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Reduced speed limits in urban settings: motivations, measures & effects

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Abstract

Many cities around the world want to reduce the negative impacts of extensive car traffic. One step in this direction is the reduction of its maximum speed limit. This writing centers around three parts: First, I analyzed the official motivations and some experiences and drawbacks of fourteen cities – all of them European – which have reduced or plan to reduce the general speed limit to 30 km/h (20 mph). Second, I reviewed the scientific literature on the effects of reduced urban speed limits. Since these were almost exclusively limited to traffic-related aspects and ignored the wider social, psychological, and public space related aspects, I extended the review to studies which investigated the effect of (reduced) motorized traffic on these wider aspects, e.g. during street experiments. Third, I developed a survey that can be used to study these wider aspects. The survey was tested on different street types (residential, touristic/commercial, through street) with different speed limits (30 and 50 km/h). The first result is that the most-stated motivations for a reduced speed limit are reducing injuries/deaths, reducing noise, promoting cycling and walking, and increasing livability. Second, apart from traffic safety and noise pollution, the scientific knowledge about the effects of a reduced speed limit is scarce until now. In order to advance this knowledge, methods and tools should be considered that have been used to study the effects of (reduced) motorized traffic on social, psychological, health, and public space related aspects. The third result is, however, that these aspects are affected by numerous variables apart from speed limit, e.g. the width of the street and the presence of greenery or car parking. In addition, the wider effects of a reduced speed limit might evolve over longer time scales which could make them challenging to study in the presence of general trends or measures that reduce car traffic.

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1 Introduction

Historically, urban streets were the space where a multitude of activities happened, e.g. work, trade, washing, social interactions, and child play. Transport of people and goods was just one among these many usages. Interestingly, conflicts about street space usage go back to at least ancient Rome, where Julius Caesar banned commercial deliveries during daytime due to congestion [1]. A similar conflict arose when the first automobiles appeared in the 19th century. They were extremely noisy, took a lot of space and were dangerous for people, resulting in a broad opposition. Exemplary are the Red Flag Act in Great Britain, which introduced a speed limit of 3.2 km/h for automobiles and required that a person waving a red flag walked in front of each car [2], and the canton of Graubünden (Switzerland), where all cars were banned until 1925 [3]. In the 1920s the bicycle had the highest mode-share in most European cities [4].

This changed with the uprising of modernism, where cars were increasingly seen as the future transport mode and the symbol of wealth and progress. Cities were then planned with a large spatial division of living, work, and leisure activities [5]. Car usage rose and the car and oil lobby became increasingly powerful [6]. They were able to introduce laws which favored the free flow of vehicles at the expense of all other street usages. In many countries even crossing streets by foot was forbidden except at designated locations after a campaign against “jaywalking” was launched [6]. Similarly, child play was only allowed at places where they would not interfere with car traffic, i.e. fenced playgrounds. A feedback loop emerged: the more and bigger roads were built, the faster people could travel longer distances by car, which made more people to buy cars and have activities further distanced apart. This caused more car traffic which again made it necessary to build more and bigger roads, and so on [7].

However, the closer the reality got to the “car-centered utopia” envisioned by modernists, the more the problems have become apparent: many people get injured and killed, noise and air pollution seriously affect public health [8]; highways, streets, and parking areas take a substantial amount of space and thereby divide communities and take over the public place. Other modes, especially walking and cycling, are pushed off the streets. This results in car dependency which becomes problematic for children, adolescents, old or poor people, and everyone who simply doesn’t like or cannot financially afford driving [9]. Related to space used, car-traffic is extremely inefficient compared to other modes what makes even very wide streets quickly clocked-up. Furthermore, car usage is a very expensive mode of transport, both for individual car drivers and for society [10, 11]. Recently, also secondary problems receive more attention [12]: for example, children lack autonomy and have impaired spatial navigation skills when regularly being shuttled by parents, social interactions and social cohesion decrease since residents spend less time in the street and neighbors don’t bump into each other, social safety and crime become problematic since there are “no eyes” on the street and residents don’t feel responsible so much for the neighborhood, and people who can’t afford a car lack economic opportunities which makes it hard for them to escape poverty. Last but not least, private car usage is the largest emitter of greenhouse gases in the transport sector [13] and car infrastructure with its large asphalt surfaces intensifies the impact of heat waves [8].

As these problems of high car usage are increasingly recognized, many cities around the globe want to increase livability by reducing car usage or at least its negative impacts. Reducing the maximum speed that cars are allowed to drive is a relatively easy and quickly to implement step in this direction.

Furthermore, there is also top-down pressure as the EU [14] and the UN [15] speak out for 30 km/h as the maximum speed in built-up areas as one measure to prevent all crashes with serious outcomes (“Vision Zero”).

2 Literature overview

In this section I will first give an overview over the cities which reduced their speed limit to 30 km/h and their motivations to do so by screening news articles and official documents. This also covers the accompanying discussions and the potential challenges and drawback. Afterwards I lay out findings from the scientific literature and describe what effects have (not) been measured.

2.1 Overview of motivations, ambitions, and experiences of cities which go for a lower speed limit

First, I conducted an online search[1] to find out which cities have reduced or plan to reduce the speed limit to 30 km/h in most of their streets, i.e. not only residential or side streets but also main streets. Table 1 gives an overview of the most important – defined as being a pioneer or large – cities. It becomes apparent that most of these cities have only reduced the speed limit in the last couple of years. Furthermore, most cities are in western Europe, mostly France and Spain. For each city, I extracted the motivations and ambitions by trying to find official sources since media articles often do not report all the official motivations. The list of the news sources that I encountered and used to find the official sources is found in Supp. Tab. 1 the appendix.

Motivations & ambitions

Table 2 lists how often each motivation was given by the fourteen cities. With the exception of Zürich[2] all cities stated increased traffic safety, i.e. less collisions and collisions being less severe, as a main goal. The majority of cities (11 of 14) also gave noise reduction as a reason, while only three cities (Graz, Madrid, and Lille) gave less air pollution as a reason. Improving the usage of active/alternative transport modes was given by eight cities as a motivation, and improving the quality of public space by five cities. Increasing the livability, the friendliness of the city, or the quality of life were given by seven cities. Improved health was only mentioned by Bilbao and Barcelona (apart from Wales), namely as a consequence of less noise and of using more active transport modes, respectively. Only two cities (Lille and Amsterdam) gave the reduction of car usage as a motivation, even though not as a main motivation but more as a welcomed side effect. Reducing the effects of the climate emergency was given by one city (Barcelona). Not given once as an immediate motivation was the improvement of child play or child independence and the improvement of social interactions, social cohesion, or social safety.

Table 1: The motivations and goals of cities which have reduced or plan to reduce their city-wide speed limit from 50 to 30 km/h.

Year	City	Motivations & goals	Source
1992	Graz	safety, less pollution & noise	[16]
2016	Edinburgh	safety, active modes, livability & quality of life	[17]
2016	Grenoble	safety, less noise, reinventing & calming public space, promote active mobility	[18]
2018	Madrid	safety, "cohabitation" of different modes, air quality	[19]
2019	Helsinki	Vision Zero (no serious injuries or deaths due to traffic)	[20]
2019	Lille	safety, calmness, evolution of behavior, more „soft“ mobility and public transport, moderated/reduced car traffic, less pollution & noise	[21]
2019	Bilbao	safety, CO2 emissions, less noise and thus better health, improved quality	[22]

1 Mostly *Google* and *Google News* were used. Apart from that, many articles referred to cities which have previously reduced the speed limit.

2 Zürich gives exclusively the legal requirement of reducing noise levels for residents living on main streets as a reason.

		of life for residents	
2020	Barcelona	safety, less noise, more active mobility, physical activity, well-being, livability, reduced effects of climate emergency	[23]
2021	Brussels	safety, less noise	[24]
2021	Paris	safety, less noise, more space for active mobility, increase quality of public space and its different usages, increased traffic flow	[25]
2021	Montpellier	„safer, more fluid, more peaceful“, sharing space, increase of well-being (“bienveillance”), “cohabitation” of different modes, more attentiveness to city environment	[26]
2021-2030	Zürich	noise reduction according to legal requirements	[27]
2021	all Spanish cities	align with EU/UN safety guidelines, e.g. -50% severe crashes	[28]
2022	Lyon	safety, less noise, calming traffic, public space for other usages, more active mobility, friendlier streets	[29]
2023	Amsterdam	safety, less noise, less car usage, more public space for other usages, increased livability	[30]
2023	all Welsh cities	safety, more active mobility, increased livability, increased mental & physical health	[31]

The ambition of all these cities is to have 30 km/h as the norm in the whole city and that streets with higher speed limits are exceptions to the norm. The percentage of streets which are 30 km/h (or less) varies across the cities, e.g. in Barcelona it is 68%, while in Lille it is 88%. Madrid and Edinburgh (both 80%) and Amsterdam (82%) are in between.

Table 2: How often each motivation was listed and by whom.

