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Developing and refining a programme theory for understanding how twenty mile per hour speed limits impact health

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ABSTRACT

Background and aim: Traffic speed is an important determinant of health, affecting both the frequency and severity of road traffic collisions and casualties. Reduced traffic speed may also improve conditions for walking and cycling. Twenty mile per hour (30km per hour) speed restriction schemes are one policy option for reducing traffic speeds. The aim of this study was to develop and refine a programme theory for understanding how such schemes may impact on health outcomes.

Methods: The programme theory was developed through an iterative process. Firstly, a logic model (diagrammatic version of the programme theory) was created through discussions with 20 mph programme delivery staff from the local authority and through reviewing literature. The second stage consisted of interviews with key stakeholders, and focus groups with the public to further develop and refine the logic model. Data were analysed using Framework Method.

Results: This study first presents an early stage logic model (phase 1) of how the 20 mph speed limit is proposed to work. Qualitative data are then presented (phase 2), describing potential mechanisms as to how the scheme could influence health outcomes through changing i) driver behaviour; ii) casualties and casualty severity; iii) walking and cycling behaviour; iv) air quality; and v) street pleasantness. Participants identified a need for driver education and enforcement in order to reduce speeds, and the importance of improving perceptions of safety for achieving increased walking and cycling. A refined version of the logic model is presented.

Implications: The programme theory will be used as a framework to evaluate the implementation of 20 mph speed limit schemes in Edinburgh and Belfast, aiding in study design decisions such as outcome data to be collected and in the generation of specific testable hypotheses.

1. Introduction

Transport is an important determinant of health (Wilkinson and Marmot, 2003). Motorised transport, in the World Health Organisation (WHO) European region, is responsible for 120,000 deaths and 2.4 million casualties annually (WHO, 2009). High volumes of motorised vehicle traffic are associated with higher levels of overweight and obesity (McCormack and Virk, 2014), and

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reduced levels of community cohesion (Hart and Parkhurst, 2011). Road transport accounts for a substantial proportion of air pollutant emissions, posing a direct health risk (National Institute for Health and Care Excellence, 2017). Further, road traffic accounts for three quarters of transport-related carbon dioxide emissions, contributing to artificial climate change and its associated health risks (Haines et al., 2006; Woodcock et al., 2009). Private motorised traffic is predicted to increase by 80% in the coming decades (Woodcock et al., 2009).

Traffic speed is an important determinant of road traffic safety. Not only does it affect collision outcomes (in high-income countries, traffic speeds contribute to roughly a third of deaths on roads), but also their frequency (WHO, 2017). High traffic speeds are a barrier to walking and cycling (Buehler et al., 2016a), and Bauman et al. (2012) report traffic speed as a correlate of lower physical activity in children. WHO best practice guidance suggests speed limits of 30kph (18.6 mph) or lower when motorised traffic mixes with pedestrians and cyclists (WHO, 2017).

Reduced traffic speed could also lead to a population shift towards active travel (primarily walking and cycling for the purpose of functional travel rather than for leisure (Saunders et al., 2013)). Higher levels of active travel are correlated with higher overall levels of physical activity (Sahlqvist et al., 2012) which is a key health determinant (Lee et al., 2012). Kelly et al. (2014) found risk reductions in all-cause mortality of 11% and 10% for walking and cycling respectively; active travel is likely to have contributed to these reductions. Active commuting specifically is also associated with healthier weight, body-composition (Flint and Cummins, 2016), and enhanced psychological wellbeing (Martin et al., 2014).

Traffic speed management is one way to reduce road collisions and impact on physical activity. The term incorporates a range of measures to reduce speeds, including setting and enforcing appropriate laws; modifying roadways and road architecture; adapting vehicles; and education on the dangers of speeding (WHO, 2017). Consistent reductions in collisions, casualties and deaths resulting from speed camera installations have been observed (Pilkington and Kinra, 2005). A meta-analysis of area-wide urban traffic calming schemes reported casualty reductions of 25% in residential streets (Elvik, 2001). Retting et al. (2003) identified replacing conventional intersections with modern roundabouts as being the most effective speed control intervention with regard to collision reduction.

Twenty mile per hour (20 mph) schemes in the UK, and equivalent 30kph restrictions in Europe are becoming increasingly common as speed management interventions (Buehler et al., 2016b; Cairns et al., 2014). The intentions of these schemes are often multi-faceted, but with a key aim of reducing road traffic casualties (Cairns et al., 2014). Secondary aims include encouraging walking and cycling, and improving the quality of communities (Buehler et al., 2016a; Bury, 2015a).

There are typically two methods of implementing 20 mph speed restrictions: 20 mph zones utilising physical traffic calming features (e.g. speed bumps) (Grundy et al., 2009), and 20 mph speed limits which consist of road signage and markings, sometimes supported by legislation (Toy, 2012). Many UK cities and local authorities have implemented 20 mph zones in recent decades which have been effective in achieving reductions in speed of up to 9 mph (Webster and Layfield, 2003). Twenty mph speed limits, utilising road signage and markings, could provide a cheaper alternative to zones (as there is no need for physical infrastructure) and may therefore have greater potential for large-scale implementation (e.g. citywide). However, these schemes have achieved more modest speed reductions of between 1 and 3 mph (Atkins, 2010; Pilkington et al., 2018; Turley, 2013). In the UK, Portsmouth City Council was the first local authority to introduce a citywide 20 mph speed limit. Bristol and Edinburgh have more recently implemented similar citywide schemes. Smaller scale 20 mph limits (e.g. city-centre schemes) have been introduced, or are being planned, in other cities such as Belfast, Glasgow and Sheffield. Despite the modest speed reductions observed resulting from 20 mph speed limits, there may still be important implications for health.

In an umbrella review, Cairns et al. (2014) investigated the impact of 20 mph (and 30 kph) schemes on health and health inequality outcomes. This study, which included five reviews describing ten primary studies in total, provided evidence suggesting 20 mph schemes reduce traffic speeds and casualties, however there was insufficient evidence to conclude on active travel behaviour or health inequalities. Furthermore, only two of the included primary studies investigated speed limits; the remaining eight investigated zones (incorporating physical traffic calming measures). This umbrella review called for future high-quality evaluations of 20 mph schemes. More recently, research has provided further evidence of the potential benefits of 20 mph speed limits on a wide range of health-related outcomes such as road traffic casualties, air quality and active travel and has highlighted the potential cost savings (Jones and Brunt, 2017).

Evaluations of health interventions have traditionally focussed on whether intervention A is better than intervention B, with little attention given to the underlying theoretical reasons for the change. Recently, the role of theory has gained more prominence in both the design and evaluation of public health interventions (Breuer et al., 2016). However, a recent systematic review of behavioural interventions designed to reduce car use highlighted the lack of a theoretical base (Arnott et al., 2014). Further, there has been a lack of robust theory-driven evaluations of transport interventions (with some notable exceptions e.g., iConnect evaluation of new walking and cycling infrastructure (Ogilvie et al., 2011)), despite published guidance on how such evaluations should be designed (Hills and Junge, 2010).

In this context, we use the term theory to describe the set of principles on which the practice of an activity is based. A theory-based evaluation approach argues that theories should be made explicit, and the evaluation steps (and design) should be built around them: by elaborating on assumptions; revealing causal chains; and engaging all concerned stakeholders. Understanding the (often multiple) mechanisms of change provides evaluators with testable hypotheses to identify the exact points where change may or may not be occurring (Stame, 2004). The first step in any theory-based evaluation is understanding the underlying programme theory. Rogers (2008) describes programme theory as "...developing a causal model linking programme inputs and activities to a chain of intended or observed outcomes, and then using this model to guide the evaluation" (p. 30).

Twenty mile per hour speed limit schemes are complex interventions, consisting of multiple interacting activities (Craig et al.,

2008), including: the passing of relevant legislation; installing new road signage and markings; awareness-raising and education campaigns; and enforcement. These interventions occur within a complex system, where the effects may result from dynamic processes (e.g. feedback loops) as a result of the setting or context (Hawe et al., 2009). Brown et al. (2017) discuss traffic calming interventions as forming part of a broader environment, potentially making it difficult to attribute changes in walking and cycling to traffic calming itself versus the broader built environment. Thus, a theoretical understanding of how, and to what extent, such interventions cause changes in outcomes is a fundamental underpinning of a robust evaluation. The aim of this study was therefore to develop a programme theory to help guide evaluations of 20 mph speed limits, through aiding the understanding of causal mechanisms between intervention activities and outcomes.

