportunity for social interaction and community support.
- Supporting and building communities – data from the British Crime Survey shows that speeding traffic is the top rated anti-social behaviour in local communities. The aim of 20mph is to help create more pleasant communities. Calmer speeds, and ultimately reduced car use for local trips, will lead to less noisy and more people-centred communities.

2.6 Research Questions

The research took a holistic, public health approach to evaluating the impact of the 20mph limit in Bristol. Although there was a focus on the traditional road safety measures of vehicle speeds and road traffic casualties, there was also an emphasis on wider public health effects such as changes in people walking and cycling, and community perceptions about their local environment.

The overarching research question was:

What impact has the Bristol 20mph speed limit roll-out had on health and wellbeing across the city?

The proposed research project sought to answer the following questions:

Speeds and Road Traffic Casualties

1. Have average speeds of vehicles reduced following the introduction of the 20mph limit, what are the patterns across the city in the change of speeds and are there still problematic areas/routes?
2. Has the number of road traffic casualties (deaths and injuries) decreased on those roads where the 20mph speed limit was introduced?
3. Has the introduction of 20mph had measurable effects on speed or road traffic casualties on other roads (i.e. has the speed been affected where it is still 30mph)?

Wider public health benefits

4. Has the number of people who are walking or cycling in the city increased following the introduction of the 20mph limits?
5. What changes in attitudes have occurred in the 20mph areas following implementation, including those specifically related to the reduced speed limit?

3 Methodology and Methods

As noted previously, the introduction of the 20mph speed limit across the city aimed not only to reduce road traffic casualties by lowering traffic speeds, but also to encourage more people to walk and cycle, and to improve community wellbeing. As such, the evaluation took a holistic approach to assessing impact, utilising a range of data sources that had been collected by Bristol City Council as part of their comprehensive data monitoring and collection programme. This included measuring:

- Vehicle speeds and compliance
- Travel modes
- Road traffic casualties
- Perceptions and attitudes

The research team at UWE were given access to all these data sets, to enable the most holistic evaluation possible to be undertaken, examining outcomes before and after the introduction of the 20mph speed limits across the city. The sub-sections below outline the nature of the various data sources and how these data sources were used by the research team in the evaluation.

The roads surveyed in the data sets were based on the old cordon sites that the council have used for several years to monitor the speed of vehicles coming in, travelling around, and moving out of the city. However, to provide a fuller picture of the city speeds additional roads were added into the local data sets, which included the A and B roads that have seen a change in speed limit and several local distributor roads classified as U roads. In terms of the nature of the various road types: A roads are major roads intended to provide large-scale transport links within or between areas; B roads are intended to connect different areas, and to feed traffic between A roads and smaller roads on the network; and unclassified roads are local roads intended for local traffic, with over 60% of roads in the UK being in this category.(15)

3.1 Vehicle speeds

In order for the introduction of 20mph speed limits to potentially impact on other outcomes such as road traffic casualties and quality of life, it is first necessary to confirm whether the new lower limits have resulted in a reduction in average motorised traffic speeds. To explore the impact on speeds, the evaluation assessed changes in motorised vehicle speeds before and after the introduction of the 20mph speed limit, both on roads that reduced their limit to 20mph and those that retained a higher limit. This was done to determine both whether introducing a lower limit of 20mph prompted drivers to reduce their speed on those roads, and whether this then also influenced driving behaviour elsewhere, including on roads where the limit remained at 30mph or above. To do this, two sources of vehicle speed data were used: data from Automated Traffic Counts (ATC) and Trafficmaster data. Both sources of vehicle speed data will now be explained.

3.1.1 Automated Traffic Counts (ATC)

Automatic Traffic Counters (radars) measure speed of traffic through the laying of a strip across the road which vehicles travel over. Such strips are usually placed at the point on the road where average traffic speed is greatest. ATCs collected data for roads for seven days, twenty four hours a day. They are designed for free flowing traffic on flat straight roads with one lane of traffic in each direction. Their accuracy will be affected by any factors which affect these ideal conditions (e.g. a delivery vehicle parked in front of the radar will block its ability to detect other vehicles). Data in Bristol were collected from 2014 to 2017 during one or two weeks a year (in winter and summer).

In order to utilize the full data set, before-after individual vehicle speeds were extracted and used in the analysis, rather than the average road speed over 24 hours as is normally done with such monitoring. By using individual vehicle speed, a much more detailed picture of average speeds in Bristol was obtained, as individual speeds change significantly depending on time of day (day and night speeds are generally very different). This resulted in over thirty-six million individual vehicle observations being used to analyse before-after changes in vehicle speeds, giving the study great power to detect any changes in motorized vehicle speed following the introduction of the 20mph speed limits.

Average vehicle speeds can be affected by a range of factors, including the weather and time of year. Taking into account such factors when assessing the impact of 20mph speed limits on traffic speed can help to give a clearer picture of how the new speed limit has affected traffic speeds. A statistical modelling process (General Linear Mixed Models) was used to control for (take into account) other factors that could affect changes in vehicle speeds across the city over the period of study. This included the effect of calendar time, as the 20mph intervention was implemented on a rolling basis throughout the city, with different areas having different installation dates. The General Linear Mixed Model also allowed controlling for the effects of other time variables (time of day; weekend and weekday; season) and other confounding variables (road type and area).

3.1.2 Trafficmaster data

Motorised traffic speed is also recorded using commercially-available Trafficmaster data. The Trafficmaster in-car Global Positioning System (GPS) records the position of vehicles in which it is fitted and this data is then used to calculate the vehicle's speed. The difference with this way of monitoring speeds compared to the ATCs is that instead of measuring speeds at one point on the road, the data cover most routes in the city at a link-by-link level, for most times of the day. These data have been used to undertake a series of "route studies" giving a detailed breakdown of speeds along particular routes.

The data potentially covers all routes travelled by such vehicles across the city, at all times of day. The make-up of the sample is constantly changing. The current vehicle fleet population is composed of 70,000 vehicles, with 68% cars, 30% light goods vehicles, 1% heavy goods vehicles and another 1% are other vehicles (e.g. buses, taxis, caravans). A recorded journey is defined by the ignition-on to ignition-off of a vehicle. When the data are recorded, if a vehicle is parked for an excessive period of time at the same spot (e.g. longer than 5 minutes) then the Trafficmaster processing assumes that this is the end of the journey and would end the journey at the point it reached that position. Therefore a parked vehicle will not be included in the journey time.

3.2 Road traffic casualties

Data regarding personal injury road collisions that have been reported to the police (known as Stats 19 data) are provided to the Council by Avon & Somerset Police. This provides details about each incident, including location, severity and contributory factors. The personal injury road collision database contains records dating back to 1990. Personal injury road collisions that have been reported to the Avon & Somerset Police and forwarded to the council are held on the database. Damage only crashes, near misses and unreported casualties are not recorded.