#	Motivation	Cities
13	Less collisions & injuries	Graz, Edinburgh, Grenoble, Madrid, Helsinki, Lille, Bilbao, Brussels, Paris, Montpellier, Barcelona, Lyon, Amsterdam
11	Less noise	Graz, Edinburgh, Grenoble, Lille, Bilbao, Brussels, Paris, Barcelona, Zürich, Lyon, Amsterdam
8	More cycling & walking	Edinburgh, Grenoble, Madrid, Paris, Lille, Barcelona, Lyon, Amsterdam
6	Increased livability	Edinburgh, Bilbao, Montpelier, Barcelona, Lyon, Amsterdam
5	Significance public space	Grenoble, Paris, Lyon, Montpellier, Amsterdam
3	Less air pollution	Graz, Madrid, Lille
2	Less car traffic	Lille, Amsterdam
2	Improved health	Bilbao, Barcelona
1	Climate adaptation	Barcelona

Drawbacks and challenges

From the media articles, official statements/documents, and from personal conversations with employers from the City of Amsterdam it became clear that cities also expect certain disadvantages and immediate challenges when reducing the speed limit from 50 to 30 km/h. Scientific references are provided for topics that I have further investigated.

First, buses and trams that share the road with cars will also travel slower on some parts of the route. However, since stops or traffic lights are often not far apart and buses and trams do not accelerate or decelerate very strongly the fraction of the route where they can ride much higher velocities than 30 km/h is quite low. Thus for the average user the increase in travel time is usually in the order of less than one or two minutes. Over the whole line this can however add up to several minutes what makes it necessary to invest in more vessels and employ more drivers to keep offering the same service.

Similarly, emergency services often have longer arrival times, especially when streets are physically redesigned for a lower speed limit. To fulfill the regulations of reaching every resident in a given time this might make it necessary to invest in further adjustments, e.g. more stations from which emergency services can reach the population.

Another aspect is that arterial roads in cities during peak times operate at car capacity limits and that a significant amount of resources have been used to make traffic lights operate optimally for a given speed (limit). When cities want to reduce the impact on car capacity, most traffic lights would have to be reprogrammed. Similarly, cities which expect vehicles to clear intersections with more than 30 km/h would have to reprogram the traffic lights at these intersections by increasing the intergreen time. This is often the case in Amsterdam where cyclists and slower motor scooters usually have separated traffic lights at main roads and cars are assumed to clear the intersection with 50 km/h. An increased intergreen time usually means that less cars can cross an intersection. This is however in alignment with the ambition of the city to reduce car traffic ("Amsterdam autoluw" [32]).

Furthermore, critics often argue that car trips will take longer because velocity is reduced and because there would be more traffic jams. As with public transport trips, increased travel times due to reduced velocity for an average car trip is in the range of less than two minutes [33]. Especially at peak times – which span an increasingly long part of the day in growing cities – the average speed on main roads is often below 20 km/h. Furthermore, for many cities increasing the travel times for cars is a desired effect in order to make other modes of transport more attractive compared to car usage. Car journeys being less attractive reduces congestion and congestion usually also regulates itself.[3]

Last but not least, fuel consumption and CO2/NOx emissions might increase when a car is driven at 30 instead of 50 km/h (see next section for a more detailed discussion). However, these effects are rather small and are far offset by a more continuous traffic flow (less accelerations) and less car traffic (due to less capacity and other modes being more attractive) [35].

3 The *Downs-Thomson paradox* for example describes how the degree of congestion is not caused by limited road capacity but by how unattractive alternative modes are [34].

A significant challenge is to make car drivers actually follow a lower speed limit. Car drivers report that it feels unnatural or even exhaustive to drive 30 km/h on a street that has been designed for 50 km/h [36–38]. Therefore, speed controls and other enforcement strategies are not very effective if not implemented on a broader scale. It is more effective to redesign streets, at least with provisional measures like e.g. speed bumps.

Another challenge is that acceptance for lower speed limits among car drivers is often not very high before the implementation. Some time after the implementation, however, most car drivers realize that the negative impacts are not as bad as expected and the approval increases [33, 39–42]. Residents are usually in favor already before the implementation.

Other cities and countries

Lisbon also decided to reduce its city-wide speed limit, although only from 50 to 40 km/h [43].

Oslo has a plan of various measures to reduce its car traffic by 30% until 2030 and to quickly reach Vision Zero, however a city-wide speed limit of 30 km/h is not planned yet [44].

In Germany, current federal laws do not allow cities to decide for speed limits less than 50 km/h outside designated residential areas or near schools. However, the desire of cities to change this is huge and more than 270 cities and communities have joined an initiative that demands from the federal government the possibility of setting up lower speed limits [45]. So far, however, the minister of transport – member of the liberal party – shows no intention of giving cities this freedom.

In cities in the UK, Ireland, US, Canada, Australia, and New Zealand, the changes are mostly still about making 30 km/h (or 20 mph, respectively) the speed limit in distinct residential areas, even though more and more cities are discussing to extend these areas over the whole city [46]. As mentioned above, Wales, for example, has recently passed a law to introduce a country-wide speed limit of 20 mph on all “residential roads and busy pedestrian streets“.

2.2 Scientific literature review: which effects have been measured

The scientific literature was scanned using Google Scholar with various search terms.[4] Additionally, I cam across several scientific studies during the research about the cities in the previous section. All applicable studies were checked for interesting references and where they have been cited (backward and forward snowballing). It turned out that numerous studies have been done on the effects of reduced speed limits. Since, however, city-wide speed limits including main roads are mostly new, almost all studies are based on reduced speed limits in certain streets or areas (usually residential or around schools). Most studies investigate the actual speeds driven by car drivers and the statistics of collisions and injuries/deaths. Also quite common are studies measuring the reduction of noise and emissions, traffic flow and travel times, route and mode choices, public support, perceived safety of pedestrians and cyclists. Even though many cities analyzed in the previous section gave livability, friendliness of the city, quality of life, and significance or usage of public space as a key motivation these aspects have so far been only seldomly investigated.

4 These included “30 km/h”, “20 mph”, “speed limit”, “maximum speed”, “reduced speed”, “traffic calming” and some combinations of it.

Actually driven speeds

Many studies have investigated how much the actually driven speeds are reduced when the speed limit is reduced from 50 to 30 km/h [33, 36, 39, 40, 47, 48]. Driven speeds usually decrease but the size of change depends on various factors like the speeds driven before, if design changes like speed bumps have been installed, the degree of enforcement, the amount of pedestrians and children on the street, the information campaign, and the hour of the day. Furthermore, compliance of a reduced speed limit is usually higher when the speed limit has been reduced in zones compared to just single streets. Interestingly, a commonly observed phenomenon is the “spill over effect” [48, 49] in which the driven speeds also decrease on streets on which the speed limit was not reduced. This is attributed to the phenomenon that drivers quickly adapt to a driven speed so that 50 km/h feels subjectively faster after having driven with 30 km/h for a while compared to constantly driving 50 km/h.

Reduction of collisions, injuries, and fatalities

One of the largest effects of a reduced speed limit is the reduction in collisions and serious injuries or fatalities. A review from 2020 found that collisions decreased between 24% and 45%, injuries decreased between 42% and 49% and serious injuries including fatalities decreased between 24% and 63% [48]. Collisions in which cyclists were involved were found to be reduced by 17%, and in which pedestrians were involved between 21% and 32%. The exact reductions are probably depending on how much the actually driven speeds are reduced, how dangerous the street design is in general, and the amount of “vulnerable” street users.

The following example illustrates why lower speeds have a huge impact on collisions and injuries: An average car driver traveling at 30 km/h will stop after a distance of approximately 12 m, while an average car driver traveling with 50 km/h will still have a speed of 48 km/h after 12 m and still a speed of 26 km/h after 20 m.[5] These speeds correspond to falling head first from a height of 9 m and 2.5 m, respectively. These numbers show why being hit by a car with 30 km/h is on average survived by 9 out of 10 persons, while when being hit with 50 km/h only 2 out of 10 persons survive. [50]

Many studies compare the reduction of collisions and injuries within the area of a reduced speed limit with the reduction in control areas. This makes sense in order to account for general trends. On the other hand, however, the reduction in the control area might also be partly caused by a spillover effect if it is too close to the intervention area. For example, two studies found a reduction in collisions of 7% and 18%, respectively, and a reduction in injuries of 8% and 21%, respectively, in areas where the speed limit was not changed but which were next to newly set up 30 km/h zones [51, 52].

Emission of noise and pollutants

The reduction in noise emissions is dependent on the specific location and was found to be in the range of 1,5 – 4.8 dB(A) with average values reported around 3 dB(A) [18, 40, 53] . This is equivalent to a reduction of about 50% of car traffic volume. However, on roads where the speed

5 Full breaking after a reaction time of 0.8 s with a deceleration of 8 m/s^2 (corresponding to a dry and clean asphalt street).

limit is not decreased the noise levels could actually rise as an effect of increased car traffic volume. A modeling study found that the noise reduction is far more important for improvements of public health than the number of reduced collisions [54]. This is mostly caused by better sleep and reduced stress levels what, among others, has a positive impact on the prevalence of cardiovascular diseases and diabetes.

Regarding air pollution – i.e. CO2, NOx, and particulate matter – one has to distinguish between different assumptions: First, measuring the emission levels when a car is driven at constant speeds (30 km/h vs 50 km/h), second assuming a realistic driving cycle of accelerations and decelerations (which differ with different speed limits), and third, assuming that the amount of kilometers traveled by car actually changes (since traveling by car becomes less attractive and/or car capacity is reduced at 30 km/h). Regarding the first two assumptions, the findings from the literature are inconsistent as some studies report an increase in emissions [35, 41] and others report a decrease [55–57]. The amount of particulate matter emissions decreases in any case when driving 30 km/h instead of 50 km/h and the exact reductions of NOx strongly depend on the composition of vehicles and their emission characteristics (e.g. motor type and emission class). When taking into account the third assumption, namely that less kilometers are traveled by car when reducing the speed limit, the literature consistently reports or assumes a reduction of emissions [35, 40, 55, 56].