2. Methods

2.1. Study design

In this study, the programme theory was developed using a mixed approach incorporating both top-down and bottom-up phases. In Phase 1 (top-down), an initial logic model (a summarised diagrammatic presentation of the theory (Rogers, 2008)) was developed (Fig. 1) utilising data identified through a non-systematic narrative review of the academic and grey literature on the topic of 20 mph interventions. This was complemented by discussions held with, and documents provided by local authority officers delivering the 20 mph speed limit intervention in Edinburgh. This initial logic model looked to identify the intervention inputs and resources (e.g. local authority, law enforcement agency), tasked with carrying out activities (e.g. approving the Speed Limit Order making the limit enforceable, and installing new signage) to create the output – the finalised 20 mph speed limit intervention components that were delivered. The model also sought to specify the intermediate outcomes (e.g. traffic speed reductions and perceptions of safer streets) and outcomes (e.g., decreased casualty rates and increased active travel) that would potentially occur should the intervention components be implemented as intended.

In Phase 2 (bottom-up), the logic model was further informed and refined through a programme of qualitative work consisting of two streams; semi-structured interviews with key stakeholders involved in, or who had a vested interest in Edinburgh's scheme, and focus groups and interviews with members of the general public covering a range of demographics. The inclusion of stakeholders in theory development is considered an ideal scenario (Wight et al., 2016). The data collected were used to help identify mechanisms of change explaining how intervention activities were proposed to lead to purported changes in health outcomes.

2.2. Intervention setting and characteristics

Although intended that the created programme theory will be applicable to most jurisdictions implementing such policies, data presented in this study were collected in Edinburgh, where a phased citywide 20 mph speed limit has been implemented between 2016–2018 (four implementation phases across six geographical areas). Edinburgh is the capital city of Scotland (UK) with a population of 499,000. The local authority area covers 261km². The City of Edinburgh Council began the introduction of the citywide 20 mph speed limit in July 2016, following a pilot scheme launched in March 2012. An evaluation of this pilot reported reduced speeds of 1.9 mph on affected roads, increases in journeys by foot and bicycle of 7% and 5% respectively, and a reduction in car journeys of 3% (Turley, 2013). The intervention was introduced to cover the local authority area.

The aims of the 20 mph speed limit were to: *reduce traffic speeds; reduce the number and severity of casualties on relevant streets; increase walking and cycling; and to change citizens' perceptions relating to 'liveability' and 'people-friendliness' of Edinburgh's streets, and for an establishment of the 20 mph network* (Bury, 2015a).

The speed limit was introduced via four main activities: i) signage and road markings, without additional physical traffic calming measures; ii) the passing of a Speed Limit Order to enable enforcement; iii) an education and awareness-raising programme; and iv) enforcement of the new speed limit.

2.3. Phase 2 sampling and recruitment

Two groups of participants were included in the qualitative study: key stakeholders (stream 1) and the general population (stream 2). A combination of purposive and snowball sampling was undertaken to ensure that a range of views were obtained. There were no formal exclusion criteria for either of the streams.

2.3.1. Stream 1: key stakeholders

Key stakeholders were identified via: a database provided by the local authority; existing partnerships between the research team and stakeholders; and through identifying relevant individuals from organisations or groups likely to be able to provide insight or hold an interest. Interview participants were also asked to identify other stakeholders likely to be of interest. Stakeholders fell under three categories: i) those directly involved in the planning or implementation of the scheme; ii) those whose professional role was closely aligned to the scheme, and iii) those who would be directly affected by the scheme (e.g. representatives from bus and taxi companies in Edinburgh). Potential participants were invited via email and telephone contact. Twenty individuals were invited to participate of which four declined the invitation or did not respond.

2.3.2. Stream 2: general population

A pragmatic approach to sampling was taken. Contact details for pre-existing groups within the speed limit implementation areas, provided by the local authority, were utilised. To limit bias within the sample, existing contacts from the research team were used to identify additional groups likely to be differentially affected by the scheme (Gorman et al., 2003). Recruitment aimed to include individuals utilising different modes of transport across different areas of the city. Each group was approached through a gatekeeper (who held contact details for those within the group of interest), and approval was granted to contact group members. Each group member was sent an invitation email along with an information sheet. A £10 high street voucher was offered as an incentive. Once several members of a group had volunteered, they were contacted via email to arrange a focus group. If no time or location was agreed, individuals were invited to participate in a short interview.

2.4. Data collection

2.4.1. Development of topic guide

The interview (Appendix A) and focus group (Appendix B) topic guides aimed to elicit data to develop the programme theory. Topics were selected based on key elements of 20 mph speed limits identified during phase 1, and through discussions with the authorship group and local authority officials implementing the intervention. Topics covered by the Stream 1 interview guide were: participant knowledge and perceived rationale of the scheme, participant role in the scheme, and likely personal impact of the scheme. Also discussed were potential benefits and disadvantages of the 20 mph scheme, barriers and facilitators to implementation and its success, monitoring, enforcement, and future policy implications. The topic guide for Stream 2 covered 'why the scheme was being introduced' and 'how it would affect participants'. This topic guide was piloted, with minimal changes made.

2.4.2. Data collection time-frame

Collection of qualitative data for Streams 1 and 2 took place between October 2015 and February 2016 (the first implementation phase of the 20 mph limit became enforceable in July 2016).

2.4.3. Stream 1

Interviews with key stakeholders were semi-structured to allow for required topics to be covered, and for alternative lines of enquiry where appropriate. All but two interviews occurred at the participant's workplace. A local venue was mutually agreed for the remaining interviews. Interviews were principally one-to-one but two interviews involved two participants. Interview duration ranged between 15 and 60 minutes. KT conducted all interviews.

2.4.4. Stream 2

Focus groups took place at a location convenient for the majority of participants. These lasted approximately one hour, and the short interviews lasted approximately 15 minutes. All Stream 2 focus groups and interviews were conducted by BM.

2.5. Ethics and informed consent

Ethics approval was obtained from the Moray House School of Education Ethics Committee at The University of Edinburgh. Participants were provided with an information sheet and an opportunity to ask questions, and informed consent was obtained prior to interview.

2.6. Data coding and analysis

Data analysis was conducted in line with the seven phases of Framework Method (Gale et al., 2013). Interviews and focus groups were audio recorded and then anonymised. Interview data were managed using qualitative data management package NVivo 10 (QSR International). Phase one, transcription of audio files, was conducted verbatim by an external service. Two researchers (KT and RJ), from differing academic backgrounds, read all Stream 1 transcripts to ensure familiarisation with the interviews – phase two of Framework Method, and identified as a vital stage in interpreting the interview data.

For the third phase – coding – two researchers (one male research assistant from a physical activity for health background (KT); one female project lead from a public health background (RJ)) coded three transcripts independently. Multiple data coders are advocated in the Framework Method, to allow for alternative viewpoints and to ensure one particular perspective does not dominate. Inter-rater reliability between the two coders was not formally tested, acknowledging the influence factors such as power differential, gender dynamics and differences in background knowledge have in any attempt to establish reliability in qualitative research (Smith and McGannon, 2017). The researchers met regularly to discuss issues around coding and revise the coding strategy accordingly.

Coding was predominantly deductive, seeking to identify data describing mechanisms for how the intervention would impact certain health-related outcomes: traffic speed; road casualties and casualty severity; active travel behaviour; air pollution; and lastly, 'liveability' and pleasantness of streets. These themes were informed by the initial logic model and through discussion with authorship group. The process was iterative, with several mechanisms of change being developed and then refined, until both researchers were confident that the mechanisms were supported by the data. Themes were also identified inductively. Coding for mechanisms regarding the five health-related themes was agreed as the working analytical framework (phase four), and phase five then consisted of these codes being applied to the remaining Stream 1 transcripts by one researcher (KT). After coding all Stream 1

transcripts, coded data were charted to allow comparisons across both cases and themes. Whilst charting data, care was taken to make sure of retaining the ‘feel’ of each interview, whilst reducing the data appropriately.

Once this stage of analysis was complete, a third researcher (HB) coded the transcripts from Stream 2, applying the five health-related themes described. The seventh and final stage – interpreting the data, was performed through discussions with the research team to finalise the programme theory.