When a road collision occurs on the public highway and someone involved has been injured the incident should be reported to the police who will complete a collision book. This set of data has details about the circumstances of the collision, including the types of vehicles involved, the resulting casualties and factors that may have contributed to the collision occurring. The data form the basis for annual statistics on road collisions and casualties published by the Department for Transport and Local Authorities. Extensive use is made of the data by those working in the field of collision prevention and road safety education e.g. to establish priority collision sites for remedial measures or as evidence on which to base educational programmes and training aimed at specific road users. The accumulated data is also used by a range of establishments for research into road safety measures.

Data are received electronically from the police on a weekly basis in the form of three interrelated data tables and are then systematically processed by the Data Monitoring Officer in order to formulate an objective summary of the circumstances of the collision.

The casualty record has details about the age, gender, injury severity and class i.e. driver/passenger/pedestrian, of each casualty. For pedestrian casualties their location and movement on the carriageway are recorded. The vehicle record has details about the vehicle type, direction of travel, objects hit, vehicle manoeuvres and junction location of vehicle, vehicle point of impact, carriageway type, driver age, and driver gender. The main attendant circumstances table has details about the collision location, date, time of day, light conditions, weather, carriageway hazards, road type, junction detail, road surface condition, speed limit, contributory factors and a grid reference.

Eight years of data was available for road traffic casualties that occurred in Bristol, between the 1st January 2008 and 31st December 2016. Reference populations related to single collisions cannot be easily determined, in the sense that each casualty does not relate to a discreet geographical population due to the fact that the total number of drivers, walkers and cyclists at each given day is not known.

3.3 Wider public health effects

3.3.1 YouGov tracker survey on attitudes and behaviours towards 20mph limits

Bristol City Council commissioned a tracker survey in partnership with the University of the West of England (UWE Bristol) with the aim of understanding attitudes and behaviours with respect to 20mph speed limits in Great Britain, with a boosted sample in Bristol. This survey planned to ascertain levels of support and opposition, the reasons for these, and the likely reaction to 20mph limits once they were in place. This has provided measures of attitudes and claimed behaviours for Bristol compared with other UK wide urban centres with 20mph limits, and insights into behaviour change.

The first tracker survey took place in May 2013, and was repeated in May 2015 and May 2017. The Tracker Survey fieldwork was contracted to YouGov (a large provider of social and market research). The survey was carried out online and the sample size was 3074 GB adults, including approximately 500 residents of Bristol.

The figures in the reports have been weighted to be representative of all GB adults (aged 18+). The survey was administered to members of the YouGov panel of 400,000+ individuals who agreed to take part in surveys. An email was sent to panellists selected at random from the base sample according to the sample definition, inviting them to take part in the survey and providing a link to

the survey. The responding sample is weighted to the profile of the sample definition to provide a representative reporting sample. The profile is normally derived from census data.

This document reports the findings that have been presented by the UWE Bristol team who led the analysis.

3.3.2 Neighbourhood Survey

Household interview surveys were carried out by an independent research organisation, Crystal Market Research, before and after the implementation of each phase of the 20mph limit roll-out. These surveys provide quantitative research among the public, measuring the extent to which the new speed limits have achieved their wider societal objectives in terms of public approval of the scheme, travel habits and use of local streets. Similar data for Bristol as a whole are available from the Council's annual Quality of Life survey.

For each of the six phases of the 20mph rollout, a household interview survey was undertaken 6 months prior to and 18 months after its implementation. Thus 12 surveys were carried out; 6 pre implementation and 6 post implementation. The post surveys were conducted at the same time of year as the pre surveys in order to avoid seasonal influences on the results.

In each survey a representative sample of around 250 adults living in the Phase area were interviewed, face to face, at home. To achieve a representative sample, quotas were set for wards within the Phase areas, based on adult population density. Within each ward, quotas were set for gender, age (16-24, 25-44, 45-64, 65+) and economic activity, based on Census data for that ward. To achieve a good geographical spread across each Phase area interviews were conducted in all the Lower Level Super Output Areas within that Phase area. The same questionnaire was used in all the Pre surveys. The Post questionnaire was identical to the Pre questionnaire in order to be able to track changes in behaviour and attitude with some questions about the impact of 20mph specifically.

This document reports the findings from a series of reports produced by Crystal Market Research that analysed before-after changes across the phase areas.

4 Findings

This chapter reports the findings from the evaluation of the introduction of 20mph speed limits across Bristol, using the data sources outlined in Section 3. Each data source is presented separately. Where findings are reported as being statistically significant, this means the result found is unlikely to be due to statistical chance – i.e. we can have more confidence in the findings.

4.1 Vehicle speeds

It is important to note that success is not defined by all average speeds being under the set speed limit of 20mph – it is about bringing vehicle speeds down closer to 20mph, and assessing any positive impacts of that speed reduction compared to the situation before the introduction of the lower limits.

4.1.1 Automatic Traffic Count (ATC) data

On average, on roads where the 20mph speed limit was introduced, there was a 2.7mph statistically significant decrease in vehicle speeds after the introduction of the limit, when controlling for other factors that might affect speed (areas, calendar year, time of day, season, type of road, and day of week). In the areas that remained 30mph, there was a statistically significant but negligible reduction in speed (0.04 mph) (Appendix B).

4.1.2 Trafficmaster GPS data

Trafficmaster speed data showed a statistically significant reduction of 0.8mph on roads where the 20mph speed limit was introduced, with traffic speeds reducing from 17.8mph to 17.0mph. The potential differences between ATC data and Trafficmaster data can be explained by several factors. First, ATC data measure spot speed, while Trafficmaster measures average speed along a whole road; ATC speeds are higher than Trafficmaster speeds, also due to the fact that the ATC radars are positioned in the most problematic spot of a road. Second, the Trafficmaster measurements were taken in a sample of roads that was slightly different from the ATC sample. Among the roads where Trafficmaster data were measured there was a higher proportion of small residential roads, where speeds tend to be lower than in other types of roads. Third, while ATC data include data from several time periods after the 20mph installation (up to Winter 2017), Trafficmaster data only refer to speeds 6 months before and 6 months after the new speed limit installation.

The remainder of this section refers to ATC speeds, unless specified otherwise.

4.1.3 Time of day

Controlling for time of day, on roads where the 20mph speed limit was introduced, day speeds (7am to 7pm) reduced by 2.7mph compared to before the introduction of the limit, and night speeds (7pm to 7am) reduced by 2.4mph. On roads that remained 30mph, day speeds decreased by 0.2mph, while night speeds increased by 0.2mph (Appendix C.1). These changes are statistically significant.

Average speeds¹ on 20mph roads across the city are now 21.8 mph during daytime (7am to 7pm), and 24.1 mph at night time. In 30mph roads, average speeds are 25.1 mph during daytime and 27.6 during night time.