Traffic flow and travel times

Travel times were found to increase between 3% and 5 % [33]. These increases are usually far lower than most people intuitively assume [58]. The reason is that in dense urban areas the proportion of the time that can be driven considerably more than 30 km/h is quite low, especially during the times of day at which most car journeys take place.

Shift towards active modes

It is usually assumed that a lower speed limit promotes cycling and walking [33, 59, 60]. The reasoning is that vulnerable street users feel safer and that car usage becomes less attractive. The scientific evidence, however, is not clear and rigorous studies are difficult to perform [61, 62]. The reason for this difficulty is that mode shifts usually occur over longer periods of time and these have to be compared against the general trend, for which control sites (or control *cities* due to the spill over effect) are necessary. This is often not feasible as over long time periods many other changes occur that effect mode shifts. However, a lack of rigorous evidence for increased use of active modes does not imply evidence against it. It probably makes sense to assume that active modes become more attractive due to less subjective danger. However, the general assumption that car usage is reduced since it becomes less attractive with lower speeds might not necessarily be the case: first, one could argue that car capacity is at its limit in dense urban areas anyway and free car capacities due to mode shifts of some car users would induce new car users until the streets are at capacity again. Similarly, it might be the case that due to lower speeds and more steady traffic flow some people might find car driving more attractive than before [63].

Public health

As already mentioned above, the improvements due to reduced noise are probably huge [54]. Similarly, the effects of reduced air pollution in the case of less car traffic could prevent a large number of years of life lost [64]. If active travel modes are increased this could also provide a substantial health benefit due to more physical activity [61], however, this aspect remains poorly studied. The overall health effects through the large reduction in injuries is probably relatively small when compared to the (possible) extents of increased health due to less noise, less air pollution, and more physical activity. I have not found any studies that looked into the effects on mental health and well-being.

Public support

As with other measures that restrict car traffic in urban areas, public support increases substantially during the implementation [33, 39–42]. This is mostly related to the fact that the effects regarding longer travel times and increased congestion are highly overestimated and the effects of more continuous and relaxed traffic flow are underestimated by the general population and especially by car drivers. In addition, the positive effects become palpable only after the implementation which probably makes them more appreciated afterwards.

Effects on social and psychological aspects, public space, livability

Even though some cities which I analyzed in the previous section gave positive effects on society, psychological well-being, public space, and livability as a motivation, these effects have been barely investigated. In fact, I found only one study from the gray literature which also looked at some social effects of a reduced speed limit [33]. There, citizens were asked four related questions, namely if the reduction of the speed limit has made the city a more desirable place (22% agree), if more people are on the street (8% agree), if the street provides a safer environment for children (28% agree), and if one sees more children playing on the street (8% agree). It is thus clear that the effects of a reduced speed limit on the following aspects remain poorly studied: livability, significance and usage of public space, social interactions, social cohesion, life satisfaction, sense of belonging, and sense of street ownership. Also, the exact effects on mental and physical health have not been directly measured. However, some of these aspects have been studied while investigating the effects of motorized traffic or its reduction, and some of the used approaches and methods used in these studies could probably also be used to investigate the more extensive effects of a reduced speed limit. In the following section, I will thus give an overview of these studies.

2.3 Motorized traffic in urban areas: effects on social, psychological, health, and public space related aspects

To get insights into how car traffic might affect the various aspects apart from traffic-related variables I will first give an overview of studies that have used streets, which differed in car traffic volumes, speeds, and street design. Then, I will give an overview over studies that have investigated the effects that manifest during measures that (temporarily) ban or reduce car traffic.

Investigating the effects of car traffic volumes, speeds, and street design

Already in the late 1960s the effects of car traffic volume and speed on livability were studied by Donald Appleyard and colleagues through measuring variables like social interactions, experienced

stress, sense of home territory, and significance/awareness of the street space [65, 66]. Several investigational tools were used to compare three streets with different traffic volumes and speeds: in personal interviews with residents lasting about an hour, observations of the street design and people's behavior, noise measurements, and objective measurements of pedestrians and traffic activity. During the interviews, residents were also shown a map of their street and were asked to point out where friends or acquaintances lived, and where they engaged in activities outside their home. The result was that on the street with heavy traffic residents knew fewer neighbors (especially on the other side of the street), were less satisfied with their living situation, had their home territories restricted to their own house or even flat and used more the side of their homes oriented away from the street. In addition, there were less social activities in street (e.g. child play, neighbors gathering or talking to each other) and almost no sense of community. On the other hand, on the street with light traffic there were children playing, adults hung out in front of houses, and the indicated home territory stretched into public space in front of the houses and often even covered the whole street. Even though the streets were mentioned to be of "similar types", they were just three in total (one street each with light, medium, and heavy traffic) and thus statistical reliability is missing.

A similar study from 2008 investigated how social relations of residents and their contentment with the street varied across five streets (one 50 km/h street, one 30 km/h street, and three "encounter zones" with a 20 km/h speed limit) which also differed in street width, traffic volumes, and the amount of car parking [67]. The streets were located in one neighborhood in Basel (Switzerland) and the sociodemographic characteristics across the streets were comparable. Similarly to Appleyard and colleagues the environmental qualities of the streets were assessed, surveys and personal interviews with residents were conducted, and the physical and social activities in the streets were observed. The result is that all variables investigated showed that the streets with a 20 km/h speed limit provided a higher utility to the residents than the 30 km/h, and that almost all variables showed that the 30 km/h street provided a higher utility than the 50 km/h street. The variables included "tranquility and beauty" of the street, if the street fosters the personal development and freedom of children and older people, the perception of traffic safety, the fear of being victim of harassment and physical attack, the confidence in getting help in an emergency, the number of neighbors known and the percentage of known neighbors who live on the opposite side of the street, if the street is used to linger, the amount of people chatting, sitting, child play, or other activities; if residents feel they can actively participate in decision-making processes affecting their streets, if they feel home in their street, if it provides everything they need to feel happy, if it comes close to an ideal image of a street and if they feel socially integrated. Interestingly, there were two variables which indicated that the 30 km/h street was perceived as less attractive than the 50 km/h street: significantly less residents of the 30 km/h street agreed that their street was a special street and that it provides everything they need to be happy compared to residents living on the 50 km/h street. The authors could not really explain this but mentioned that also in Donald Appleyard's study many residents of the street with medium traffic volumes stated their street lacks specialty.

Another reference which gives extensive insights into how the built environment and the design of traffic infrastructure potentially influence livability and social behavior is the famous book *Cities for People* by Jan Gehl [68]. He also gives numerous examples on how to study public life in cities [69]. One important finding is that humans react very sensitively to the design of public space:

people only dwell in public spaces if a number of conditions are met. These conditions include for example not too much noise and stress from car traffic, seating opportunities at the right places, and spaces which are not too big and empty and which are protected from harsh weather.

Investigating the effects of temporarily reduced motor traffic

There exist several studies which investigated the various social, psychological, and health-related effects of reduced motor traffic during street experiments or temporary car bans. Some of the methods used there might be used also for studying the effects of a reduced speed limit.

During these street experiments, car traffic was temporarily reduced or removed and the respective space was used for other activities and functions. They can be categorized into three different approaches: First, with *Play Streets* a street was closed for cars for several weeks (permanently or only during certain days of the week) and children could play under supervision [70–74]. Usually also play gear was provided. Second, during *Open Streets* (sometime also called *Ciclovias*), main streets or larger areas are made car free and opened for pedestrians, cyclists, skaters, and all kind of other activities like playing or sporting [75–84]. A third approach has been termed “Intersection Repair”. There, neighbors were invited to engage in a community project around intersections in residential areas where the tarmac would be painted and artistic elements were added [85–87]. These community projects had the explicit goal to bring neighbors together and letting them redesign the intersection space. In Table 3 the methods are listed that have been used for measuring the effects of reduced motor traffic and/or community projects.

Table 3: The social and health-related aspects that were investigated during street experiments (left) and how they were measured (right).

Aspects	Methods/Measurements
Social interactions	Questionnaires [71, 73, 74]
	Open interviews [87]
	Semi-structured interviews [72]
	Focus groups [72]
	Observations, counting [72, 85]
Social cohesion	General questionnaires [73, 74, 78, 85–87]
	Social capital assessment tool [75, 86, 88]
Social safety	General questionnaires [71, 74]
	“Neighborhood Environment Walkability Scale” [82, 89]
Physical health/activity	Cameras on the street [77]
	GPS data of bicycles [77]
	Anthropometrics (BMI) [74, 82]
	Pedometers, accelerometers [74, 83]
	“System for Observing Play and Recreation in Communities” [78, 83, 90]
	Surveys [75, 80, 83]

	Quantifying health problems [54]
Mental health	Validated questionnaires/scales (e.g. for depression, well-being)[86]
Significance & attractiveness of public space	Child drawings [72–74, 91] Semi-structured interviews, focus groups [72] Questionnaires [81, 85, 87] Drawing “home territory” on a map [66] “Open Streets Initiatives Measuring Success Toolkit“ [84] “Stanford Neighborhood Discovery Tool” [81]

3 How the wider effects of a reduced speed could be investigated

After having gained insights from the literature the goal was to develop investigational tools that allow to quantify the potentially extensive effects (see Tab. 3) of a reduced speed limit for cars in urban areas. These tools were tested in a pilot study in various streets and adapted if necessary. This section describes the tools, methods, and insights gained from the pilot study.