3. Results and discussion

3.1. Phase 1: development of initial logic model

Fig. 1 presents the initial logic model developed during Phase 1, informed by previous literature (Atkins, 2010; Bristol City Council, 2012; Cairns et al., 2014; Tapp et al., 2015; Toy et al., 2014), discussions with, and documentation (Bury, 2015a,b) from programme staff in the City of Edinburgh Council, and discussions within the research team. This phase of theory development particularly helped the research team in becoming aware of: the main components of the 20mph speed limit intervention in Edinburgh (legislation; installation of road signage and markings; awareness-raising and education; and enforcement activities), the organisations responsible for delivering the above-mentioned components (e.g. local authority 20mph programme team; law-enforcement agency), and the resources used (e.g. raw materials) to be able to introduce these intervention components. This process also educated the research team on the local authority’s intended/anticipated intermediate and longer-term outcomes resulting from the policy (e.g. reductions in traffic speeds, increased walking and cycling, and improved perceptions of “liveability” and people-friendliness of streets (Bury, 2015a)).

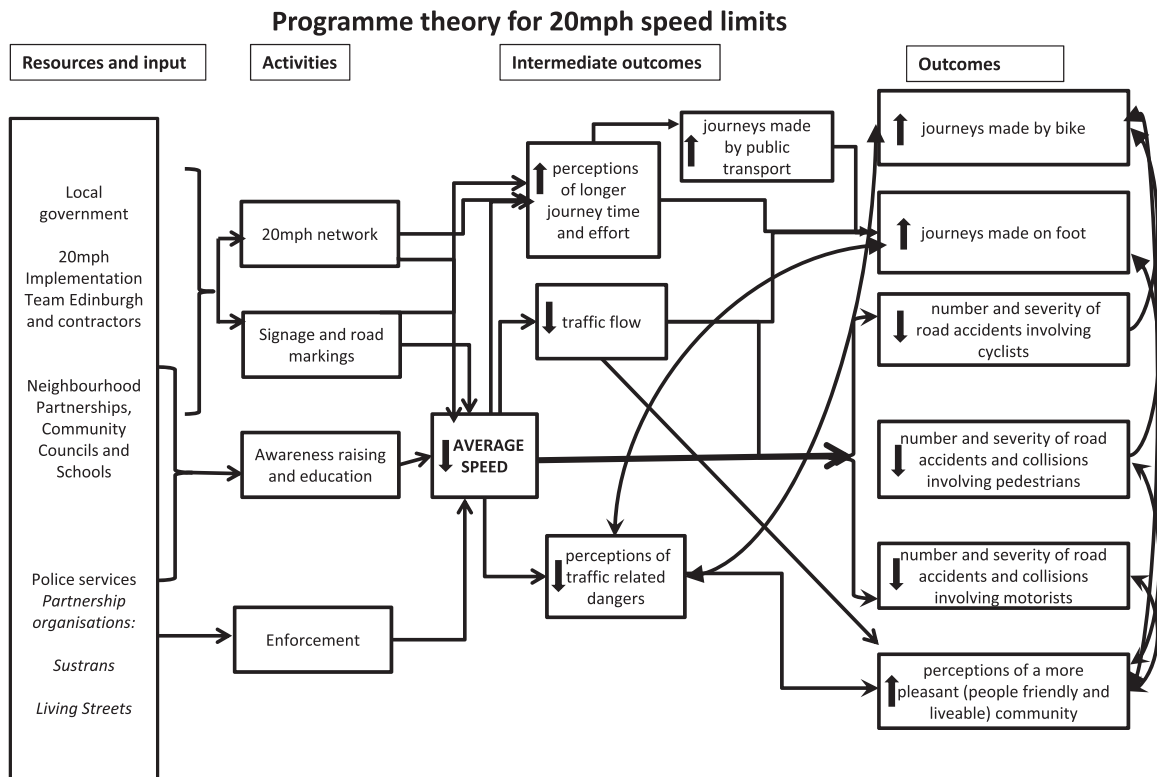


Fig. 1. Initial logic model developed during Phase 1.

3.2. Phase 2: Refining the logic model utilising qualitative data

This section discusses the mechanisms identified, addressing five key areas, namely, how the scheme may influence: traffic speeds; casualties and casualty severity; walking and cycling behaviour; air quality; and street ‘liveability’ and ‘pleasantness’. The aim was not to provide an exhaustive list of mechanisms proposed, but describe some key pathways identified and how they relate to previous literature. Mechanisms identified by both key stakeholders and the general public contributed to the development of the programme theory. This allowed a fuller picture to be attained of how the scheme may work not only from the perspective of those

closely involved in development or delivery, but also of those who are exposed to and potentially impacted by the scheme on a day-to-day basis.

3.2.1. Characteristics of participants from Streams 1 and 2

Seventeen key stakeholders participated in 15 interviews as part of Stream 1; to protect participants' identities their professional titles are not disclosed. Table 1 provides participant affiliations. Table 2 provides characteristics of focus groups and interviews conducted with representatives from the general public within the implementation areas as part of stream 2.

Table 1

Key stakeholder participant and affiliations (Stream 1).

Participant number	Participant affiliation/organisation	Role of organisation/affiliation
1	City of Edinburgh Council	Providing public services to Edinburgh + responsible for the implementation of the 20 mph citywide speed limit in Edinburgh.
2	Sustrans	A charitable organisation that enhances the choices of the public to make sustainable travel choices, through walking, cycling and public transport.
3	Lothian Buses	Largest municipal bus company in UK – majority shareholder is City of Edinburgh Council + main provider of bus services in Lothian.
4 + 5	Central Taxis Edinburgh	Edinburgh's largest black taxi company
6	Institute of Advanced Motorists	Charitable organisation promoting road safety by improving driver and rider skills through coaching and education.
7	Living Streets Scotland	Charitable organisation working to enhance choice and experience of walking, and to make walking the natural choice.
8	Scottish Fire and Rescue Service	Scotland's emergency response team tackling incidents including road traffic collisions.
9	City of Edinburgh Council	Providing public services to Edinburgh + responsible for the implementation of the 20 mph citywide speed limit in Edinburgh.
10	City of Edinburgh Council – Streets Ahead road safety team	Body within local authority responsible for implementing the pilot 20 mph speed limit in South Central Edinburgh.
11 + 12	Transport Scotland	Involved in the implementation of other road safety interventions (that could potentially influence findings of the current project) e.g. Safer routes to school, and school streets.
13	NHS Lothian	Scottish Government Agency responsible for delivery of major infrastructure projects, and overseeing the operation of Scottish Transport Networks.
14	City of Edinburgh Council – Elected member	Responsible for monitoring, protecting, and improving the health of those who live in Edinburgh and the Lothians.
15	City of Edinburgh Council – Elected member	Responsible for agreeing policies about provision of services and how the Council's money is spent (e.g. 20 mph speed limit).
16	Motorcycle Action Group	Responsible for agreeing policies about provision of services and how the Council's money is spent (e.g. 20 mph speed limit).
17	Police Scotland	A volunteer-led riders' rights organisation, campaigning to protect and promote motorcycling. This group was identified as likely to be anti-20 mph limit.
		Responsible for the policing of Scotland, improving safety and wellbeing of people, places and communities.

Table 2

General public focus group and interview characteristics (Stream 2).

Target group of focus group/interview	Participant identification	No. of focus groups/ interviews	No. of participants
Teachers (primary school staff)	FG1	1 focus group, n = 5 2 interviews, n = 2	7
Young professionals	FG2	1 focus group, n = 4	4
NHS employees	FG3	1 focus group, n = 4 2 interviews, n = 2	6
Local school parent council members	FG4	1 focus group, n = 3	3
Older adult community group	FG5	1 focus group, n = 7	7
Postgraduate students	FG6	1 focus group, n = 6	6
Residents of one Edinburgh neighbourhood within area of Edinburgh where 20 mph were to be implemented	FG7	1 focus group, n = 4	4
Total		7 focus groups, n = 33 4 interviews, n = 4	37

3.3. Potential mechanisms of change

3.3.1. How the 20 mph speed limit intervention activities influence traffic speeds

The implementation of a 20 mph signage-only speed limit represents a complex intervention, comprising of several interacting and complementary components (Moore et al., 2015). It occurs within, and interacts with a wider policy and transport system. The intervention components/activities (legislation; signage and road markings; awareness-raising and education campaign; and enforcement activities) may influence driving behaviours either individually, or by acting in combination. For example, signage may not be sufficient, on its own, to change behaviour. People may need to know why the signage is there (education) and understand that they will incur a penalty for not complying with the limit (enforcement).