4.1.4 Weekdays vs Weekends

Compared to before the introduction of the 20mph speed limit, average speeds on weekdays reduced by 2.6mph on 20mph roads, while on weekends they decreased by 3mph. On roads that remained 30mph, speeds reduced by 0.2mph on weekends, but did not vary in 30mph streets in weekdays ($p > 0.05$) (Appendix C.2). These changes are statistically significant. It is a positive finding that speeds decreased even on weekends, when traffic volumes are lower. Average speeds¹ from Monday to Friday were found to be 22.2mph on 20mph roads and 25.6mph on 30mph roads. Average speeds on weekends are now 22.5mph on 20mph roads and 26.9mph on 30mph roads.

4.1.5 Winter vs Summer

Average speeds¹ in winter on roads where the 20mph speed limit was introduced reduced by 2.3 mph, while in summer they declined by 4.7 mph. On roads that remained 30mph, speeds went down by 0.04mph in winter and by 1.8mph in summer (Appendix C.3). It is noticeable that speeds reduced by a greater amount in the summer, even though traffic volumes are lower with more opportunity to drive faster with less congestion. These changes are statistically significant. Average speeds¹ in winter are now 22.4 mph on 20mph roads and 25.6mph on 30mph roads. Average speeds in summer are now 22.6mph on 20mph roads and 26.1mph on 30mph roads.

4.1.6 Road type

Looking at different types of roads, some differences between A, B, and unclassified (U) roads were found. Speed reduced by 3.7mph on A and B roads where the 20mph speed limit was introduced, while speeds decreased by 0.3mph on A and B roads where the limit remained at 30mph. On U roads, speed reduced by 1.6 mph on roads where the 20mph was introduced, and by 0.1mph on roads that retained the 30mph limit (Appendix C.4). These changes are statistically significant.

Average speeds¹ following the introduction of 20mph speed limits are below 24 mph in 20mph A, B, and U roads. On the rest of the network average speeds are 26.8mph, below the 30mph speed limit.

4.1.7 Average speeds across areas of the city

Average speeds following the introduction of the 20mph speed limits vary among areas of the city (Table 1).

¹ Not controlling for areas, calendar year, time of day, season, type of road, and day of week.

Table 1: ATC average speeds by area and speed limit of roads following the introduction of the 20mph speed limits²		
	New speed limit (mph)	Average daily speeds (mph)
Pilot	20	19.54
	30	22.06
Central	20	21.66
	30	23.59
Inner South	20	21.75
	30	25.99
Inner North	20	23.26
	30	24.35
East	20	23.10
	30	26.76
Outer North	20	24.45
	30	27.52
Outer South	20	25.69
	30	28.68

It was possible to calculate changes in vehicle speeds (as measured by ATCs) before and after the introduction of the 20mph speed limits in certain areas of the city for 20mph and 30mph roads (Appendix C.5). When controlling for calendar year, season, day of the week, time of day, and road type, in the Inner North area, the average speed reduction on 20mph roads was 5.9mph, while in both Outer North and Outer South it was approximately 3.3mph. In the East area, speeds on 20mph roads reduced by 1.9mph. These changes are statistically significant.

The picture for roads which retained a 30mph limit varies (Table 1). In the Inner North area, average speeds on 30mph roads reduced by 4.9mph. In the Outer North and Outer South areas there was a smaller reduction in speed in the streets that retained the 30mph limit (0.5mph and 0.4mph reduction respectively). However, in the East area there was an increase in average speed of 2.1 mph on 30mph roads. These changes are statistically significant.

As can be seen in Table 1, average speeds in 20mph streets are below 24 mph in the Pilot, Central, Inner North, and Inner South areas. In 30mph streets, average speeds are below 30mph.

4.1.8 Trafficmaster data by area of the city

Trafficmaster data show that in 20mph roads in Central, Inner South, Inner North, and Outer South Bristol the average speed reduction was under 1mph (Table 2), while in the East and Outer North areas the reduction was above 1mph. These changes are statistically significant (Appendix D).

² Not controlling for areas, calendar year, time of day, season, type of road, and day of week.

Area	Average speed before intervention (mph)	Average speed after intervention (mph)	Trafficmaster average speed variation (mph)
Central	13.89	13.51	-0.38
Inner South	19.06	18.60	-0.46
Inner North	18.93	18.08	-0.84
East	18.05	16.90	-1.15
Outer North	19.27	18.01	-1.26
Outer South	19.94	18.97	-0.96

4.1.9 Roads that are the exception to the trend

According to the ATC data, 94% of the 20mph and 30mph roads surveyed saw a reduction in average speeds following the introduction of 20mph speed limits. Speed decreased on 100 roads out of 106, with 6 roads having increased average speed. These are three 20mph roads and three 30mph roads, although it is worth noting that the average speed in two of the 30mph roads is still below 30mph (Appendix E). Among 20mph roads, twenty-six 20mph roads out of 106 recorded average speeds above 24mph, of which twelve have 24-hour average speeds above 26mph. The list of roads that were exceptions to the overall trend can be found in Appendix E.

4.2 Road traffic casualties

4.2.1 Overall casualties

Table 3 reports the number of injuries in each area before and after the introduction of 20mph speed limits, on both roads to which the 20mph speed limit applied and those that retained a 30mph limit. Annual rates of fatal, serious, and slight injuries following the introduction of the 20mph speed limits are lower than the respective injury rate before the limits were introduced, thus showing a reduction in the number of injuries. The estimated total number of reduced injuries across the city each year is 4.53 fatal, 11.3 serious, and 159.3 slight.

Phase	Injury type	Intervention period (before and after 20mph limit)	Number of months (adjusted)	Absolute number of injuries	Annual rate of injury	Difference in annual rate of injury post minus pre
Pilot (East + South)	Fatal	Before (1/1/2008 to 21/10/10)	34	2	0.71	-0.4 (-54.9%)
		After (22/10/10 to 31/12/2016)	74	2	0.32	
	Serious	Before (1/1/2008 to 21/10/10)	34	49	17.29	-6.4 (-37.2%)
		After (22/10/10 to 31/12/2016)	74	67	10.86	
	Slight	Before (1/1/2008 to 21/10/10)	34	550	194.12	-24.8 (-12.8%)
		After (22/10/10 to 31/12/2016)	74	1044	169.30	