3.1 Design and methods of a first pilot study

Investigational tools

To get some first insights on the feasibility of investigating these aspects, a pilot study was designed. For that, applicable measurements were taken or adapted from existing studies and additional measurements were thought of. The resulting survey consisted of different tools (Tab. 4): most questions were Likert questions, i.e. the participants indicate on a scale from 1 to 5 how much they agree with a certain statement. Additionally, participants were asked to give key words to describe their street (including positive and negative aspects), and another method was to let participants draw their “home territory” on a map of the street. Finally, people were asked demographic questions, if they have access to a private car, and what mode of transport they use most often.

Apart from surveying people on the street, private objects like benches and pot plants placed in front of houses or shops were counted, and the behavior of people using the street and the modes of people passing through it were categorized and measured both quantitatively and qualitatively. This includes the number of people talking, sitting, or standing; the number of people walking with baby strollers or dogs, the number of children or adolescents playing, the walking speed of pedestrians, and where pedestrians walked or crossed the street.

Last but not least, the amount of each different traffic mode (pedestrians, cyclists, scooters, cars/trucks, others) was counted. For pedestrians and cyclists, this was done by differentiating between the assumed gender (male vs female).

Table 4: The investigational tools that were used in the pilot study.

Measure type	Question / what measure	Correlated with / possible effects on
Likert questions	This street feels safe during the day.	social/traffic safety, livability, mental health
(all participants)	This street feels safe during the night.	social/traffic safety, livability, mental health
	This street is a good place for children to grow up.	child independence, life satisfaction, livability, social & perceived traffic safety
	This street is a good place to grow old.	livability, life satisfaction, mental health
	Walking is comfortable on this street.	livability, active mobility, physical health, perceived traffic safety
	Cycling is comfortable on this street.	active mobility, physical health, perceived traffic safety
	This street is safe for children to walk or cycle To school on their own.	active mobility, physical health, child independence
	The environment of this street is friendly.	livability, mental health, life satisfaction, social safety
	I have been worried/afraid about the speed of vehicles on this street.	perceived traffic safety, livability, life satisfaction, mental health, active mobility, child play
	Someone I know has been worried/afraid about the speed of vehicles on this street.	perceived traffic safety, livability, life satisfaction, mental health, active mobility, child play
	People on this street share the same values.	social cohesion, life satisfaction, mental health
	I feel part of a community in this street.	social cohesion, life satisfaction, mental health
(only residents)	This street is a good place to live.	livability, life satisfaction, mental health
	I feel at home in this street.	life satisfaction, mental health, taking care of street
	I feel the street belongs to us (me & my neighbors).	taking care of street, political engagement
	I know the neighbors in my street well.	social interactions, social safety
	I like to spend time in front of my house.	livability, social interactions, street ownership, social safety
(only non-residents)	This street is nice.	livability, life satisfaction, mental health
	I like to come to this street.	livability, social safety, perceived traffic safety
	I would propose this street as a meeting point.	livability, social safety
	I could easily feel at home in this street.	livability, social safety
Non-Likert questions (only residents)	If having children: How many friends does your (youngest) child have in this street?	social interactions, child play
	How many neighbors do you talk to (same/other side of the street)?	social interactions, social cohesion, social safety, mental health, separating effect of street
Exploratory measure	Key words (3 general ones, 1 positive, 1 negative)	
Counting objects	Pot plants	street ownership, livability
	Chairs, benches, tables	social interactions, street ownership, livability
	Play gear	social interactions, livability, physical health, perceived traffic safety
	Other private objects (art, gardening tools, books,..)	street ownership, livability
Observe behavior	Sitting	street ownership, livability, social safety
	Standing	street ownership, livability, social safety
	Talking	social interactions
	Walking with dogs	livability, social safety, perceived traffic safety
	Walking with baby strollers	livability, social safety, perceived traffic safety
	children/adolescents playing	street ownership, livability, social interactions, physical & mental health, social safety, perceived traffic safety
	Other behavior (making music, taking pictures,…)	livability, social interactions, social safety
	Walking speed	perceived traffic safety, livability

	where do people walk and cross the street	perceived traffic safety, livability
Traffic counting	Pedestrians, cyclists, scooters, cars/trucks, others	
Area of home territory	Drawing home territory	street ownership, livability, social safety
Demography	Age, gender, education	
Mobility	Car access, most used transport mode	

Methodological approach

A proper approach for the (main) study of investigating the effects of a reduced limit would be to perform measurements at streets before and after the speed limit is reduced while also performing the same measurements at control streets where the speed limit is not changed. This way, it would be possible to find differences between intervention streets and control streets even in the presence of an underlying general trend of changes – unrelated to the speed limit reduction – in all streets (difference-in-differences). To account for an underlying general trend is necessary since the investigated aspects probably evolve over longer periods of time. However, streets can differ in many aspects (e.g. if they are mostly residential, commercial, touristic, or through streets; by the design of the street, by socioeconomic variables of its residents) and street-pairs with similar streets should be chosen as intervention and control streets. Thus, my goal was to perform the pilot study in different street pairs: I looked at two similar residential streets where the only difference between the streets should be the speed limit. Analogously, I looked for two through streets and two touristic streets, where each street pair was supposed to differ only in the speed limit. The residential street pair was Marathonweg/Olympiaweg in Amsterdam-Zuid, the through street pair was two parts of the Marnixstraat (Amsterdam-Centrum), and the touristic street pair was the south and north part of Nieuwezijds Voorburgwal in Amsterdam-Centrum (see. Tab. 5).

Table 5: The three street pairs considered for the pilot study with the seven locations at which the pilot study of a part of it was performed.

Street pair type	Street name	Location	Limit
Residential	Olympiaweg	Betw. Turnerstraat & Speerstraat	50 km/h
	Marathonweg	Betw. Olympiaweg & Achillesstraat	30 km/h
Through street	Marnixstraat (north & middle)	Marnixpl. & Bloemengracht	50 km/h
	Marnixstraat (south)	Passeerdersgracht	30 km/h
Touristic/commercial	Nieuwezijds Voorburgwal (nor.)	Nieuwezijds Kolk	50 km/h
	Nieuwezijds Voorburgwal (sou.)	Between Postzegelmarkt & Spui	30 km/h

3.2 Gained insights

Streets differ not only in the speed limit

My goal was to find and test measures with which it is possible to estimate the effect of a reduced speed limit on a number of social and health-related aspects. However, these aspects are also affected by many other variables what became especially apparent when comparing the two residential streets (Marathonweg vs. Olympiaweg, see Fig. 1). Even though the streets are on first view quite similar from an objective perspective (street width, traffic volumes, cycling lanes, trees), the streets “feel” immediately very different. Table 6 lists the differences that might be responsible

for this subjective difference. These should be kept in mind when attributing differences found in the investigation to the speed limit. For example, the number of benches in front of houses could be different because of the speed limit but also because of the available space. Furthermore, one should also take into account if residents have access to (private) gardens on the back of their houses. In the Marnixstraat and the Nieuwezijds Voorburgwal the apparent differences between the two (or three in the case of Marnixstraat) parts were even larger. Since so many aspects play a role I dropped the initial goal in statistically comparing two or three street pairs as it would have been impossible to tell if potential differences were caused by a different speed limit or other differences.

Table 6: How even two apparently similar streets differ in various respects.

Differing variables	**Marathonweg**	**Olympiaweg**
Speed limit	30 km/h	50 km/h
Width (house to house)	25 m	27 m
Sidewalk connected to houses	Yes	Plant area of 1,5 - 2 m width (houses separated fr. sidewalk)
Walls of houses	Contain details (e.g. ornaments, windows stick out), look beautiful	Plain walls, look monotonous
Distance between neighboring houses (door to door)	Smaller (usually 7-8 m)	Larger (usually approx. 15 m)
Roofs of houses	Pitched roofs	Flat roofs
Car parking	Lay-bays (groups of 3-5 cars)	Continuous parking lane
Sun in the street (orientation)	Morning (northwest-southeast)	Afternoon (northeast-southwest)

Personal interviews

In total, 16 persons were interviewed at 3 different locations at 4 different dates.[6] Pedestrians walking or people lingering in street were approached and asked in English if they want to participate in a study about the street. Almost everybody understood and spoke English. After some trial and error it became clear that “Hello, do you live in this street?” as an opener led to much more interviews than e.g. “Hello, I am from the University of Amsterdam and doing a study on this street.” In the beginning, the questionnaire was designed exclusively for residents of the respective street and non-residents were not interviewed. From the third date on, a questionnaire was developed that was also suitable for non-residents and after being asked if the interviewed person is a resident the applicable questionnaire was chosen. Similarly, it might make sense to ask interviewees if they are tourists to account for possible different perceptions on street design and appearance. In most cases, the interview took about 5-6 minutes to complete. It became clear that some questions were not easily understood by everybody and these questions were moved to the end of the interview in order to keep people engaged as long as possible.[7] Asking for key words was

6 The locations were Marathonweg (9 participants out of 72 persons approached in 2 hours) , Olympiaweg (7 participants out of 26 persons approached in 90 minutes), and Marnixplein (7 participants out of 21 persons approached in 90 minutes). All interviews took place on July and August 2022 during dry and warm/hot weather during the day on a week day. I was supported by Swantje Hanke who helped me in interviewing and creating an adapted version of the questionnaire which is also applicable to non-residents.