Several mechanisms by which the intervention activities could plausibly reduce traffic speeds were identified by participants. Three of these are presented below: self-enforcement of the speed limits; changing attitudes and social norms toward traffic speeds through education; and an adaptation in driving behaviour resulting in a ‘knock-on effect’, further regulating speeds.

3.3.1.1. Proposed mechanism one: Self-enforcement of the new limits.

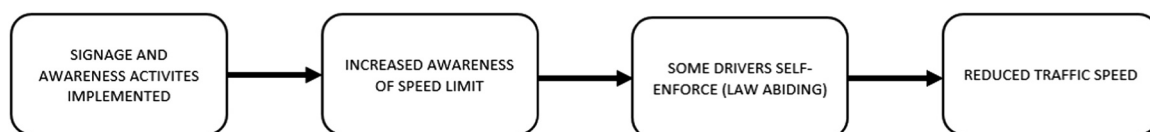


Fig. 2. Proposed mechanism one: Self-enforcement of the new limits.

Several participants discussed that most drivers choose to abide by the law, thus self-enforcing the new speed limit, negating the need for official law enforcement (Fig. 2). One participant stated:

“But the majority of drivers drive carefully and safely, and within the law. And I think when the law reduces the speed to twenty miles per hour in residential streets the majority of drivers will abide by it. Physical measures or not.” Stream 1– Participant 15.

It is presumed that there is an expectancy from a substantial portion of the public that laws will be enforced, and punishment will follow, if not complied with. Our findings of expectations of drivers choosing to self-enforce this speed limit are consistent with those of Tapp et al. (2015), who carried out a population-wide survey of GB drivers’ attitudes to lower speed limits. They discussed the importance to some drivers of obeying the law, and that this ‘over-rides’ an individual’s personal opinion of such a limit. Drivers choosing to self-enforce this new speed limit is dependent on awareness of the change.

Whilst this will modify the behaviour of some, an awareness of the new speed limit may not be sufficient to change the behaviour of others. One participant indicated the need for enforcement to help achieve compliance:

“I actually think a big percentage of the population would pay heed to just the signs. But there also has to be a bit of a threat as well. You know, like cameras or something like that.” Stream 2- FG3.

Some participants voiced concern over a potential lack of enforcement activity, and a resultant lack of speed reduction. One stated:

“...there will be very limited enforcement of the scheme overall ...So that’s a concern that if people ...perceive that and there’s enough people out there that are willing to flout it, and that they see other people flouting it, that it doesn’t actually get the traction that they need.” Stream 1- Participant 11.

3.3.1.2. Proposed mechanism two: Changing attitudes and social norms toward traffic speeds through education.

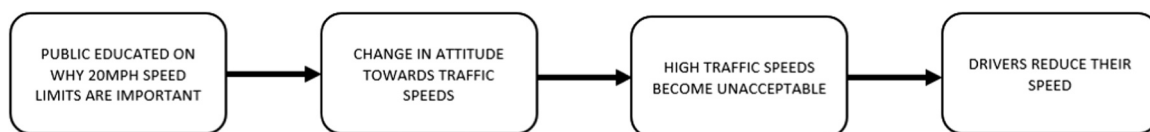


Fig. 3. Proposed mechanism two: Changing attitudes and social norms toward traffic speeds through education.

Several participants discussed the importance of educating the public on ‘why’ the new lower speed limits are being introduced. An educational campaign could act to reinforce the reasons for introduction, and reduce the need for enforcement of the scheme. One stakeholder indicated what they believed the importance of education was with regard to setting these limits:

“This isn’t just about setting speed limits. If the drivers understand why the speed limits are being set like that, to reduce collisions with pedestrians, cyclists, safer routes to school, all the positives, there is obviously an education piece there to make sure that drivers are aware that’s why the speed limit has been reduced, it’s not just because the council said so.” Stream 1- Participant 8.

Thus, it is hypothesised that education may play an important role in changing attitudes towards traffic speeds (Fig. 3) through influencing behavioural beliefs (e.g., the potential health-related consequences) of driving at 20 mph is beneficial. As one participant stated:

“It’s all about people buying into it. It’s not about forcing people and limiting people so they can’t physically do the speeds, it’s about making them not want to do the speeds, otherwise it doesn’t work.” Stream 1- Participant 1.

Originating from Ajzen’s Theory of Planned Behaviour (Ajzen, 1991), attitude would be defined in this context as the degree to which an individual has a favourable or unfavourable evaluation of driving at 20 mph. Previous research has demonstrated attitude as being a significant predictor of intention to comply with a speed limit (Elliott et al., 2003) however, there is evidence that a positive attitude towards a 20 mph speeds limit may not be reflected in actual driving behaviour (Tapp et al., 2015).

It was viewed that over time, a change in attitude may lead to a shift, where driving over 20 mph becomes socially unacceptable. Previous research has indicated that the public do identify speeding traffic as an anti-social behaviour (Poulter and McKenna, 2007). Several participants began drawing parallels with previous health-related policies, such as drink driving, the enforcement of wearing seat belts, and smoking in public places, indicating that over time, higher traffic speeds would be seen as *“socially unacceptable, antisocial behaviours”* (Stream 1- Participant 2):

“...but over time I think it’s one of these things like seatbelts and drink driving, and all that sort of stuff, that people just start to see what is a safe speed in an urban setting to drive.” Stream 1- Participant 7.

This finding supports the work of others who have proposed social norms to be an important construct in determining drivers’ adherence to speed limits (Toy et al., 2014).

Whilst the link between smoking and ill-health is now widely accepted, Tapp et al. (2016) suggest that the link between traffic speed and safety is still contested; for some it is ‘bad driving’ that causes problems rather than traffic speed itself. This narrative could be of interest when assessing changes in attitudes and normative behaviour in relation to the new speed limits.

3.3.1.3. Proposed mechanism three: ‘Adapted driving behaviour leads to knock-on effect’.

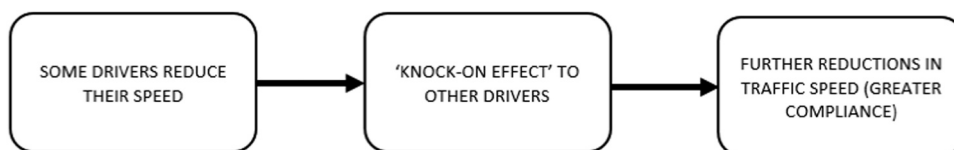


Fig. 4. Proposed mechanism three: ‘Adapted driving behaviour leads to knock-on effect’.

Building on the previous mechanism that proposed a change in normative beliefs of driving at 20 mph may lead to a reduction in speed, mechanism three more explicitly suggests what was described as a ‘*knock-on effect*’ (Stream 1- Participant 9) (Fig. 4) from drivers that have already adapted their behaviour and reduced their speed, will subsequently influence other drivers who will ‘*copy*’ this behaviour (Stream 1- Participant 9). One stated:

“...the majority of the people that are driving around at twenty miles an hour, or around about twenty miles an hour, will drag the rest of the traffic down to that speed, and therefore over time we’ll see less and less people flouting the twenty miles an hour rules. ‘Cause everyone else does it so it’s got to be the right thing to do. ...from a psychology point of view, I’m convinced that will happen...” (Stream 1- Participant 11).

It is plausible, that a reduction in speed could be observed not due only to a change in driver psychology leading to drivers ‘copying’ the behaviour of others, but also as a result of the physical obstruction resulting from a reduction in speed of other drivers. Participants did caution however that this outcome was likely to take time. Tapp et al. (2016) investigated compliance with 20 mph speed limits in an online survey of drivers and residents in Great Britain. They discuss a ‘virtuous circle’ linked with descriptive norms – whereby the strong support for speed limits in general, along with the potential word of mouth from those strongly in favour of the limits, and their adherence, will bring about copycat behaviour and reduce the speed of the ‘mainstream middle’; the group who’s behaviours are most susceptible to change. Tapp et al. (2016) do caution of the potential for the opposite to occur; a ‘vicious circle’ leading to non-compliance, resulting from, for example, unintentional speeding or a lack of support for such speed limits.

3.3.2. How 20mph limits impact casualties, and casualty severity (proposed mechanisms four and five)

Reducing road traffic collisions and the casualty outcomes associated with them is a primary target of traffic calming and speed-related interventions (Brown et al., 2017). Mechanisms proposed as to how the scheme may influence collision rates, and resultant

casualties and their severity are now discussed.