		to 31/12/2016				
Central	Fatal	Before (1/1/2008 to 19/1/2014)	72	13	2.2	-0.8 (-40.9%)
		After (20/01/14 to 31/12/2016)	36	4	1.3	
	Serious	Before (1/1/2008 to 19/1/2014)	72	206	34.3	-5.0 (-14.6%)
		After (20/01/14 to 31/12/2016)	36	88	29.3	
	Slight	Before (1/1/2008 to 19/1/2014)	72	1874	312.3	-55.7 (-17.8%)
		After (20/01/14 to 31/12/2016)	36	770	256.7	
Inner South	Fatal	Before (1/1/2008 to 10/7/2014)	78	8	1.2	-0.4 (-33.3%)
		After (11/07/14 to 31/12/2016)	30	2	0.8	
	Serious	Before (1/1/2008 to 10/7/2014)	78	123	18.9	2.7 (+14.3%)
		After (11/07/14 to 31/12/2016)	30	54	21.6	
	Slight	Before (1/1/2008 to 10/7/2014)	78	1076	165.5	-3.1 (-1.9%)
		After (11/07/14 to 31/12/2016)	30	406	162.4	
Inner North	Fatal	Before (1/1/2008 to 28/9/2014)	81	11	1.6	-0.3 (-18.75%)
		After (29/09/14 to 31/12/2016)	27	3	1.3	
	Serious	Before (1/1/2008 to 28/9/2014)	81	99	14.7	-1.3 (-9.5%)
		After (29/09/14 to 31/12/2016)	27	30	13.3	
	Slight	Before (1/1/2008 to 28/9/2014)	81	829	122.8	-29.5 (-24.0%)
		After (29/09/14 to 31/12/2016)	27	210	93.3	
East	Fatal	Before (1/1/2008 to 26/3/2015)	87	11	1.5	-1.5 (-100%)
		After (27/03/15 to 31/12/2016)	21	0	0.0	
	Serious	Before (1/1/2008 to 26/3/2015)	87	101	13.9	-1.4 (-9.4%)
		After (27/03/15 to 31/12/2016)	21	22	12.6	
	Slight	Before (1/1/2008 to 26/3/2015)	87	1173	161.8	-25.8 (-15.9%)
		After (27/03/15 to 31/12/2016)	21	238	136.0	
Outer North	Fatal	Before (1/1/2008 to 18/6/2015)	89	4	0.5	0.1 (+20%)
		After (19/06/15 to 31/12/2016)	19	1	0.6	
	Serious	Before (1/1/2008 to 18/6/2015)	89	61	8.2	0.0

		After (19/06/15 to 31/12/2016)	19	13	8.2	
	Slight	Before (1/1/2008 to 18/6/2015)	89	567	76.4	-17.7 (-23.2%)
		After (19/06/15 to 31/12/2016)	19	93	58.7	
Outer South	Fatal	Before (1/1/2008 to 22/9/2015)	93	9	1.2	-1.2 (-100%)
		After (23/09/15 to 31/12/2016)	15	0	0.0	
	Serious	Before (1/1/2008 to 22/9/2015)	93	67	8.6	0.2 (+2.3%)
		After (23/09/15 to 31/12/2016)	15	11	8.8	
	Slight	Before (1/1/2008 to 22/9/2015)	93	777	100.3	-2.7 (-2.7%)
		After (23/09/15 to 31/12/2016)	15	122	97.6	

The number of fatalities, serious and slight injuries were compared both before and after the intervention, controlling for the period of time for the before and after period. Twenty-one comparisons were made (for the seven areas multiplied by the three injury severities). Four of the comparisons suggests a statistically significant difference at the 95% level of confidence assuming the collisions are a Poisson variable: these were for slight injuries in the pilot area, central area, inner north area, and east area (see Appendix F for details).

Aggregating all areas together, the reduction in the number of serious and slight injuries is significant (Appendix F). It is recognised that this analysis is a simple before and after comparison, that has not used comparison sites, or adopted a stepped wedge method of analysis as was done for the speed data. These findings should be regarded as tentative. Other data would be required to investigate any association between these data and the speed data reported above.

Table 4 below shows the estimated yearly value of the prevention of casualties. Based on the Department for Transport's 2016 costing per casualty, the casualties avoided are estimated to have produced an annual saving of more than £15 million.(16) Factors that are included in the cost calculations include costs of emergency services, lost output, damage to property, and the substantial costs associated with human costs (including grief and misery).

Severity	Number of casualties avoided per year	Estimated value of prevention, per casualty	Estimated value of total casualty savings per year
Killed	4.53	£1,971,998	£8,933,150.94
Serious	11.3	£228,149	£2,578,083.70
Slight	159.27	£23,514	£3,745,075
Totals	175.1	£2,223,661	£15,256,309

The above changes in fatalities, serious injuries and slight injuries are marked and align with international evidence that reports that a 1mph average speed reduction in urban areas is associated with a 6.2% reduction in collisions.(3) The total cost of casualties in Bristol was over £53 million in 2016, so although £15 million is a substantial reduction, more still needs to be done to

reduce conflict and injury on the roads. It is important to note that because of our study design, we are not able to state with certainty that the reductions in casualties are due to the introduction of the 20mph limits. However it is a promising trend that should continue to be monitored.

4.2.2 Casualties among vulnerable groups

Table 5 shows the estimated number of individual injuries/deaths avoided among several vulnerable groups based on the annual rate of injuries before (pre) and after (post) the introduction of 20mph speed limits. Figures are city-wide. Due to the small numbers, which would be prone to random fluctuation, figures were not calculated by area.

Among fatal injuries, the number of children’s deaths per year has decreased by 0.6 across the city, with an estimate of 2 child lives saved in just over three years. Across the city post-intervention, the number of older adults’ deaths per year has decreased by 1.06, with an estimate of 3 older adult lives saved in two years. Finally, it is estimated that almost 3 pedestrian deaths are avoided each year post intervention.

Table 5: Difference in annual rate of deaths and injuries in Bristol among vulnerable groups, before (pre) and after (post) 20mph speed limit introduction

Injury type	Difference in annual rate of injury (post minus pre)		
	Child	Older adult	Pedestrian
Fatal Injuries	-0.6	-1.06	-2.74
Serious Injuries	-1.28	-1.34	-2.09
Slight Injuries	-7.68	-25.77	-24.54

Among serious injuries, across the city 1.28 severe child injuries are avoided each year post intervention, with an estimate of more than 4 child serious injuries avoided in just over three years. The number of older adults who were seriously injured on the road decreased, with 1.34 serious injuries avoided each year post intervention. The estimate is of 4 older adult lives saved in three years. Finally, the number of pedestrian serious injuries decreased by 2.09 each year; 2.09 pedestrian severe injuries are avoided compared with the pre-intervention period.

The number of slight child injuries per year has decreased by 7.68. The number of older adults who had slight injuries also decreased, with 25.77 slight injuries among older adults and pensioners avoided each year compared with the pre-intervention period. Finally, the number of slight pedestrian injuries decreased, with an estimated 24.54 slight pedestrian injuries avoided each year compared with the pre-intervention period.

4.3 Wider public health effects

Unlike the analysis on speed and casualties, the findings below come from secondary reports, completed by other researchers. The aim of including these findings is to contextualise the main speed and casualty analysis through a recognition of wider public health benefits of the introduction of 20mph speed limits.