7 Most prominent were “People on this street share the same values.” and “I feel part of a community in this street.”

moved to the beginning of the interview in order to avoid framing by the content of the questionnaire. Furthermore, the number of positive and negative key words that was asked for was reduced from three to one each since for most interviewees giving three times three key words was too much. Even without doing statistical analysis it became clear that the variance is quite high since it was a quite common phenomenon that two subsequent interviewees rated many Likert statements very differently. Drawing the home territory was asked from a subset of participants (only for Marathonweg and Olympiaweg). Most participants understood what was asked from them after giving a detailed explanation, but indicated only a very small area in front of their house. The reason might be that the maps had a standard A4 paper size with low resolution and because of that participants did not really recognize the details of the area in front of their house.

Figure 1: Two residential streets that seem similar by first view but still differ by many aspects (see Tab. 6). Left: Marathonweg (30 km/h), right: Olympiaweg (50 km/h).

Traffic and object counting

At six locations traffic and objects were counted.[8] The traffic was counted for 10 minutes at each location. For very busy places like the Postzegelmarkt it is necessary to split up the counting of different modes between several persons or do them subsequently. Objects were counted by walking through the street within the defined area. Benches set up by residents and business were counted, but not benches set up by the City of Amsterdam. In order to avoid that single spots with a very high amount of pot plants distort the statistics, both the number of spots and the number of pot plants in each spot were counted (analogously with benches/chairs and tables). It was found that in the Marnixstraat the numbers of each object were rather low ($N<5$) what could make it hard to detect significant differences if not a large amount of streets are investigated. In the two residential streets most of these numbers were higher, however the occurrence of play gear was still very low ($N<3$).

Observing behavior

The behavior was observed at the same six locations as the traffic/object counting and was done for ten minutes each. In order to do proper before-vs-after comparisons the area in which behavior is observed should be specified as precisely as possible. This is also true for the locations at which people walk or cross the street. People standing at tram or bus stops where not counted. It should be clearly defined if people who are walking and talking (or switch from standing to sitting during the observation period) should be counted for each category or just for one. Similarly, it should be clearly defined if people talking on the phone are counted as people talking. The decision if people are walking slowly, normally fast, or fast turned out to be very subjective, thus it should be kept in mind that different observers use the categories differently. It might make sense to also count the number of groups (more than one person walking/standing/sitting together) since this might correlate with how suitable the street is perceived to be with acquaintances. In residential streets, the amount of people who fall into another category except for walking on their own is quite low. Thus, to get reasonable high numbers the observation time has to be quite long (several hours) or it should be done during the evenings or on the weekend. Even in the Marnixstraat, which had the highest numbers, the numbers were quite low.[9]

3.3 Conclusion

Through looking into previous studies and in discussions with academic peers I developed a survey to study the potential effects of a reduced speed limit on social and health-related aspects. I tested the survey on several locations in Amsterdam and continuously adapted it. Counting objects, behavior and traffic needs clear definition of what, where, and how is counted. In general, it should be possible to measure social and health-related aspects with this survey. However, it became clear that many other features of the street apart from the speed limit potentially effect these aspects. Thus, a high number of street pairs probably is necessary to obtain statistically solid insights. It also

8 The north part of Nieuwezijds Voorburgwal was a large construction side and was closed for through traffic, thus no counting was done there.

9 Apart from walking and talking the highest number was pedestrians with dogs at Bloemengracht ($N=4$) and pedestrians with baby strollers at Passeerdersgracht ($N=3$).

became clear that residential streets differ very much from through streets and touristic streets and that the effects of a reduced speed limit might depend on the street type.

4 Discussion & Outlook

In this work I first listed the motivations of 14 cities for reducing their general speed limit to 30 km/h by analyzing their official documents, followed by an analysis of the scientific literature regarding the measured effects. There, I found that almost all cities want to reduce the negative impacts of fast car traffic: mostly injuries/deaths due to collisions and noise pollution but also lack of physical activity, impaired livability, and poor usage of public space. Comparing these ambitions to the scientific studies it became clear that apart from collisions and noise, the scientific knowledge on these effects is poor. A reason for this is probably that these studies were mostly conducted by traffic researchers without involving social scientists. To close this knowledge gap I looked into studies which investigated how (reduced) car traffic effects various social, health, and public space related aspects. It became clear that these aspects incorporate a wide range of variables which might also be influenced by a reduced speed limit. Some of them are closely related to the cities' ambitions of "livability", "quality of life", and "significance of public space" (see Tab. 4). It would therefore make sense that cities state more concretely what these expressions contain so that citizens have a clearer understanding of the ambitions and that researches performing evaluation studies also investigate these variables. The clearer and more concrete the potential positive effects are for reducing car speeds (or car traffic), the higher the public support should be from the beginning. Not articulating the potential positive effects concretely enough might also partly explain why public support increases substantially during or after the implementation when the positive effects become apparent.

Building on these findings, I developed a survey that aims at measuring the effects of a reduced speed limit on social, health, and public space related aspects. It was tested on different street types in Amsterdam and can be used to do a pre-post comparison. To account for general trends or other measures of reducing car traffic this should also be done at control streets where the speed limit is not changed. The City of Amsterdam, however, already decided that only main streets with more than one lane per direction or very separated streets will remain at 50 km/h. On the other hand, several features of a street influence the measured variables and that even street pairs which look similar at first sight might differ substantially at closer sight (see Tab. 6). This limits the feasibility of assigning intervention-control street pairs but instead intervention and control streets (or street sections) would have to be randomly sampled for each street type. The latter, however, implies that quite a large sample size would be necessary to find significant effects in the underlying large varieties across streets, what could substantially reduce the amount of streets or street sections that receive a reduced speed limit. In addition, the spill-over effect – car speeds are reduced even in control streets – could make it hard to obtain statistically solid results.

The measured effects of a reduced speed limit can have a quite direct causal relationship (e.g. reduced speeds mean less noise what increases mental and physical health) or can be more indirect

via altered behavior or changed perceptions about public space in front of the house.[10] Since many variables are at play there could theoretically be a huge amount of causal links (some of them are laid out in Supp. Fig. 1), probably also including feedback loops and interaction effects. However, the scope of this work was not to develop a method that intents to discover the causal relationships but instead to find out if and by what degree the various social and health-related aspects are effected by a reduced speed limit.

Another important aspect which was not part of this work are the economic effects of a reduced speed limit. Apart from the immediate effects of less costs due to less collisions, also the effects of increased physical and mental health could be huge. As with other traffic calming measures the increased livability caused by lower car speeds probably has a positive economic effect on local businesses [92, 93]. Furthermore, the car is very expensive both for society and individuals as the internal and external costs are far higher than for any other mode except flying [10, 11].

Most likely a reduced speed limit to 30 km/h alone is not enough to substantially get rid of the many negative impacts caused by extensive car traffic. Car volumes have to be reduced substantially and streets have to be redesigned to create public spaces which allow and stimulate behavioral patterns that positively effect the social and health-related aspects that were laid out to be investigated in this report.

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References

1. Fu J, Jenelius E (2018) Transport efficiency of off-peak urban goods deliveries: A Stockholm pilot study. Case Studies on Transport Policy 6:156–166. https://doi.org/10.1016/j.cstp.2018.01.001

10 One example: parents assume that reduced speeds make it safer to let their children play outside, children make friends with neighboring children, what then could lead to increased social interactions between neighboring parents, what again could make them to spend more time on the street, what then again could lead to an increase sense of street ownership and taking care of the street (e.g. through taking care of plants, cleaning up dirt, and/or asking local politicians to reduce the amount of through traffic or parking spots), what again would make the street more attractive for neighbors to hang out and increase their social interactions, what then could increase social safety, trust, and/or a sense of community, what could lead to less stress, better mental health and an increase in well-being and life satisfaction. Neighbors who regularly communicate with each other and speak about problems in the street could also be more likely to show up at political meetings and demand e.g. further measures that reduce car speeds and motorized through traffic.

11 The Smart Urban Mobility (SUM) group at the AMS Institute and the Planning Urban Mobility and Accessibility (PUMA) group at the University of Amsterdam.

