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Effectiveness of 30 km/h speed limit – A literature review

George Yannis, Eva Michelaraki *

National Technical University of Athens, Department of Transportation Planning and Engineering, 5 Heroon Polytechniou str., Athens GR-15773, Greece

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ABSTRACT

Introduction: Road crashes are a major social problem, resulting in 1.19 million fatalities and over 50 million injuries annually. Speeding is the primary cause of road crashes worldwide, particularly in cities where pedestrians, cyclists, and motorcyclists are especially vulnerable. This paper aims to review and assess the effectiveness of implementing a 30 km/h speed limit. *Method:* To achieve this objective, a comprehensive literature review was conducted, evaluating the impact of 30 km/h speed limits on safety, emissions, energy consumption, traffic flow, livability, and health. The systematic literature review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. *Results:* Current scientific evidence indicated that the introduction of 30 km/h speed limits in cities can save over 40% of lives, alongside significant positive effects on the environment, energy consumption and public health, including reduced fuel consumption and increased walking and cycling. *Practical Applications:* Public awareness campaigns and promoting the use of public transport and active mobility options, such as walking and cycling, could further support the adoption of 30 km/h speed limits in cities.

1. Introduction

Road crashes are a significant global issue, resulting in 1.19 million fatalities and more than 50 million injuries annually (World Health Organization, 2023). Over 50% of all road crashes, fatalities, and injuries involve Vulnerable Road Users (VRUs), including pedestrians, cyclists, motorcyclists, and their passengers.

The Global Plan for the Decade of Action for Road Safety 2021–2030 aims to reduce road traffic deaths and injuries by 50% by 2030 (World Health Organization, 2019). Achieving this target necessitates the implementation of evidence-based interventions known to decrease road traffic fatalities and injuries. Thus, the establishment of a 30 km/h speed limit is one such evidence-based intervention.

Higher travel speeds are particularly harmful to VRUs, such as pedestrians, cyclists, and motorcyclists, as they lack substantial protection to absorb the impact of a road crash. Consequently, they are more likely to die or sustain serious injuries in vehicular collisions compared to vehicle occupants at the same impact speed. According to Sharpin et al. (2021), there is a 40% chance of a pedestrian dying if hit by a vehicle traveling at 50 km/h, compared to a 13% chance at 30 km/h. Furthermore, Karndacharuk and McTiernan (2019) highlighted that speed limits equal to or less than 30 km/h can also reduce the injury risk and death of car occupants. Most importantly, people have a 90% chance of surviving after being hit by a vehicle (e.g., car or truck) going at 30 km/h, but less than 50% at 50 km/h or higher.

Vision Zero is a road safety concept aimed at achieving zero fatalities or serious injuries in road traffic (European Parliament Resolution, 2021). The idea is to create a road system that minimizes the impact of human errors and prioritizes road safety for everyone, everywhere. The call for a 30 km/h speed limit in built-up areas is based on the understanding that lower speeds can significantly reduce the severity of crashes and increase the chances of survival in the event of a collision. This approach aligns with broader global efforts to improve road safety and reduce the number of road traffic fatalities and injuries. Countries and regions worldwide are adopting various measures to create safer road environments, with setting lower speed limits in urban areas being one such strategy. It is important to note that road safety policies and recommendations can vary between regions and countries, and local authorities may implement different measures based on their specific circumstances and traffic conditions.

In the same context, the Safe System Approach is a human-centered strategy aimed at eliminating fatal and serious injuries for all road users (World Road Association, 2019). It acknowledges that humans are prone to errors and that the road transport system should be designed to absorb these errors without resulting in severe consequences. The approach is based on the principles of safe roads, safe vehicles, safe speeds, and safe

* Corresponding author.
E-mail address: evamich@mail.ntua.gr (E. Michelaraki).

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users. Specifically, the Safe System Approach ensures that any road safety intervention keeps the impact speed below the threshold likely to cause death or serious injury in the event of a crash. Typically, the impact speed should remain below 30 km/h for a pedestrian struck by a vehicle (International Transport Forum, 2006).

Several cities, such as Glasgow, have launched road safety strategies with the goal of eliminating all road fatalities and serious injuries by 2030 (ERTICO, 2021). Glasgow's new Vision Zero approach employs a range of measures identified as essential for creating a 'Safe System.' These measures are designed to minimize the likelihood of collisions and reduce the consequences when they do occur. These measures may include improved road safety engineering, enforcement, education projects, the introduction of safety cameras at key locations, cycle training schemes, initiatives to improve road safety around city schools, and road safety campaigns. Historical data show that countries adopting the Safe System approach, implementing evidence-based interventions such as 30 km/h speed limits, tend to have the lowest fatality rates per population and the fastest rate of reduction in fatality numbers (Welle et al., 2018). The implementation of a 30 km/h speed limit aligns with a key component of the Safe System approach, which emphasizes the importance of managing vehicle speeds to reduce crash severity. Lowering speed limits, particularly in urban areas or areas with high pedestrian activity, is a common intervention to improve road safety.