The links between traffic speed and collision frequency and casualty severity are well evidenced. Greater traffic speeds increase the likelihood of collisions in the first instance (Aarts and van Schagen, 2006) (Fig. 5), and in a collision situation, higher impact speeds result in more severe casualty outcomes (Rosen and Sander, 2009) (Fig. 6). Several participants highlighted both of these points:

“And it might just be running into the back of somebody. ... the likelihood of that is less if everyone's driving a little bit slower.” Stream 1- Participant 8.

“For physiological reasons, if you're struck at twenty mile an hour – or probably not struck at twenty mile an hour 'cause you would hope that the brakes had been hit – that you've got much more ability in terms of the resilience of your body to deal with that impact. ...that's basically the fundamental physics of this.” Stream 1- Participant 7.

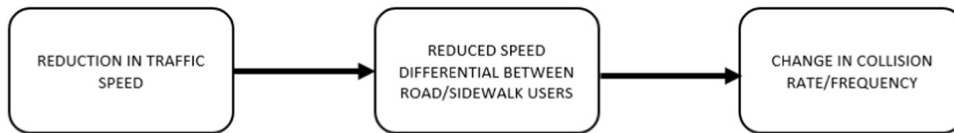


Fig. 5. Proposed mechanism four: lower traffic speed results in reduced collision risk.

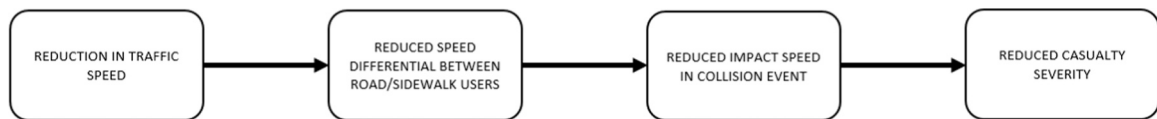


Fig. 6. Proposed mechanism five: lower traffic speed results in lower collision impact speeds.

The risk of pedestrian fatality in a collision at 50 km per hour (kph) (31 mph) is twice of that than at 40 kph (25 mph), and five times that than if struck at 30 kph (18.6 mph) (Rosen and Sander, 2009). (Tefft, 2013) provides similar estimates for the risk of severe injury or death in a collision situation; a 10% average risk if struck at 17 mph, a 25% risk at 25 mph, and a 50% risk if struck at 33 mph.

As the impact that traffic speed has on collision frequency and outcome is clear, it appears intuitive that the impact the 20 mph speed limit has on collisions will be dependent upon the reductions in traffic speed observed. Twenty mile per hour zones, incorporating physical traffic calming measures that ‘force’ a reduction of speed upon the driver, have achieved reductions in speed of approximately 9 mph, and as such these schemes have observed casualty reductions of 42% (Grundty et al., 2009).

Twenty mile per hour speed limits do not incorporate physical measures ‘forcing’ slower speeds, and as such will likely have to rely on alternative methods to achieve speed reduction (e.g. driver education, law enforcement, cultural change). Emerging evidence suggests speed reductions of between 1 mph and 3 mph resulting from 20 mph speed limit schemes are possible (Atkins, 2010; Pilkington et al., 2018; Turley, 2013). One modelled estimate suggests a reduction in average speed of 1 mph could reduce collision frequency by 6% on urban roads already characterised by low speeds (Taylor et al., 2000). It is therefore feasible that a reduction in collision frequency of between 6–18% could be achieved if speed reductions comparable to those reported in the above-mentioned studies are observed.

3.3.2.1. Proposed mechanism six: lower traffic speed results in more severe collision outcomes.

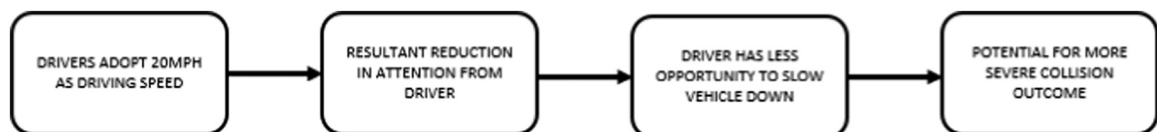


Fig. 7. Proposed mechanism six: lower traffic speed results in more severe collision outcomes.

One participant took a counter view to those described previously regarding collision outcomes, suggesting a likely increase in driver inattention could be detrimental (Fig. 7):

“...if drivers are driving in twenty mile an hour, shall we say, in their cruise control on their vehicle... ..not paying as much attention as they would if they were travelling faster. ...Child runs into the road, and yes, your driver doing thirty miles an hour, if hits them at thirty they're much more likely to be severely killed or injured. But if a driver's paying attention, he's gonna hit the brakes and slow down.” Stream 1- Participant 16.

Another participant suggested an increase in collisions could result from an increase in volume of pedestrian and cyclist activity:

“...So it's people feeling that it's safer, so we're getting the active travel benefit out of it, but proportionately there'll be more accidents.”
Stream 1- Participant 11.

3.3.3. How 20 mph speed limits would influence active travel

This section reports on three plausible mechanisms identified as to how the 20 mph speed limit could influence active travel: improving perceptions of safety; improving route choice for walking and cycling; and reducing the speed differential between motorised and non-motorised vehicles.

3.3.3.1. Proposed mechanism seven: Improving perceptions of safety.

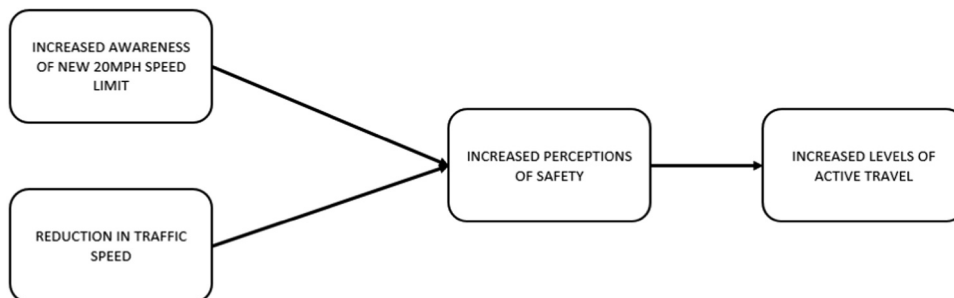


Fig. 8. Proposed mechanism seven: Improving perceptions of safety.

Several participants discussed the potential for the 20 mph speed limit to improve the public's perception of speed and safety, with likely positive implications for active travel behaviour (Fig. 8). Safety from traffic is embedded in several theoretical frameworks for understanding active travel behaviour (Gotschi et al., 2017; Singleton, 2013). Lower perceived traffic speeds are associated with increased cycling levels (Mertens et al., 2016), and Panter et al. (2014) report an increase in car journeys in environments perceived as dangerous for cycling and road crossing. One participant stated:

“We know that safety, and perceptions of safety, are a very important influence on that [active travel]. So the evidence seems to suggest that if you lower speed, generally, people will feel safer and people will be more happy to do it.” Stream 1- Participant 12.

Another participant, who was sceptical about the likely impact of the scheme (e.g. they did not believe that the new speed limit would have any influence on traffic speeds), did indicate that perceptions of safety may improve for some as a result of new-found awareness of the scheme being in place:

“...I don't think the speed it [traffic] really moves at is gonna [going to] change. So if somebody's out riding their bicycle, I don't think they're going to be any safer than they were before. However, I think that... the perception might be that the streets are a little safer.”
Stream 1- Participant 4.

Drawing from social-cognitive theory (Bandura, 1986), Ma et al. (2014) propose that perceptions of the environment play a direct role in influencing cycling behaviour, whereas the objective environment has an indirect role through influencing perceptions. Thus, it is possible to hypothesise that the public's perception of safety may increase via becoming aware of the new speed limits, potentially leading to changes in active travel, regardless of whether traffic speed does or doesn't change (as described above by participant 4). However, if there was a modal shift towards active travel that reduced levels of motorised travel, there would likely be an increase in actual safety, due to active travel posing less of a risk than motorised forms of travel (Jacobsen, 2003).

3.3.3.2. Proposed mechanism eight: Improving route choice for walking and cycling.

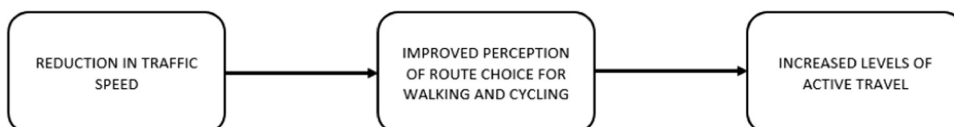


Fig. 9. Proposed mechanism eight: Improving route choice for walking and cycling.