2. Agnew J (2020) Steam engines on UK roads, 1862–1865: Banning orders, agricultural locomotives and the ‘red flag’ Act. The International Journal for the History of Engineering & Technology 90:53–74. https://doi.org/10.1080/17581206.2020.1797447

3. Hänggi M (2020) Automobilismus: Die grosse Irrfahrt. https://www.woz.ch/-aba8. Accessed 29 Aug 2022

4. de la Bruheze AA (2000) Bicycle use in twentieth century Western Europe: the comparison of nine cities. In: Proceedings of the Velo Mondial 2000 World Cycling Conference

5. Corbusier L, Eardley A (1973) The athens charter. Grossman Publishers New York

6. Norton PD (2011) Fighting traffic: the dawn of the motor age in the American city. MIT Press

7. Badoe DA, Miller EJ (2000) Transportation–land-use interaction: empirical findings in North America, and their implications for modeling. Transportation Research Part D: Transport and Environment 5:235–263. https://doi.org/10.1016/S1361-9209(99)00036-X

8. Khreis H, Warsow KM, Verlinghieri E, et al (2016) The health impacts of traffic-related exposures in urban areas: Understanding real effects, underlying driving forces and co-producing future directions. Journal of Transport & Health 3:249–267. https://doi.org/10.1016/j.jth.2016.07.002

9. Wiersma JK (2020) Commuting patterns and car dependency in urban regions. Journal of Transport Geography 84:102700. https://doi.org/10.1016/j.jtrangeo.2020.102700

10. Gössling S, Kees J, Litman T (2022) The lifetime cost of driving a car. Ecological Economics 194:107335. https://doi.org/10.1016/j.ecolecon.2021.107335

11. Andor MA, Gerster A, Gillingham KT, Horvath M (2020) Running a car costs much more than people think — stalling the uptake of green travel. Nature 580:453–455. https://doi.org/10.1038/d41586-020-01118-w

12. Bruntlett C, Bruntlett M (2021) Curbing traffic: The human case for fewer cars in our lives. Island Press

13. Ribeiro S, Figueroa M, Creutzig F, et al (2012) Global Energy Assessment - Toward a Sustainable Future. Chapter 9 - Energy End-Use: Transport

14. European Parliament resolution (2021) EU Road Safety Policy Framework 2021-2030 – Recommendations on next steps towards “Vision Zero”

15. Sixth UN Global Road Safety Week (2021) How to Build Streets for Life. https://www.unroadsafetyweek.org/en/streets-for-life. Accessed 29 Aug 2022

16. Eltis News Editor (2016) Limiting speed to increase safety and reduce pollution in Graz (Austria). https://www.eltis.org/discover/case-studies/limiting-speed-increase-safety-and-reduce-pollution-graz-austria. Accessed 24 Aug 2022

17. Petherick D (2015) Edinburgh Streets: 80% will have 20mph speed limit. https://edinburghfestival.org/2015/01/13/edinburgh-streets-80-will-20mph-speed-limit/. Accessed 24 Aug 2022

18. Grenoble Alpes Métropole (2020) Evaluation du dispositif “villes et villages à 30 km/h”

19. Ayuntamiento de Madrid (2018) Entra en vigor la Ordenanza de Movilidad Sostenible para mejorar la convivencia vial. https://www.madrid.es/portales/munimadrid/es/Inicio/Actualidad/Noticias/Entra-en-vigor-la-Ordenanza-de-Movilidad-Sostenible-para-mejorar-la-convivencia-vial/?vgnextfmt=default&vgnextoid=6e9ec3f4b80a6610VgnVCM2000001f4a900aRCRD&vgnextchannel=a12149fa40ec9410VgnVCM100000171f5a0aRCRD. Accessed 24 Aug 2022

20. Dimitrova M (2019) Helsinki imposes lower speed limits. https://www.themayor.eu/en/a/view/helsinki-imposes-lower-speed-limits-2723. Accessed 24 Aug 2022

21. Ville de Lille Lille à 30 pour une ville apaisée. https://www.lille.fr/Lille-a-velo/La-Ville-agit/Lille-a-30-pour-une-ville-apaisee. Accessed 24 Aug 2022

22. IZARRA J (2022) Bilbao impone el límite de 30 por hora en todas sus calles. https://www.elmundo.es/pais-vasco/2020/09/21/5f690e48fc6c8376228b4595.html. Accessed 24 Aug 2022

23. Ajuntament Barcelona (2020) A city at 30 km/h. https://www.barcelona.cat/infobarcelona/en/tema/mobility-and-transport/a-city-at-30-km-h_921411.html. Accessed 24 Aug 2022

24. Ville de Bruxelles (2020) Bruxelles zone 30 depuis le 1er janvier 2021. https://www.bruxelles.be/bruxelles-zone30. Accessed 24 Aug 2022

25. Ville de Paris (2021) La vitesse limitée à 30 km/h dans la majorité des voies parisiennes. https://www.paris.fr/pages/generalisation-de-la-vitesse-a-30-km-h-les-parisiens-ont-donne-leur-avis-16967. Accessed 24 Aug 2022

26. Mairie de Montpellier Montpellier apaisée passe à 30 km/h. https://www.montpellier.fr/4667-montpellier-apaisee-passe-a-30-km-h.htm. Accessed 24 Aug 2022

27. Stadt Zürich (2021) Mehr Schutz vor Lärm durch weitgehende Einführung von Tempo 30. https://www.stadt-zuerich.ch/pd/de/index/das_departement/medien/medienmitteilung/2021/juli/210714a.html. Accessed 27 Aug 2022

28. Dirección General de Tráfico (2020) Reformas legales para reducir los accidentes de tráfico. https://revista.dgt.es/es/noticias/nacional/2020/11NOVIEMBRE/1110-Cambios-Legislativos.shtml. Accessed 27 Aug 2022

29. Ville de Lyon (2022) La ville à 30 km/h. https://www.lyon.fr/deplacements/la-ville-apaisee/la-ville-30-kmh. Accessed 27 Aug 2022

30. Gemeente Amsterdam (2021) Amsterdam veilig en leefbaar - Beleidsdocument 30 km/u in de stad

31. Welsh Government (2021) Introducing 20mph speed limits: frequently asked questions. https://gov.wales/introducing-20mph-speed-limits-frequently-asked-questions. Accessed 27 Aug 2022

32. Gemeente Amsterdam (2020) Amsterdam makt ruimte - Agenda Amsterdam Autoluw

33. Atkins Limited, AECOM, Maher M (2018) 20mph research study - process and impact evaluation: headline report

34. Dechenaux E, Mago SD, Razzolini L (2014) Traffic congestion: an experimental study of the Downs-Thomson paradox. Exp Econ 17:461–487. https://doi.org/10.1007/s10683-013-9378-4

35. Jones SJ, Brunt H (2017) Twenty miles per hour speed limits: a sustainable solution to public health problems in Wales. J Epidemiol Community Health 71:699–706. https://doi.org/10.1136/jech-2016-208859

36. Milton K, Kelly MP, Baker G, et al (2021) Use of natural experimental studies to evaluate 20mph speed limits in two major UK cities. Journal of Transport & Health 22:101141. https://doi.org/10.1016/j.jth.2021.101141

37. Dinh DD, Kubota H (2013) Drivers' perceptions regarding speeding and driving on urban residential streets with a 30km/h speed limit. IATSS Research 37:30–38. https://doi.org/10.1016/j.iatssr.2012.12.001

38. Tapp A, Nancarrow C, Davis A (2015) Support and compliance with 20mph speed limits in Great Britain. Transportation Research Part F: Traffic Psychology and Behaviour 31:36–53. https://doi.org/10.1016/j.trf.2015.03.002

39. Fildes B, Lawrence B, Oxley J (2019) Low speed limits in residential areas in Melbourne, Australia. Traffic Injury Prevention 20:S155–S157. https://doi.org/10.1080/15389588.2019.1661678

40. Sammer G (1994) General 30 kph speed limit in the city: the results of a model project in the city of Graz. In: Proceedings Of The Third International Conference On Safety And The Environment In The 21st Century: Lessons From The Past, Shaping The Future, November 7-10, 1994, Tel Aviv, Israel

41. Williams D, North DR (2013) An evaluation of the estimated impacts on vehicle emissions of a 20mph speed restriction in central London. Transport and Environmental Analysis Group

42. Lawrence B, Fildes B, Thompson L, et al (2020) Evaluation of the 30km/h speed limit trial in the City of Yarra, Melbourne, Australia. Traffic Injury Prevention 21:S96–S101. https://doi.org/10.1080/15389588.2021.1895990

43. Diário de Notícias (2022) Câmara de Lisboa aprova redução em 10 km/h da velocidade máxima de circulação. https://www.dn.pt/local/camara-de-lisboa-aprova-reducao-em-10-kmh-da-velocidade-maxima-de-circulacao-na-cidade-14847460.html. Accessed 27 Aug 2022

44. Oslo kommune The Car-free Livability Programme 2019

45. Lebenswerte Städte und Gemeinden Die Städteinitiative "Lebenswerte Städte durch angepasste Geschwindigkeiten." https://www.lebenswerte-staedte.de/. Accessed 27 Aug 2022

46. 30km/h – making streets liveable! United Kingdom Trendsetter cities for 30 km/h. https://en.30kmh.eu/why-30kmh-20-mph/trendsetter-cities-for-30-kmh-20mph/uk-united-kingdom-trendsetter-cities-for-30-kmh/. Accessed 27 Aug 2022

47. Nightingale GF, Williams AJ, Hunter RF, et al (2021) Evaluating the citywide Edinburgh 20mph speed limit intervention effects on traffic speed and volume: A pre-post observational evaluation. PLOS ONE 16:e0261383. https://doi.org/10.1371/journal.pone.0261383

48. Cleland CL, McComb K, Kee F, et al (2020) Effects of 20 mph interventions on a range of public health outcomes: A meta-narrative evidence synthesis. Journal of Transport & Health 17:100633. https://doi.org/10.1016/j.jth.2019.100633

49. Sun D, El-Basyouny K, Ibrahim S, Kim AM (2018) Are school zones effective in reducing speeds and improving safety? Can J Civ Eng 45:1084–1092. https://doi.org/10.1139/cjce-2018-0060

50. Global Road Safety Partnership (2008) Speed management: a road safety manual for decision-makers and practitiioners

51. Engel U, Thomsen LK (1992) Safety effects of speed reducing measures in Danish residential areas. Accident Analysis & Prevention 24:17–28

52. Grundy C, Steinbach R, Edwards P, et al (2009) Effect of 20 mph traffic speed zones on road injuries in London, 1986-2006: controlled interrupted time series analysis. Bmj 339:

53. Bruxelles Mobilité (2021) Bruxelles Ville 30 - un an après. In: Bruxelles Mobilité. https://mobilite-mobiliteit-brussels.prezly.com/bruxelles-ville-30-un-an-apres. Accessed 27 Aug 2022

54. Rossi IA, Vienneau D, Ragettli MS, et al (2020) Estimating the health benefits associated with a speed limit reduction to thirty kilometres per hour: A health impact assessment of noise and road traffic crashes for the Swiss city of Lausanne. Environment International 145:106126. https://doi.org/10.1016/j.envint.2020.106126

55. Int Panis L, Beckx C, Broekx S, et al (2011) PM, NOx and CO2 emission reductions from speed management policies in Europe. Transport Policy 18:32–37. https://doi.org/10.1016/j.tranpol.2010.05.005

56. Madireddy M, De Coensel B, Can A, et al (2011) Assessment of the impact of speed limit reduction and traffic signal coordination on vehicle emissions using an integrated approach. Transportation Research Part D: Transport and Environment 16:504–508. https://doi.org/10.1016/j.trd.2011.06.001

57. Casanova Kindelán J, Fonseca González NE (2011) Environmental assessment of low speed policies for motor vehicle mobility in city centres. Global Nest Journal 14:192–201

58. Archer J, Fotheringham N, Symmons M, Corben B (2008) The impact of lowered speed limits in urban/metropolitan areas

59. Buehler R, Dill J (2016) Bikeway Networks: A Review of Effects on Cycling. Transport Reviews 36:9–27. https://doi.org/10.1080/01441647.2015.1069908

60. Pilkington P, Bornioli A, Bray I, Bird E (2018) The Bristol Twenty Miles Per Hour Limit Evaluation (BRITE) Study

61. Brown V, Moodie M, Carter R (2017) Evidence for associations between traffic calming and safety and active transport or obesity: A scoping review. Journal of Transport & Health 7:23–37. https://doi.org/10.1016/j.jth.2017.02.011

62. Cairns J, Warren J, Garthwaite K, et al (2015) Go slow: an umbrella review of the effects of 20 mph zones and limits on health and health inequalities. J Public Health (Oxf) 37:515–520. https://doi.org/10.1093/pubmed/fdu067

63. Turner K, Jepson R, MacDonald B, et al (2018) Developing and refining a programme theory for understanding how twenty mile per hour speed limits impact health. Journal of Transport & Health 10:92–110. https://doi.org/10.1016/j.jth.2018.08.004

64. Cepeda M, Schoufour J, Freak-Poli R, et al (2017) Levels of ambient air pollution according to mode of transport: a systematic review. The Lancet Public Health 2:e23–e34. https://doi.org/10.1016/S2468-2667(16)30021-4

65. Appleyard D, Lintell M (1972) The Environmental Quality of City Streets: The Residents' Viewpoint. Journal of the American Institute of Planners 38:84–101. https://doi.org/10.1080/01944367208977410

66. Appleyard B (2021) Livable Streets 2.0. Elsevier

67. Sauter D, Huettenmoser M (2008) Liveable streets and social inclusion. Urban Des Int 13:67–79. https://doi.org/10.1057/udi.2008.15

68. Gehl J (2010) Cities for people. Island Press, Washington, DC

69. Gehl J, Svarre B (2013) How to study public life. Springer

70. Espinoza A, McMahan S, Naffzinger T, Wiersma LD (2012) Creating Playgrounds, Where Playgrounds Do Not Exist: A Community Based Approach. Californian Journal of Health Promotion 10:13–19. https://doi.org/10.32398/cjhp.v10iSI-Obesity.1466

71. D'Haese S, Van Dyck D, De Bourdeaudhuij I, et al (2015) Organizing "Play Streets" during school vacations can increase physical activity and decrease sedentary time in children. International Journal of Behavioral Nutrition and Physical Activity 12:14. https://doi.org/10.1186/s12966-015-0171-y

72. McGlone N (2016) Pop-Up kids: exploring children's experience of temporary public space. Australian Planner

73. Murray J, Devecchi C (2016) The Hantown Street Play Project. International Journal of Play

74. Cortinez-O'Ryan A, Albagli A, Sadarangani KP, Aguilar-Farias N (2017) Reclaiming streets for outdoor play: A process and impact evaluation of "Juega en tu Barrio" (Play in your Neighborhood), an intervention to increase physical activity and opportunities for play. PLOS ONE 12:e0180172. https://doi.org/10.1371/journal.pone.0180172

75. Torres A, Sarmiento OL, Stauber C, Zarama R (2013) The Ciclovia and Cicloruta Programs: Promising Interventions to Promote Physical Activity and Social Capital in Bogotá, Colombia. In: https://doi.org/10.2105/AJPH.2012.301142. https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2012.301142. Accessed 6 Jun 2022

76. Engelberg JK, Carlson JA, Black ML, et al (2014) Ciclovía participation and impacts in San Diego, CA: The first CicloSDias. Preventive Medicine 69:S66–S73. https://doi.org/10.1016/j.ypmed.2014.10.005

77. Cohen D, Han B, Derose KP, et al (2016) CicLAvia: Evaluation of participation, physical activity and cost of an open streets event in Los Angeles. Preventive Medicine 90:26–33. https://doi.org/10.1016/j.ypmed.2016.06.009

78. Zieff SG, Chaudhuri A, Musselman E (2016) Creating neighborhood recreational space for youth and children in the urban environment: Play(ing in the) Streets in San Francisco. Children and Youth Services Review 70:95–101. https://doi.org/10.1016/j.childyouth.2016.09.014

79. Perry CK, Ko LK, Hernandez L, et al (2017) Ciclovia in a Rural Latino Community: Results and Lessons Learned. J Public Health Manag Pract 23:360–363. https://doi.org/10.1097/PHH.0000000000000555

80. Salazar-Collier CL, Reininger B, Gowen R, et al (2018) Evaluation of Event Physical Activity Engagement at an Open Streets Initiative Within a Texas–Mexico Border Town. Journal of Physical Activity and Health 15:605–612. https://doi.org/10.1123/jpah.2017-0112

81. Zieff SG, Musselman EA, Sarmiento OL, et al (2018) Talking the Walk: Perceptions of Neighborhood Characteristics from Users of Open Streets Programs in Latin America and the USA. J Urban Health 95:899–912. https://doi.org/10.1007/s11524-018-0262-6

82. Triana CA, Sarmiento OL, Bravo-Balado A, et al (2019) Active streets for children: The case of the Bogotá Ciclovía. PLOS ONE 14:e0207791. https://doi.org/10.1371/journal.pone.0207791

83. Meyer MRU, Bridges Hamilton CN, Prochnow T, et al (2019) Come together, play, be active: Physical activity engagement of school-age children at Play Streets in four diverse rural communities in the U.S. Preventive Medicine 129:105869. https://doi.org/10.1016/j.ypmed.2019.105869

84. Hipp JA, Eyler AA, Kuhlberg JA (2013) Target Population Involvement in Urban Ciclovias: A Preliminary Evaluation of St. Louis Open Streets. J Urban Health 90:1010–1015. https://doi.org/10.1007/s11524-012-9759-6

85. Semenza JC (2003) The Intersection of Urban Planning, Art, and Public Health: The Sunnyside Piazza. American Journal of Public Health. https://doi.org/10.2105/AJPH.93.9.1439

86. Semenza JC, March TL, Bontempo BD (2007) Community-Initiated Urban Development: An Ecological Intervention. J Urban Health 84:8–20. https://doi.org/10.1007/s11524-006-9124-8

87. Semenza JC, March TL (2008) An Urban Community-Based Intervention to Advance Social Interactions: Environment and Behavior. https://doi.org/10.1177/0013916507311136

88. Krishna A, Shrader E (1999) Social capital assessment tool. In: Conference on social capital and poverty reduction. The World Bank

89. Adams MA, Ryan S, Kerr J, et al (2009) Validation of the Neighborhood Environment Walkability Scale (NEWS) Items Using Geographic Information Systems. Journal of Physical Activity and Health 6:S113–S123. https://doi.org/10.1123/jpah.6.s1.s113

90. McKenzie TL, Cohen DA, Sehgal A, et al (2006) System for Observing Play and Recreation in Communities (SOPARC): Reliability and Feasibility Measures. Journal of Physical Activity and Health 3:S208–S222. https://doi.org/10.1123/jpah.3.s1.s208