Within the above framework, the aim of this paper was to critically review and assess the effectiveness of 30 km/h speed limit in urban areas. To achieve this object, a thorough literature review was conducted, examining changes in safety, environment, energy, traffic, and liveability before and after the implementation of reduced speed limits.

The discussion and introduction of 30 km/h speed limits in cities often face strong resistance and significant inertia, while the voices of supporters tend to be weak and ineffective, leading to hesitant politicians and authorities. Additionally, there is limited scientific evidence regarding the combined effects of 30 km/h speed limits across multiple aspects, rather than focusing solely on safety (Beek, 2022; Fridman et al., 2020) or the environment (Madireddy et al., 2011). While the effectiveness of speed limit reductions has been studied in various contexts, assessing their impact on an urban environment using a multi-parameter approach, considering safety, environment, energy, traffic, liveability and health, is a novel undertaking. This forms the motivation for the current research, which aims to assess the effectiveness of 30 km/h speed limits in terms of safety, emissions, energy consumption, traffic flow, liveability, and health. The research questions this systematic review attempts to answer are as follows:

1. What is the combined effect of implementing a 30 km/h speed limit in urban areas on safety, environment, energy, traffic, liveability and health?

2. Which of the abovementioned parameter is most significantly impacted by 30 km/h speed limit?

This paper is structured as follows. Initially, an overview of the Global Plan for the Decade of Action for Road Safety, Vision Zero, and the Safe System approach is provided. Subsequently, the theoretical background regarding the primary cause of road crashes, speeding, and corresponding indicators is given. The following section outlines the methodological approach of the current research. The main part of the paper consists of an extensive literature review examining the effectiveness of 30 km/h speed limits in terms of road safety, traffic efficiency, environmental impacts, and more, across several cities. An overall discussion is then presented, highlighting road safety-related conclusions. Finally, the main findings are summarized and recommendations for implementation modalities are also discussed.

2. Background

Road safety is a significant concern in modern cities, with governing authorities and decision-makers continuously seeking measures and strategies to improve traffic safety. While multiple factors (e.g., distraction, drunk driving, absence of seatbelt and helmet use) contribute to collisions and fatalities, research has established that speeding significantly increases both the severity and probability of crash involvement.

2.1. Speeding as a key risk factor

Speed is fundamental to road safety, with substantial evidence highlighting its profound role in fatalities, injuries, and road crashes (Malyshkina & Mannering, 2008; De Pauw et al., 2014; Job & Brodie, 2022). To begin with, speed is a critical factor in preventing life-changing injuries during a road crash, which directly affects road transport. It defines the mobility rates and options of persons and goods traveling from one location to another (Aarts & Van Schagen, 2006). In today's modern life, citizens demand a high degree of mobility and the ability to travel quickly by air, rail, or road has become an integral component of society. However, driving speed also significantly impacts drivers' risk, directly affecting their involvement in potentially fatal crashes or severe injuries, as well as contributing to noise and pollutant emissions (Elvik, 2013).

It should be noted that speeding includes both excessive speed, which refers to driving above the speed limit and inappropriate speed, which refers to driving too fast for the conditions, but within the limits. Thus, speeding not only makes a crash more likely to occur, but also increases the likelihood of severe injuries or death from a crash (Nouvier, & France, 2006). According to European Road Safety Observatory (2006), a 1 km/h increase in speed results in a 3% increase in crashes, while European Transport Research Council (2019) estimated that reducing the average speed by 1 km/h on all roads across Europe could save more than 2,000 lives per year. A more recent report estimates that 10% to 15% of total road crashes and 30% of fatal road crashes are a direct result of speeding (European Road Safety Observatory, 2021).

A robust statistical correlation between road safety and speed was identified by Elvik (2018). It was revealed that decreased traffic speed can generally reduce not only the frequency of collisions but also the severity of resulting injuries. Similarly, Elvik (2009) emphasized the necessity of distinguishing the correlation between injury severity and speed from the correlation between the number of collision victims and the mean speed of traffic. It is worth mentioning that excessive speed is a major problem in all motorized countries. For instance, findings from Norway showed that if all drivers adhered to speed limits, the number of fatalities could be reduced by up to 20% (Elvik, 2009).