4.3.1 YouGov tracker survey on attitudes and behaviours towards 20mph limits

Clear majority public support for 20mph limits was found in the 2013 and 2015 surveys of general public attitudes and driver behaviour among residents of Bristol.(17) The latest 2017 data revealed a maintenance of majority support for 20mph speed limits in the city, at 62% (for residential roads) and 72% (for busy streets). This is very similar to levels across the UK. However, there is cynicism in Bristol (and across Great Britain) about lack of police enforcement of 20mph limits and a lack of compliance from “other drivers”.(17) There is also an apparent “pluralistic ignorance” effect – a widespread belief that there is little support for 20mph limits, whereas the reality is that the opposite is true. These beliefs probably contribute to the claimed lack of compliance from Bristol drivers (40% may not stick to 20mph limits), with levels worse than for Great Britain as a whole (29%). In 2017, Bristol residents adopted both positive and negative extremes compared to Great Britain generally. Negative extremes included Bristol residents being more likely to agree with lists of reasons to oppose 20mph speed limits, and less keen on the police enforcing 20mph speed limits. This may be a reflection of the fact that 39% of Bristol residents agreed that 20mph speed limits have been “introduced on too many streets”, compared to 22% in Great Britain as a whole.(17) Other attitudinal responses in Bristol were more positive towards 20mph speed limits. Slightly more Bristol residents than Great Britain as a whole (44% v 39%) said that motorists should stick to 20mph limits to accommodate cyclists better, and 42% of residents on 30mph streets wanted 20mph on their streets (which was similar to Great Britain levels).(17)

4.3.2 Neighbourhood Survey

As noted earlier, these findings relate to a series of reports commissioned by Bristol City Council, based on household interviews in each of the phase areas, before and after the introduction of the 20mph speed limit.

4.3.2.1 Safety

Residents have similar attitudes towards local road safety before and after 20mph implementation, with slight, non-statistically significant improvements post 20mph. Statistically significant improvements include; In the Central and Inner North areas, where average speeds are below 24mph, there is an indication of fewer safety fears for children walking to school on their own post 20mph. This is also the case in the Outer South area. Inner North Phase and East areas residents, where average speeds are below 25mph, are more inclined to feel it is safe to cross the road in their area post 20mph. In East areas residents are also more inclined to feel it is safe for elderly people to cross the road in their area post 20mph. Main concerns continue to centre on children playing out in the street in most areas, as only between 20% and 27% of residents feel it is safe for children to play out in the street.

4.3.2.2 Traffic noise

Generally, fewer residents are disturbed by the sound of passing traffic. In the Outer North area, where average speeds are above 24mph in 20mph streets and 27mph in 30mph streets, the variation in the proportion of people disturbed by traffic is not statistically significant.

4.3.2.3 Attitudes towards 20mph speed limits

Changing the speed limit from 30mph to 20mph seems to have softened residents' attitudes towards speeding in the Phase areas surveyed. Following the introduction of the 20mph speed limits, between 24% and 32% of residents are likely to feel it is sometimes acceptable to drive over the signed speed limit on residential roads, while before the 20mph intervention the figures were between 11% and 21%. Between 91% and 97% of residents are aware of the 20mph speed limit. Support for 20mph on residential streets remains very high and has increased or stayed the same after the 20mph speed limit introduction, except for the East area, where post implementation fewer people are in favour of the 20mph speed limit. Possibly related to this, the East area is the only area where the average speed in 30mph streets in has increased. Other findings include:

- Between 77% and 88% of individuals across the city are in favour of the 20mph speed limit in their own street; the support has increased in every area except for the East area, where 73% are in favour of the 20mph speed limit;
- Support for 20mph on residential roads has become a little more positive post implementation (at least 73% of residents are in favour of the 20mph speed limit across the city); the East area is an exception, as fewer people are now in favour of the new speed limit (70%) although the majority still support the speed limit;
- Support for 20mph on local main roads, which is generally weaker, has increased in the Central, Outer South and Outer North areas; while in the Central area 41% of residents are in favour of the new speed limit, at least 23% of residents in other areas are in favour, except for the East area, where only 17% support the new speed limit.
- Between 79% and 95% of drivers say they obey the new speed limit, except for the East area, where the figure is 69%.
- Since the introduction of 20mph, between 17% and 20% of individuals feel traffic speed has reduced on their street, except for the Outer North area, where the figure is 13%;
- Between 19% and 25% of individuals feel traffic speed has reduced on main roads, except for the Inner South area, where the figure is 12%;
- Most people think that it is clear to anyone driving around the local area that they are in a 20mph speed limit, except for the Outer North area, where only 19% of individuals think that it is clear to anyone driving around the local area that they are in a 20mph speed limit.

4.3.2.4 Active travel

Trends of walking and cycling are similar across all areas, with more people walking or cycling for 10 minutes or more in their local area most days following the introduction of the 20mph speed limit. However, it is not possible to assess whether these trends are related to the 20mph speed limit intervention. In the Central area, where average speeds are below 24mph, people tend to walk and cycle more than in other areas.

- The number of residents who walk for 10 minutes or more in their local area most days has generally increased in every area. In the Inner South, the increase was smaller than in other areas.
- The number of people who cycle for 10 minutes or more in their local area at least once a week has remained the same or has slightly increased. In the areas with speeds above 24mph (Outer North, East), cycling is still below 20%.

- More children walk or cycle to school in every area, with more than 59% of children now walking to school and at least 31% of children now cycling to school.
- The number of people using the car most days has stayed the same in every area.

These figures are also mirrored by the findings on walking and cycling from the Bristol Quality of Life survey. According to the survey:

- the number of people who walk to work has increased from 2010 to 2015 from 17.5% to 18.9%;
- the number of people who drive to work has decreased from 2010 to 2015 from 53% to 44%;
- the number of people who cycle to work has increased from 11% in 2010 to 15% in 2015.

4.3.2.5 Attitudes towards neighbourhood

Residents across the city have generally an extremely positive view of where they live in terms of how pleasant and relaxed their street and local residential streets feel, and how much they feel a part of and are satisfied with their neighbourhood. Attitudes have improved slightly after the 20mph limit implementation – but the change is not statistically significant. Levels of community sociability are stable. It is not possible to assess whether these trends are related to the 20mph speed limit intervention. Some significant improvements include: In the Inner North and Outer North areas, where average speeds before 20mph implementation were above 28mph, sense of belonging has increased since the introduction of 20mph. Social interactions have increased in the Inner North area. This is possibly related to the fact that there was a large drop in speed in the area.

4.3.2.6 Health

Perceptions of their health have not changed significantly before and after the introduction of the 20mph speed limits across all of the phase areas; between 62% and 84% of residents feel that their health has been good in the last 12 months.

5 Conclusions

- This study has found statistically significant reductions in average traffic speeds of 2.7mph across the city of Bristol, following the introduction of 20mph speed limits. This is a larger reduction than seen in previous evaluations in other cities.
- A possible explanation for the discrepancy in speed reduction between this study and previous studies of 20mph speed limits is that the current study included both residential and larger roads in the analysis, while others focus on residential roads only. Given that speeds are lower in residential roads, it might be that the speed reduction identified in this study was larger due to the proportion of larger roads included in the analysis, with greater scope for speed reductions.
- The study employed a more sophisticated analysis than previous studies of 20mph limits, including using individual speed data from over 36 million vehicle

observations and controlling for other factors that might affect changes in traffic speeds.