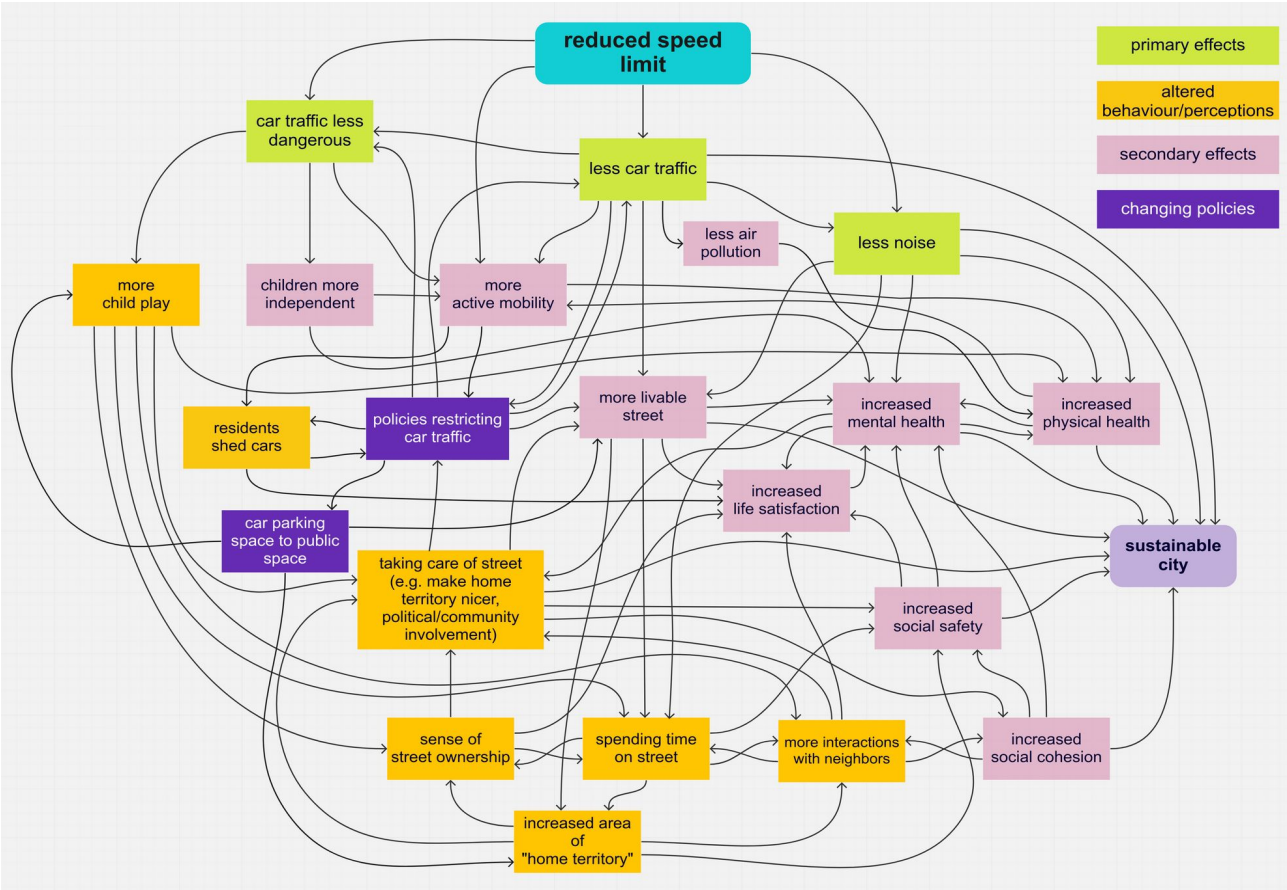
91. van Heel BF, van den Born RJG, Aarts MNC (2022) Everyday childhood nature experiences in an era of urbanisation: an analysis of Dutch children's drawings of their favourite place to play outdoors. Children's Geographies 0:1–16. https://doi.org/10.1080/14733285.2022.2071600

92. Volker JMB, Handy S (2021) Economic impacts on local businesses of investments in bicycle and pedestrian infrastructure: a review of the evidence. Transport Reviews 41:401–431. https://doi.org/10.1080/01441647.2021.1912849

93. Yoshimura Y, Kumakoshi Y, Fan Y, et al (2022) Street pedestrianization in urban districts: Economic impacts in Spanish cities. Cities 120:103468. https://doi.org/10.1016/j.cities.2021.103468

94. Hess A-K (2022) The relationship between car shedding and subjective well-being. Transportation Research Interdisciplinary Perspectives 15:100663. https://doi.org/10.1016/j.trip.2022.100663

Appendix



Supplementary Figure 1: Possible causal relationships between primary effects of a reduced speed limit, altered behavior and perceptions, secondary effects, and changing policies. Some relationships are based on findings described in Secs. 2.2 and 2.3, some on studies not mentioned in this work (e.g. car shedding leads to increased subjective well-being [94]), and most are hypothesized from own experience or common sense. In future work, the scientific literature should be browsed to find evidence for or against these hypotheses. For relationships that have not been investigated yet further research should be carried out. Note that many positive (self-enforcing) feedback loops might be possible. Furthermore, some relations have shorter time scales (e.g. a reduced speed limit immediately reduces noise) while others would have longer time scales (e.g. it would probably take years until an increased sense of street ownership leads to policies further restricting car traffic).

Supplementary Table 1: List of the news articles that have been used in this work.

Graz	https://www.eltis.org/discover/case-studies/limiting-speed-increase-safety-and-reduce-pollution-graz-austria
Edinburgh	https://www.raisethehammer.org/article/2192/edinburgh_to_enforce_30_kmh_speed_limit_on_all_residential_streets https://www.bbc.com/news/uk-scotland-edinburgh-east-fife-55863412 https://www.edinburghlive.co.uk/news/edinburgh-news/work-create-new-edinburgh-20mph-24545241
Grenoble	https://www.radiofrance.fr/franceinter/paris-bordeaux-grenoble-et-desormais-saint-brieuc-40-villes-francaises-limitent-la-vitesse-a-30-km-h-4576106 https://detours.canal.fr/paris-lille-grenoble-qua-change-la-limitation-a-30-km-h-dans-ces-villes/ https://www.cerema.fr/system/files/documents/2020/07/cerema_ce_grenoble_rapport_ma_3a_vfinale.pdf
Madrid	https://enviro.es/estas-son-todas-las-calles-de-madrid-que-estaran-limitadas-a-30-km-h/ https://www.elplural.com/politica/ordenanza-movilidad-madrid-multas-circular-a-mas-de-30-kilometros-hora_205170102
Helsinki	https://www.theguardian.com/world/2020/mar/16/how-helsinki-and-oslo-cut-pedestrian-deaths-to-zero https://www.themayor.eu/en/a/view/helsinki-imposes-lower-speed-limits-2723 https://www.eltis.org/in-brief/news/helsinki-has-no-pedestrian-fatalities-2019
Lille	https://www.francebleu.fr/infos/transports/la-vitesse-desormais-limitee-a-30-km-h-a-lille-1572370010 https://www.thelocal.fr/20210729/why-more-cities-across-france-are-imposing-30-km-h-speed-limits/
Oslo	https://www.theguardian.com/world/2020/mar/16/how-helsinki-and-oslo-cut-pedestrian-deaths-to-zero https://thecityfix.com/blog/how-oslo-achieved-zero-pedestrian-and-bicycle-fatalities-and-how-others-can-apply-what-worked/ https://www.oslo.kommune.no/getfile.php/13319592-1553857948/Content/Politics%20and%20administration/City%20development/Car%20free%20city/The%20Car-free%20Livability%20Programme%202019.pdf
Bilbao	https://www.elmundo.es/pais-vasco/2020/09/21/5f690e48fc6c8376228b4595.html https://www.laprovincia.es/sociedad/2020/09/22/bilbao-primera-gran-ciudad-mundo-13556042.html
Brussels	https//www.lesoir.be/420478/article/2022-01-26/le-nombre-de-cyclistes-augmente-de-20-lan-dernier-bruxelles https://www.rtbf.be/article/bilan-zone-30-a-bruxelles-le-nombre-de-victimes-sur-les-routes-divise-par-deux-10904242
Paris	https://cdn.paris.fr/paris/2021/06/29/b37f13917d3d5e94b856375633fcd827.pdf https://www.bbc.com/news/world-europe-58385502 https://www.lejdd.fr/Societe/david-belliard-adjoint-eelv-danne-hidalgo-les-30kmh-vont-fluidifier-le-trafic-4063952
Montpellier	https://www.midilibre.fr/2021/02/20/montpellier-des-juillet-il-va-falloir-lever-le-pied-dans-toute-la-ville-et-passer-de-50-a-30-kmh-9383755.php https://www.thelocal.fr/20210729/why-more-cities-across-france-are-imposing-30-km-h-speed-limits/
Barcelona	https://ajuntament.barcelona.cat/premsa/2020/02/24/leix-del-carrer-de-la-creu-coberta-carrer-de-sants-passa-a-ser-de-velocitat-30-km-h/
Spain	https://revista.dgt.es/es/noticias/nacional/2020/11NOVIEMBRE/1110-Cambios-Legislativos.shtml#.X6qlKFBG1rQ
Lyon	https://www.world-today-news.com/lyon-also-goes-to-30-km-h-on-almost-its-entire-perimeter/
Valencia	https://www.elmundo.es/comunidad-valenciana/2019/06/07/5cfa8cdf21efa087628b4579.html https://www.valenciablog.com/mapa-y-calles-de-la-zona-30-de-valencia/
Dublin	https://www.irishtimes.com/news/environment/dublin-city-council-defends-plan-to-extend-30km-h-speed-limit-1.4570812 https://www.breakingnews.ie/ireland/new-speed-limits-proposed-for-dublin-with-30km-h-in-most-areas-1108178.html
Toronto	https://storeys.com/lowering-speed-limit-toronto-improved-pedestrian-safety/ https://www.toronto.ca/services-payments/streets-parking-transportation/road-safety/vision-zero/safety-initiatives/speed-limit-reductions/
Italy	https://pledgetimes.com/speed-limit-30-km-h-in-the-city-will-they-also-apply-it-to-cars/
Lisbon	https://www.dn.pt/local/camara-de-lisboa-aprova-reducao-em-10-kmh-da-velocidade-maxima-de-circulacao-na-cidade-14847460.html