Several participants indicated that the introduction of the 20 mph speed limit would likely improve the number of streets and routes suitable for active travel (Fig. 9). This is likely to be linked to the previously discussed perceptions of safety; improved perceptions of safety are likely to lead to improved perception of route acceptability. One participant stated that the implementation of the 20 mph speed limit will allow pedestrians and cyclists not to have to “*plan their route ahead*” [to avoid unsupportive roads] (Stream 1- Participant 2). Another proposed that the new speed limit will lead to “*more people [pedestrians] using routes that they don’t currently use*” (Stream 1- Participant 13), and that “*...I think it’ll be making me more likely to cycle and using different routes to the strange routes that I take at the moment in order to avoid certain journeys.*” A third discussed the 20 mph speed limit as likely leading to a “*better choice*” of more direct safer routes to school (Stream 1- Participant 10). Mertens et al. (2016) found an increased perceived route choice for walking and cycling led to increased commuter cycling, and Guell et al. (2013) found that active travellers in Cambridge, UK, sought out empty streets or roads to travel on to avoid conflicts with other road users. Should streets begin to feel more pleasant as a result of the 20 mph speed limit, then cyclists and pedestrians may feel less need to scope out alternative quieter streets that may be more inconvenient.

3.3.3.3. Proposed mechanism nine: Reducing the speed differential between motorised and non-motorised vehicles.

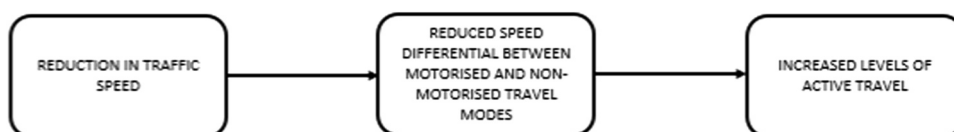


Fig. 10. Proposed mechanism nine: Reducing the speed differential between motorised and non-motorised vehicles.

Participants identified a reduction in the speed differential between motorised and non-motorised vehicles as a potential result of the introduction of the 20 mph speed limits (Fig. 10). It is likely that this could be a key mechanism for improving the perception of safety, and perceived route choice for walking and cycling. Daley et al. (2007) provide evidence that for cyclists, a large speed differential between themselves and motorised vehicles is perceived as a concern. Pucher et al. (2010) state that reduced speed limits increase cycling by “*increasing the speed of bicycling relative to the speed of driving*” (p. S116). One participant stated:

“Particularly if you’re a new cyclist, I think you can feel a bit spooked if cars are sort of revving and trying to get past you. If the speeds are slower ...I think you’re gonna have a lot less pressure...” (Stream 1- Participant 10).

3.3.4. How the implementation would influence air quality

The majority of participants were asked about the potential implications for air pollution. However, in their responses, several did not specify when discussing emissions whether they were referring to emissions of greenhouse gases or air pollutants. For the purposes of discussing this topic we use the term ‘air quality’ to describe implications for either air pollutant or greenhouse gas-related emissions. Participants identified two mechanisms by which the 20 mph speed limit could influence air quality: modal shift away from car use; and a change in driving style.

3.3.4.1. Proposed mechanism ten: modal shift away from car use.

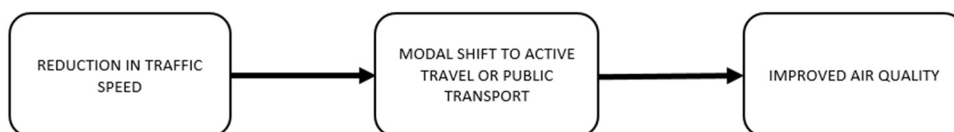


Fig. 11. Proposed mechanism ten: Modal shift away from car use.

Several participants discussed the “*...transition away from cars into more active modes of transport*” (Stream 1- Participant 11) as a mechanism by which the introduction of the 20 mph speed limit could influence air quality (Fig. 11). Air pollutant and greenhouse gas emissions both have important health implications, and road transport is currently responsible for substantial contributions to both of these (National Institute for Health and Care Excellence, 2017; Woodcock et al., 2009). A shift away from motorised travel would result in a decrease in such emissions. Whilst changes in vehicle-related energy consumption at an individual level may be trivial, when scaled up to a population and aggregated, they can be significant (Barkenbus, 2010).

Despite the increased likelihood of exposure to air pollution when travelling actively, the health benefits of active travel still outweigh the harmful effects of air pollution (Cepeda et al., 2017; Tainio et al., 2016).

3.3.4.2. Proposed mechanism eleven: Change in driving style – less acceleration and braking.

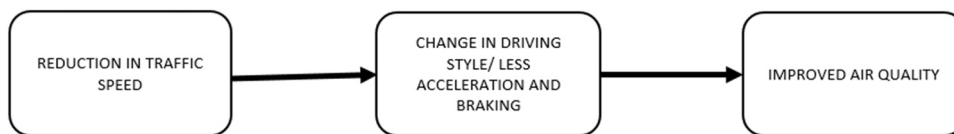


Fig. 12. Proposed mechanism eleven: Change in driving style – less acceleration and braking.

Several interviewees proposed that a 20 mph speed limit would lead to a more consistent driving style, resulting potentially from a smoother traffic flow, characterised by less acceleration and braking (Fig. 12):

“I actually think it will improve air pollution. If people ...are accelerating, braking less, they’re putting less... It’s a different driving style. And it’s driving appropriate to the gear. ...But certainly you’re gonna have vehicles accelerating less and braking less harshly.” (Stream 1- Participant 7).

Indeed, recent guidance (National Institute for Health and Care Excellence, 2017) has recommended that new lower speed limits be introduced without physical traffic calming measures, as this would lead to less acceleration and deceleration and thus reduce the negative environmental consequences.

This discussion aligns closely to some of those characteristics of ‘eco-driving’; a changing in driving style replacing an ‘aggressive’ one with a more ‘refined’ style. Eco-driving is defined by the adoption of moderate acceleration, anticipating traffic flow that thus reduces sudden starts and stops, and of particular interest, “driving at or safely below the speed limit” (Barkenbus, 2010) (p. 763). As well as calculations indicating that fuel savings of between 5–10% are a possible result of this driving style, reductions in traffic collisions also appear realistic. There appears to be overlap between the potential influence of the 20 mph limit, and eco-driving, on traffic/driving characteristics. If this turns out to be the case, there could be scope to incorporate education on the two aspects to encourage economical driving styles.

Air quality was one topic of discussion where amongst participants there was little certainty regarding the likely impact of the 20 mph speed limit, and some participants indicated that the limit was likely to worsen air quality. One participant, whilst again indicating that reduced stop-start traffic would be beneficial, described the potential negative implications:

“...stop-start traffic is not good news for air quality and certainly a car tends to give its best fuel consumption at higher speeds than twenty.” Stream 1- Participant 6.

3.3.5. How the scheme would influence liveability/pleasantness

One of the aims of the scheme is to “improve peoples’ perceptions relating to ‘liveability’ and people-friendliness of Edinburgh’s streets...” (Bury, 2015a). Liveability appears to be a wide-ranging construct. One definition describes liveable cities as “...socially inclusive, affordable, accessible, health, safe and resilient to the impacts of climate change...” (Major Cities Unit, 2010).

3.3.5.1. Proposed mechanism twelve: Improving street-crossing conditions.

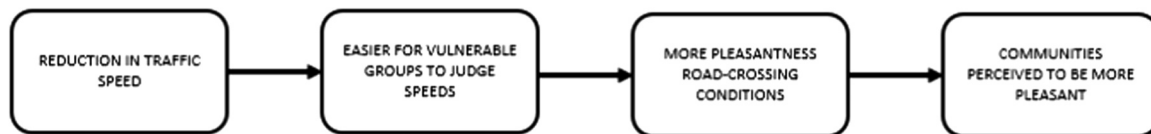


Fig. 13. Proposed mechanism twelve: Improving street-crossing conditions.