- There has been a reduction in the number of fatal, serious and slight injuries from road traffic collisions, equating to estimated cost savings of over £15 million per year.
- Although there is still majority support for 20mph speed limits in Bristol, there remains concern about compliance and behaviour of other drivers.
- Walking and cycling across Bristol has increased, both among children travelling to school and adults travelling to work.
- The introduction of 20mph speed limits in Bristol offers a model for other towns and cities across the UK, who are seeking to reduce traffic speeds, cut road traffic casualties, and promote community health and well-being.
- In order to assess effectiveness of 20mph speed limits, it is vital that other towns and cities follow Bristol's example, and prioritise the ongoing collection and analysis of appropriate data on vehicle speeds, road traffic casualties and wider public health impacts.

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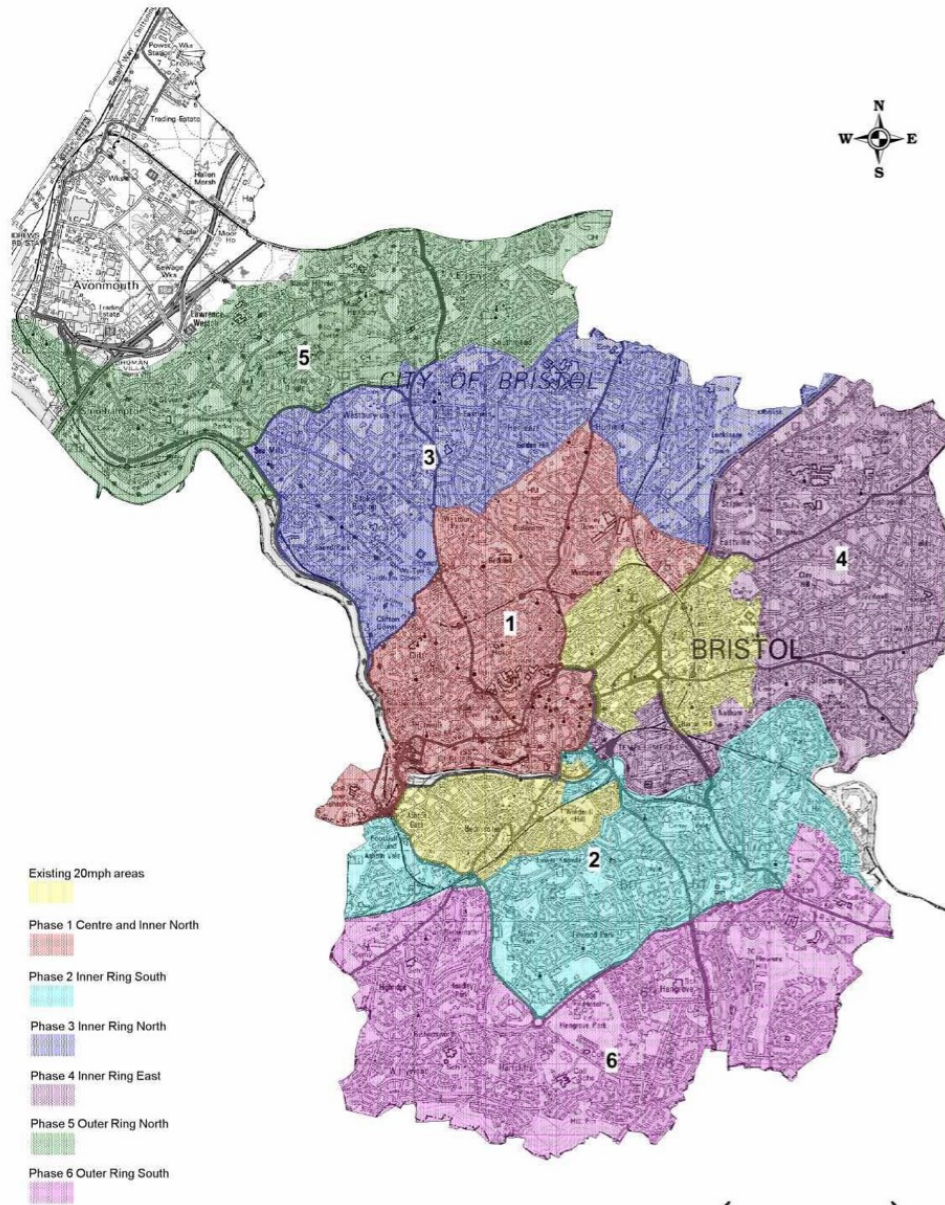
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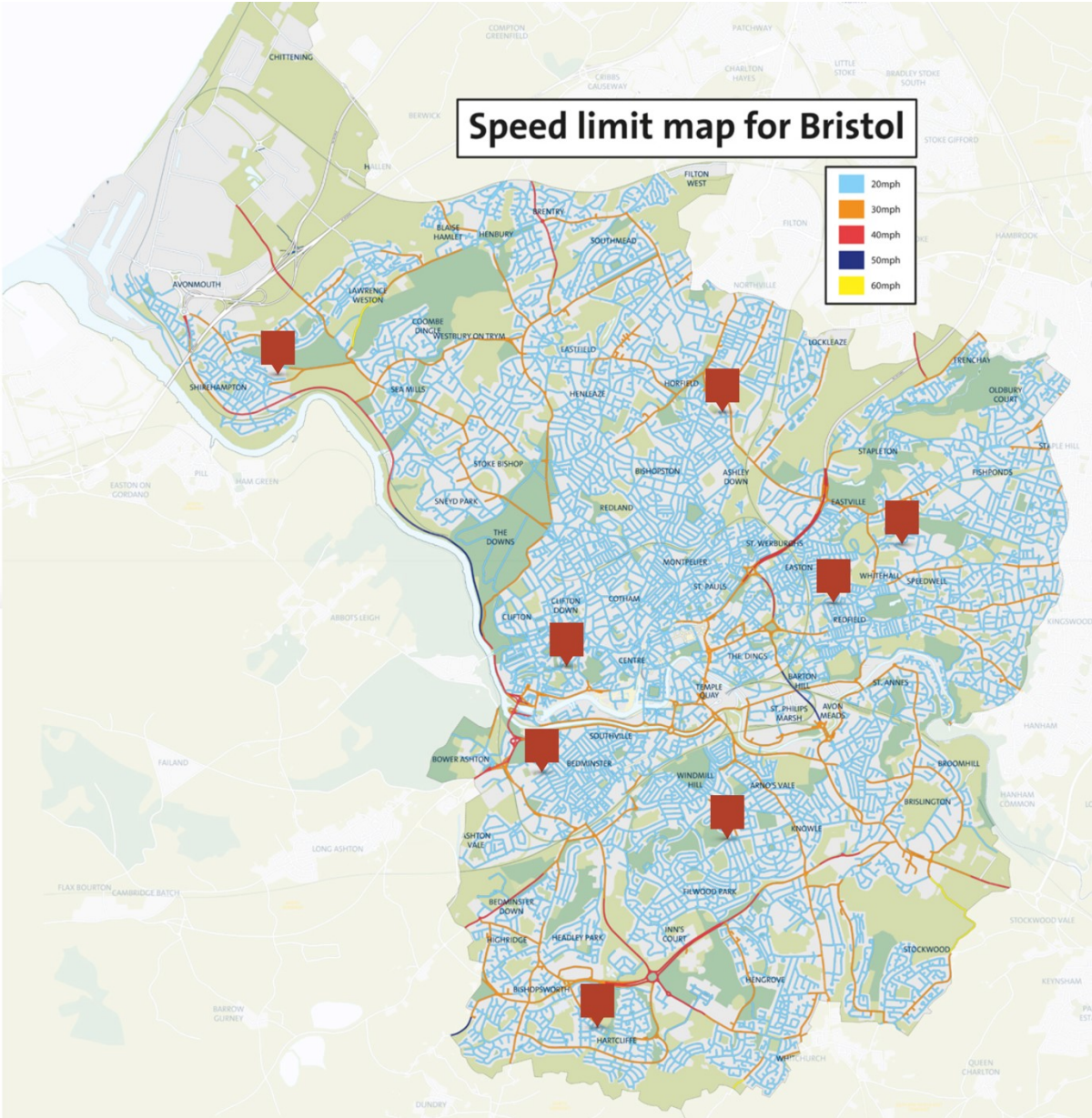
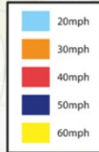
7 Appendices