Several participants discussed the impact the 20 mph speed limit could have on pedestrian road crossing, specifically with regard to young children and the elderly (Fig. 13). They discussed the ability of vulnerable groups to judge speeds becoming easier at lower speeds. Wann et al. (2011) support this, reporting that children can’t reliably detect vehicles speeds at greater than 25 mph, and that at traffic speeds of greater than 20 mph, there is an increased risk of a child making an inappropriate crossing decision.

“...It’s easier to... judge speeds for vulnerable groups, and they might feel more confident crossing. Whereas if they see a car approaching at thirty mile an hour it’s very difficult to judge, for them, if they have sufficient time. Whereas if cars are travelling at slower, there’ll be less pressure on groups such as older people.” (Stream 1- Participant 10).

Whilst the above topic wasn’t always discussed with direct reference to active travel behaviour, an improved ease of road crossing could act as an important mechanism for increasing rates of walking and cycling.

Another participant captured the essence of improving the liveability of urban areas as a result of the speed limit:

“...the main benefit would be to bring the speeds down. Just to have ...a nicer environment for people ...not to have lots of noise and not to have cars zooming past, to make it easier for people, older people, younger people to cross the road...” (Stream 1- Participant 9).

3.4. Refined logic model for understanding the health impacts of 20 mph speed limits

Fig. 14 presents the refined logic model for understanding the pathways through which 20 mph speed limits may influence health outcomes. The qualitative data presented previously allowed for the further additions to, and development of this refined logic model. The updated model also reflects a greater understanding from the research team as to the specifics of the intervention.

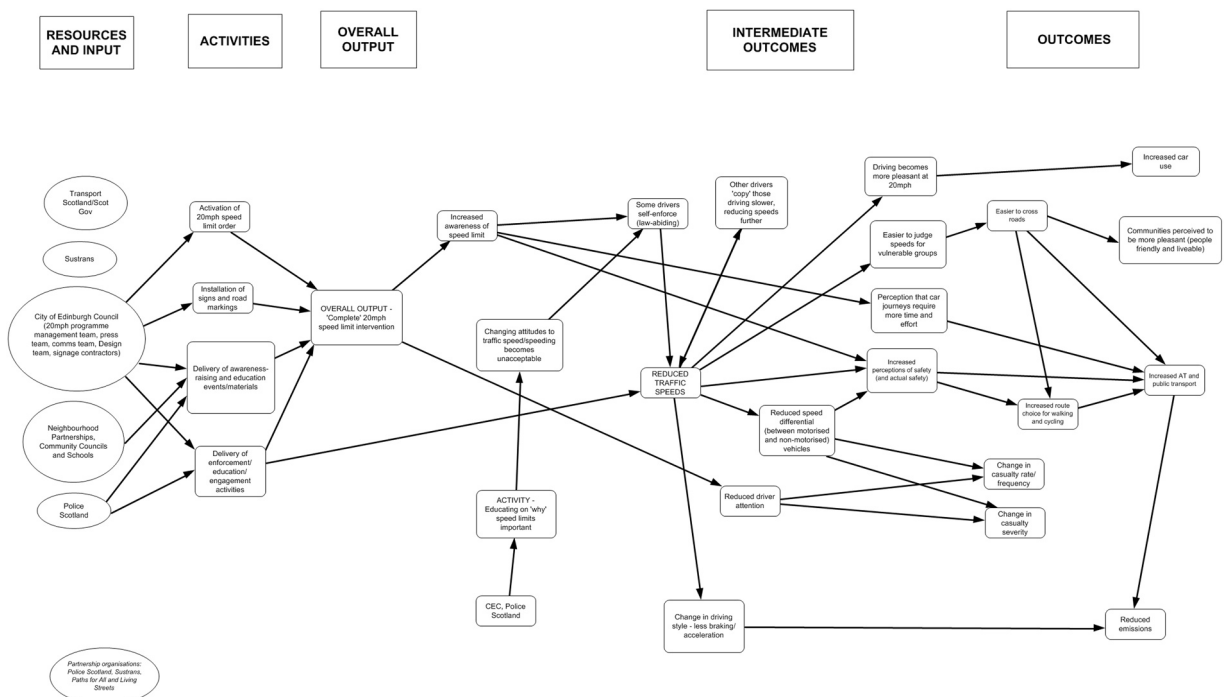


Fig. 14. Revised logic model developed through qualitative inquiry (phase 2) and developed understanding of the intervention.

4. Strengths and weaknesses

A key strength of this study is the mixed approach to theory development incorporating both top-down and bottom-up phases incorporating multiple views of stakeholders and providing greater insight into different theories and mechanisms of change. In contrast to other published evaluation frameworks of transport-related interventions (e.g. Ogilvie et al. (2011)) the programme theory did not include a specific psychological model of behaviour change. Whilst it is tempting to link to other theories this is not deemed necessary, nor always desirable when developing programme theories as they can be too rigid to take into account context and systems. In a complex intervention such as the introduction of 20 mph speed limits (Rogers, 2008), the selection of one behaviour change theory would not fully account for all the factors that would influence why behaviour change might occur in this instance; this may only bring about “partial understanding” of implementation of this intervention (Nilsen, 2015). What is deemed more important in the development of an appropriate theory of change, is that the mechanisms of change are clearly articulated (Wight et al., 2016), which has been conducted in this manuscript.

The data to develop this theory were collected in Edinburgh, the first city in Scotland introducing a 20 mph speed limit at a citywide level. These data may therefore not be representative of the views of those involved in similar schemes in other areas. However, it is likely that the pathways identified are likely to be broadly similar independent of the location of the scheme. The study does not seek to provide an exhaustive account of the potential mechanisms of change resulting from the scheme, but rather to describe the key pathways identified, and place them in the context of previous literature. One additional limitation of the current study was the inability to sample focus group participants from deprived areas; those where the ill-effects of traffic collisions are disproportionately placed (Edwards et al., 2006). However, a strength of the study is the inclusion of participants with differing opinions of the scheme, thus allowing identification of pathways by which the scheme could potentially negatively impact health, as well as identifying positive outcomes.

Development of this programme theory required collaboration between the research team and policymakers and practitioners representing the ‘resources’ and ‘inputs’ components of the logic model who are responsible for designing and implementing the intervention. It is important to acknowledge both the benefits (e.g. gaining a deeper insight into the intervention) and the potential negatives (e.g. losing the position of objective outsider) of this collaboration to the research team (Hills and Junge, 2010).

5. Implications of findings

There is a growing understanding of the need for evaluations of complex interventions to better understand the impact of 'real-world' policy decisions on public health (Craig et al., 2008). To be able to inform policymakers of the usefulness of such interventions, with regards to their impact on health-related outcomes, these evaluations need to be robust and theory-based. However, to date there has been a lack of such evaluations of transport interventions conducted, with some notable exceptions. This paper presents a programme theory proposing potential mechanisms of change by which 20 mph speed limits could influence health outcomes and has implications for researchers, policymakers and practitioners.

As an immediate action, the programme theory will guide elements of a large-scale evaluation of the health impacts of 20 mph speed limit schemes in Edinburgh and Belfast, conducted from 2017 to 2020, funded by the National Institute for Health Research (<https://www.journalslibrary.nihr.ac.uk/programmes/phr/158212/#/>). This evaluation consists of four distinct work-packages which together seek to evaluate, and understand, the processes and effects of city-wide 20 mph legislation in Edinburgh and city-centre wide in Belfast. The focus will be on health-related outcomes (traffic speed and volume, casualties and active travel behaviour) and the pathways and processes that cause this transport policy to have public health benefits. Alongside this will be research into the political and policy factors (conditions) which led to the decision to implement the new speed limit, with a view to understanding possible transferability and national impact. This work will also seek to address the impact of the interventions on health inequalities, through sampling by socioeconomic position and other factors, possibly leading to further refinements in our programme theory given this was a noted limitation of this study.

The refined programme theory will directly inform the work conducted across several work-packages. For example, it will specify data to be collected on key outcomes identified by stakeholders and in the literature as anticipated variables to be impacted by the intervention. The specified potential mechanisms of change have contributed to the formation of primary quantitative surveys to understand the public perceptions of the 20 mph speed limit, which will also be explored qualitatively. Therefore, in addition to informing the outcome evaluation, the programme theory is integral to the accompanying process evaluation that will be conducted exploring the causal mechanisms and pathways. The evaluation, involving both quantitative and qualitative data, will utilise multiple assessment time-points to understand if the programme theory is working as intended and examine any mediation in effects. For example, do changes in speeds precede changes in perceptions, which precedes changes in active travel? The evaluation will formally test the hypotheses and mechanisms of change proposed by the programme theory. Critically, this will occur incorporating a realist approach to evaluation (Pawson, 2006) placing importance on context and exploring the extent to which the programme theory, generated in an Edinburgh context, is able to explain how the outcomes occurred in both Edinburgh and Belfast. This process will look to refine the programme theory for the benefit of other researchers evaluating similar complex interventions to reduce speed, reduce car use and increase levels of active travel.