7.1 Appendix A

Appendix 1 -Proposed Phasing of 20mph rollout across the city



Speed limit map for Bristol



7.2 Appendix B

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	22.426058	.007463	33720733.000	3004.931	.000	22.411436	22.440680
Central	2.009786	.005643	33720733.000	356.148	.000	1.998730	2.020843
Inner South	2.296634	.005661	33720733	405.672	.000	2.285542	2.307726
Inner North	2.799505	.005761	33720733.000	485.974	.000	2.788219	2.810792
East	3.274177	.005771	33720733	567.370	.000	3.262870	3.285483
Outer North	5.100910	.005984	33720733.000	852.411	.000	5.089186	5.112634
Outer South	5.693851	.006682	33720733	852.172	.000	5.680760	5.706942
Pilot	0 ^b	0	.	.	.	.	.
Night	2.313207	.002462	33720733	939.636	.000	2.308383	2.318030
Day	0 ^b	0	.	.	.	.	.
2015	.131098	.004544	33720733	28.848	.000	.122194	.140001
2016	-.352447	.004103	33720733.000	-85.906	.000	-.360486	-.344409
2017	-.423109	.005180	33720733.000	-81.674	.000	-.433258	-.412959
2014	0 ^b	0	.	.	.	.	.
A/B roads	-1.192593	.002485	33720733	-479.933	.000	-1.197461	-1.187724
U roads	0 ^b	0	.	.	.	.	.
Winter	-.258144	.002946	33720733.000	-87.631	.000	-.263916	-.252373
Summer	0 ^b	0	.	.	.	.	.
Weekend	1.306767	.002604	33720733.000	501.819	.000	1.301665	1.311869
Weekday	0 ^b	0	.	.	.	.	.
20mph	-2.664013	.005541	33720733	-480.808	.000	-2.674869	-2.653157
30 mph	-.049886	.005589	33720733.000	-8.925	.000	-.060836	-.038935
Pre intervention	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

7.3 Appendix C

1: Day/night * intervention interaction

Parameter ²	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Night * 20mph	-2.439772	.008816	33720733.000	-276.750	.000	-2.457044	-2.422499
Night * 30mph	.235570	.009099	33720733.000	25.891	.000	.217743	.253396
Night * pre interv	0 ^b	0	.	.	.	.	.
Day * 20mph	-2.743215	.006066	33720733.000	-452.259	.000	-2.755099	-2.731331
Day * 30mph	-.153884	.006169	33720733.000	-24.943	.000	-.165971	-.141796
Day * pre interv	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

2: Weekday/weekend * intervention interaction

Estimates of Fixed Effects ^a							
Parameter ²	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
20mph * Weekend	-2.910641	.009330	33720733.000	-311.965	.000	-2.928921	-2.892361
20mph * Weekday	-2.589601	.005983	33720733.000	-432.848	.000	-2.601322	-2.577879
30mph * Weekend	-.230147	.009662	33720733.000	-23.820	.000	-.249077	-.211217
30mph * Weekday	.004009	.006077	33720733.000	.660	.509	-.007898	.015916
Pre interv * Weekend	0 ^b	0	.	.	.	.	.
Pre interv * Weekday	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

3: Season * intervention interaction

Estimates of Fixed Effects^a

Parameter ²	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
20mph * Winter	-2.291397	.005906	33720733	-387.961	.000	-2.302969	-2.279825
20mph * Summer	-4.665345	.014882	33720733.000	-313.498	.000	-4.694502	-4.636188
30mph * Winter	-.040635	.006261	33720733.000	-6.490	.000	-.052901	-.028368
30mph * Summer	-1.795492	.014833	33720733.000	-121.048	.000	-1.824553	-1.766430
pre interv * Winter	0 ^b	0	.	.	.	.	.
pre interv * Summer	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

4: Road type * intervention interaction

Parameter ²	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Road AB * 20mph	-3.659911	.007483	33720733	-489.115	.000	-3.674572	-3.645251
Road AB * 30mph	-.266790	.007712	33720733.000	-34.594	.000	-.281900	-.251681
Road AB * pre interv	0 ^b	0	.	.	.	.	.
Road U * 20mph	-1.553841	.006642	33720733.000	-233.942	.000	-1.566854	-1.540827
Road U * 30mph	-.099365	.006650	33720733	-14.941	.000	-.112395	-.086335
Road U * pre interv	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

5: Area * intervention interaction

Parameter ²	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
Central * 20mph	-2.163608	.006361	33720733.000	-340.131	.000	-2.176071	-2.151145
Central * 30mph	0 ^b	0	.	.	.	.	.
Inner South * 20mph	-4.482929	.006462	33720733	-693.711	.000	-4.495590	-4.470267
Inner South * 30mph	0 ^b	0	.	.	.	.	.
Inner North * 20mph	-5.924118	.021987	33720733.000	-269.441	.000	-5.967195	-5.881040
Inner North * 30mph	-4.933315	.022107	33720733	-223.156	.000	-4.976628	-4.890002
Inner North * pre interv	0 ^b	0	.	.	.	.	.
East * 20mph	-1.899410	.007664	33720733.000	-247.824	.000	-1.914426	-1.884393
East * 30mph	2.045241	.009849	33720733.000	207.651	.000	2.025944	2.064539
East * pre interv	0 ^b	0	.	.	.	.	.
Outer North * 20mph	-3.382395	.009797	33720733.000	-345.232	.000	-3.401591	-3.363199
Outer North * 30mph	-.472052	.009315	33720733	-50.679	.000	-.490302	-.453803
Outer North * pre interv	0 ^b	0	.	.	.	.	.
Outer South * 20mph	-3.262001	.010583	33720733	-308.216	.000	-3.282737	-3.241265
Outer South * 30mph	-.425883	.008969	33720733.000	-47.483	.000	-.443456	-.408310
Outer South * pre interv	0 ^b	0	.	.	.	.	.
Pilot * 20mph	-2.630829	.010114	33720733.000	-260.122	.000	-2.650644	-2.611013
Pilot * 30mph	0 ^b	0	.	.	.	.	.

a. Dependent Variable: midpt_speed.

b. This parameter is set to zero because it is redundant.

7.4 Appendix D

Area	Speed Reduction from t-test
Bristol	-0.80 mph; $t(270) = 9.41, p = .000$
Central	- 0.38 mph, $t(58) = 2.88, p = .006$
Inner South	-0.52 mph, $t(48) = 3.37, p = .001$
Inner North	-0.84 mph, $t(56) = 5.52, p = .000$
East	-1.15 mph, $t(39) = 5.23, p = .000$
Outer North	-1.28 mph, $t(20) = 4.12, p = .001$
Outer South	-1.07 mph, $t(44) = 3.39, p = .001$
20mph streets across City	-0.75 mph; $t(171) = 7.26, p = .000$
30mph streets across City	-1.04; $t(35) = 2.79, p = .000$

7.5 Appendix E

Roads that are the exception to the trend

20mph roads					
Road	New Speed Limit	Road Type	Time of day	Pre and post	Average ATC speed
Gill Avenue (East Bristol)	20	U	AM peak	Pre	22.50
				Post	23.47
			PM peak	Pre	21.67
				Post	23.67
			Day off peak	Pre	21.67
				Post	23.05
			Night off peak	Pre	22.40
				Post	25.02
			Total	Pre	21.95
				Post	23.73
Charfield Road (Outer North Bristol)	20	U	AM peak	Pre	15.78
				Post	22.64
			PM peak	Pre	15.89
				Post	20.72
			Day off peak	Pre	15.85
				Post	22.62
			Night off peak	Pre	15.95
				Post	24.22
			Total	Pre	15.87
				Post	22.84
Mowcroft Road (Outer South Bristol)	20	U	AM peak	Pre	19.69
				Post	30.72
			PM peak	Pre	19.35
				Post	29.90
			Day off peak	Pre	19.16
				Post	30.63
			Night off peak	Pre	20.04
				Post	31.65
			Total	Pre	19.47
				Post	30.78

30mph roads

Road	New Speed Limit	Road Type	Time of day	Pre and post	Average ATC speed
Henbury Road	30	U	AM peak	Pre	29.80
				Post	32.01
			PM peak	Pre	29.63
				Post	31.77
			Day off peak	Pre	29.64
				Post	31.53
			Night off peak	Pre	30.88
				Post	33.41
			Total	Pre	29.95
				Post	32.08
Lower High Street	30	U	AM peak	Pre	20.41
				Post	22.69
			PM peak	Pre	21.46
				Post	23.36
			Day off peak	Pre	21.79
				Post	23.84
			Night off peak	Pre	23.58
				Post	25.90
			Total	Pre	22.01
				Post	24.14
Two Mile Hill Road (East Bristol)	30	A	AM peak	Pre	21.86
				Post	23.76
			PM peak	Pre	21.99
				Post	23.44
			Day off peak	Pre	22.72
				Post	23.85
			Night off peak	Pre	25.10
				Post	25.89
			Total	Pre	23.25
				Post	24.45

		After (29/09/14 to 31/12/2016)	27	3	3.67	Decrease	0.01			0.67	2.58		-4.39	5.73	
	Serious	Before (1/1/2008 to 28/9/2014)	81	99											
		After (29/09/14 to 31/12/2016)	27	30	33.00	Decrease	0.19			3.00	7.94		-12.56	18.56	
	Slight	Before (1/1/2008 to 28/9/2014)	81	829											
		After (29/09/14 to 31/12/2016)	27	210	276.33	Decrease	15.68	Diff Sig	0.24	66.33	22.05		23.11	109.56	yes
East	Fatal	Before (1/1/2008 to 26/3/2015)	87	11											
		After (27/03/15 to 31/12/2016)	21	0	2.66	Decrease	1.75			2.66	1.63		-0.54	5.85	
	Serious	Before (1/1/2008 to 26/3/2015)	87	101											
		After (27/03/15 to 31/12/2016)	21	22	24.38	Decrease	0.14			2.38	6.81		-10.97	15.73	
	Slight	Before (1/1/2008 to 26/3/2015)	87	1173											
		After (27/03/15 to 31/12/2016)	21	238	283.14	Decrease	7.04	Diff Sig	0.16	45.14	22.83		0.39	89.88	yes
Outer North	Fatal	Before (1/1/2008 to 18/6/2015)	89	4											
		After (19/06/15 to 31/12/2016)	19	1	0.85	Increase	0.15			-0.15	1.36		-2.81	2.52	
	Serious	Before (1/1/2008 to 18/6/2015)	89	61											
		After (19/06/15 to 31/12/2016)	19	13	13.02	Decrease	0.02			0.02	5.10		-9.98	10.02	
	Slight	Before (1/1/2008 to 18/6/2015)	89	567											
		After (19/06/15 to 31/12/2016)	19	93	121.04	Decrease	6.27	Diff Sig	0.23	28.04	14.63		-0.63	56.72	
Outer South	Fatal	Before (1/1/2008 to 22/9/2015)	93	9											
		After (23/09/15 to 31/12/2016)	15	0	1.45	Decrease	0.62			1.45	1.20		-0.91	3.81	
	Serious	Before (1/1/2008 to 22/9/2015)	93	67											
		After (23/09/15 to 31/12/2016)	15	11	10.81	Increase	0.01			-0.19	4.67		-9.35	8.96	
	Slight	Before (1/1/2008 to 22/9/2015)	93	777											
		After (23/09/15 to 31/12/2016)	15	122	125.32	Decrease	0.06			3.32	15.73		-27.50	34.15	
Total	Fatal			12	22.55724882	Decrease	4.48	Diff Sig	0.47	10.56	5.88		-0.96	22.08	
	Serious			285	338.162985	Decrease	8.20	Diff Sig	0.16	53.16	24.96		4.24	102.09	yes
	Slight			2883	3353.743766	Decrease	65.94	Diff Sig	0.14	470.74	78.97		315.96	625.53	yes