The programme theory, and the findings of the evaluation based on this theory, have implications for policymakers and practitioners involved in the design and implementation of such interventions. The findings will contribute to the emerging evidence base on the impact of 20 mph speed limit interventions (Cairns et al., 2014; Jones and Brunt, 2017; Pilkington et al., 2018). Additionally, identifying specific mechanisms that are demonstrated to influence behaviour change may contribute to the design of specific intervention components. For example, in how education and awareness-raising components are targeted to different population sub-groups and for different outcomes.

6. Conclusion

This study describes the iterative development of a programme theory for understanding the health impacts of 20 mph speed limit schemes and discusses in detail some of the plausible mechanisms of change identified by interview and focus group participants. The design of a theory for understanding the pathways through which such speed limits may impact health could have wide potential for researchers, policymakers and practitioners looking to implement and evaluate the impact of similar complex interventions in other cities or jurisdictions.

Acknowledgements

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Conflict of interest

The authors report that they have no conflicts of interest.

Appendix A. Stream 1 interview topic guide

Perceptions of the introduction of new 20 mph speed limits in Edinburgh

Purpose of the interview

Individual interviews with key stakeholders involved in **planning, implementation, monitoring, and enforcement/adoption** of the scheme.

To explore stakeholder views on:

- The rationale behind the development of the 20 mph scheme in Edinburgh
- The key drivers and influences involved in planning of the scheme
- Perceptions of the anticipated benefits/impacts of the scheme
- Potential barriers and facilitators to successful implementation

Introduction

Thank the participant for agreeing to take part in the study

The purpose of this interview is to find out about your perceptions of the 20 mph speed limit project; specifically the rationale behind the development of the project, the key drivers and influences involved in planning, anticipated benefits and disadvantages of the scheme, and potential barriers and facilitators influencing the success of implementation.

Section 1: Knowledge and rationale

1. **Firstly, as a key organisation in making the 20 mph limits happen, would be able to start by giving a brief overview of the 20 mph project in Edinburgh? What is the project to you?**

Prompts:

- Sign only and not using traffic calming measures?
- How long did planning take?
- Who were the key drivers in making this scheme happen? Who influenced the planning of the project?
- How did the concept and idea of the project come up? Where did it come from?
- Main reason/driver for initiating the project? Particular outcome wanted at the inception of project?
- How project will impact personally?

2. **What did your role involve? What organisations/stakeholders/parties of interest were you communicating and working with?**

- What is/has the role of XX been in this project?

Prompts:

- How long were you in the post?

Section 2: Benefits of 20 mph implementation

3. **What do you perceive to be the main benefit to come out of the 20 mph project?**
4. **What are other important benefits you think that we will see as a result of the project?**

Prompts:

- Crossing roads
- air pollution
- congestion
- traffic related accidents and deaths
- number of cars on the roads
- uptake of walking and cycling
- increased attraction and pleasantness of streets
- better understanding (less hostility, frustration) between pedestrians/cyclists and motorised vehicles
- Parents more likely to let children play out?

Prompts: Economic? Any businesses in particular?

5. Do you think any specific population groups will particularly benefit out of this change?

Prompts: Children, older adults, Social economic status?

Follow up: why do think this is so? Where do these perceptions originate from?

Prompts: Common sense? Knowledge/context gained from other schemes or research that has taken place?

6. What would you personally define as success for the 20 mph project in Edinburgh?

Section 3: Drawbacks/negative impacts of 20 mph scheme

7. Do you perceive there to be any disadvantages or negative impacts of the implementation of 20 mph zones?

Prompts:

- Groups/businesses/sectors that will be particularly negatively impacted?
- Driving behaviour impacted? Aggression, frustration, lack of attention?
- Increased journey times?
- Increased congestion? Increased air pollution?

Section 4: Potential barriers to implementation

8. Do you believe there to be any particular barriers or challenges to successfully implementing this scheme? Have there been any so far?

Prompts:

- Anticipated resistance from pressure groups/organisations/businesses?
- General public?
- Funding?
- Driving behaviour?
- Issues with enforcement?
- Opposition within the council?
- Conflict between funders (i.e. between council and sustrans)?
- Changing of priorities going forward?
- Time-scale – could this potentially be changed?

Section 5: Potential facilitators to implementation

9. Are there any particular facilitators to the successful implementation of the 20 mph limits?

Prompts:

- Support from activists? Charities? General public?
- Are all stakeholders that have been involved in planning been pulling in the same direction?
- Key relationships?

Section 6: Monitoring and enforcement

10. What in your opinion are the most important aspects and outcomes to monitor during and after implementation?

Prompts:

- Particular outcome?

11. What do you think are the potential challenges and concerns with enforcing the 20 mph speed limit?

Prompts:

- Adherence
- Driver behaviour
- Do you know what will enforcement consist of?

Section 7: Final questions and remarks

12. We've been focusing on Edinburgh, do you have any views on the potential wider implications of 20 mph policy for the rest of Scotland and the UK?

Is there anything else you would like to add that we have not discussed during?

Appendix B. Stream 2 focus group topic guide

Introduction	Rationale for question
What modes of transport would you typically use? What situations change the mode of transport you use? What influences the mode of transport you use?	Gage perception of accessibility and options Gain understanding of what influences choice
<p>This may prompts short summary of the project and may require a visual aid like a map of area and poster of council promotion of project. Were council fact sheets distributed to the public?</p>	
Attitudes toward 20 mph project	Rationale for question
What do you think about the 20 mph limit being implemented in Edinburgh? Why Why do you think the 20 mph speed limit is being implemented?	Gage their actual opinion before they are influenced by the conversation Gage what the public feel the reasons for the project are.
What do you think about the existing driving speeds in the city? Why? Option The introduction of the 20 mph speed limit network is being promoted as bringing several benefits to residents and workers? What are your views on this? Prompts: What benefits (to you, others, differential impacts?), potential negatives What do you feel the impact of the project will be on the city? Neighbourhood? Community? What do you feel the negative impacts will be on the city? Why?	Attitude to existing behaviour Keeping the question reflexive by not asking for lists of positive and negative impacts.
Why do you think Edinburgh council has decided to pursue this project in particular?	Gain understanding of their attitude toward the project.
Personal Impact of 20 mph project	Rationale for question
How do you think the 20 mph will affect your daily life? Why do you think it will affect your daily life in that way? Some people think that journey times to work will increase because the traffic will build up at 20 mph? Prompting question- Will the 20 mph project affect your family's life? Why or why not?	This will help us tease out the reasons they have the specific view of the project. It might be important to understand why someone might feel the project will not affect them? Secondary effects on people in their family may affect them personally.
Perceptions of speeding	Rationale for question
Some people have said that Edinburgh does not have a speeding problem because it is so congested already. What do you think about that? Agree disagree? Some parents feel that it is unsafe for their children to walk and cycle to school at the moment because cars are going to fast in the city? How many miles per hour do you feel it is acceptable to speed. Why do you feel that? Some people have said 20 mph will increase journey times? What do you think about this do you agree? Disagree?	What is their current behaviour Understand how much their engage in the behaviour Why do they think they engage in the behaviour Understand what they feel is acceptable level of speed. Understand what situations might make drivers change their behaviour

What types of things do you think would stop people from speeding in the city?	What would stop you from preforming the behaviour?
What do you think would make people speed in the first place?	What they feel would make them start to engage in the behaviour.
Do you think it will be challenging for drivers to adjust driving behaviour to 20 mph zones? Why or why not?	Perception of ability to change behaviour.
Safety	Rationale for question
Some people believe that living on a street with 20 mph limit makes the neighbourhood feel more liveable. What do you think about this statement?	Perception of impact on safety to the city
Should 20 mph be enforced with speed cameras? How do you think it should be enforced?	Perception of responsibility
Have you ever felt unsafe, or for a family member who is, walking or cycling in the city. Follow up-What made the situation unsafe?	Own experience which may reflect perception.
Follow up- why do you think you have not felt unsafe?	
Do you think this change will make people want to cycle more?	

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