The relationship between serious injuries, fatal crashes, and speed, modeled by Nilsson (2004) and Elvik et al. (2009), is commonly illustrated by the "Power Model." According to this model, serious injury crashes are related to the third power of speed; while fatal crashes are related to the fourth power of speed. Based on the Power Model, a 5% increase in average speed can lead to an approximately 10% increase in injury crashes and a 20% increase in fatal crashes (International Transport Forum, 2006). Conversely, a 5% decrease in average speed typically results in 10% fewer injury crashes and 20% fewer fatal crashes. Thus, it is evident that changes in speed can affect both the number of collisions and the number of victims involved in each collision.

Aarts and Van Schagen (2006) examined the impact of driving speed on crash risk. Results indicated that greater speed differences among vehicles were associated with higher crash rates. It was also revealed that vehicles traveling faster than the surrounding traffic had an increased crash rate. In an interesting study by Schroeder et al. (2013), a cluster analysis identified three distinct groups of drivers based on self-reported behavioral tendencies: 30% non-speeders, 40% occasional speeders, and 30% regular speeders. According to Richard et al. (2016), drivers who exceed the speed limits often do not believe that lower speeds reduce the chances of a crash and report intentions to continue speeding.

Taking all the above-mentioned arguments into account, speeding is a widespread social problem and the number one road safety issue in many countries. It is a causative factor in approximately one-third of fatal crashes and an aggravating factor in the severity of all crashes. Therefore, coordinated actions by responsible authorities are necessary to bring about an immediate and durable response to the problem of speeding.

2.2. Appropriate speeds

To date, governing authorities and policymakers have recognized the need for action to address the major problem of speeding. In particular, speed management, which should be a key element of any road safety strategy, aims to achieve appropriate speeds across the entire road network. Speed management strategies and policies often align with broader policy goals, such as environmental protection, and may be integrated into wider transport strategies. It is imperative to elevate these objectives in order to encourage greater cooperation and collaboration or increased public acceptance. With the appropriate support from policymakers, speed management strategies can significantly contribute to achieve the triple goals of enhancing road safety, mitigating environmental impacts and reducing energy consumption.

A relatively recent and significant development in addressing the issue of speeding has been the recognition and action on the thresholds of physical resistance of the human body to the energy released during a road crash (International Transport Forum, 2006). These thresholds should play a pivotal role in legislation, regulations, and infrastructure development. Appropriate speeds for different road types, especially in urban areas where VRUs are highly vulnerable in case of a collision, should reflect the fundamental importance of protecting human life and preventing injury on all roads.

3. Methodology

The current study endeavors to critically assess the effectiveness of 30 km/h speed limit in urban areas. Towards that end, a thorough literature review was conducted, highlighting changes in terms of safety, emissions, energy, traffic, livability, and health. Studies had to meet specific selection criteria to be included in this review. More specifically, the criteria set requirements regarding the publication time, study quality and relevance, and the overall trustworthiness and validity of the publication source.

3.1. Study selection process and criteria

In order to review and assess the effectiveness of 30 km/h speed limits, a systematic search of relevant scientific and grey literature was carried out using the key terms presented in Table 1. Although there were numerous studies, articles and commercial websites investigating the effectiveness of speed limit reduction in the context of road safety, this literature search and review explicitly focused on research that objectively identifies the impact of 30 km/h speed limit in terms of safety, emissions, energy, traffic, livability, and health.

Table 1
Search terms utilized for the systematic literature review.

Key search phrase	Search terms	Identification papers	Included papers
30 km/h speed limit	"30 km/h" OR "20 mph" AND "30 km/h speed limit" OR "speed limit" OR "speed limit reduction" OR "maximum speed" OR "reduced speed" OR "urban areas" OR "benefits"OR "effectiveness"	284	60

The key terms were entered into the relevant databases using the following inclusion criteria:

– Search term included in the title, abstract or keywords,
– Studies published from 1989 onward,
– Studies including information regarding the 30 km/h speed limits in the title or abstract,
– Source preference: peer-reviewed journals followed by peer-reviewed conference papers, and then scientific reports/articles/websites.
– Language: studies published in English.

The search was conducted using the relevant databases: Scopus, ScienceDirect, Google Scholar, ResearchGate and PubMed. Publications were reviewed, screened by title (270 publications) and then by abstract. Relevant literature was documented and synthesized. The limitation was set to publications from 1989 and onwards. The study used a 35-year time span (i.e., publications published between 1989 and 2024) to provide a sufficient number of articles for review. Specifically, there were 5 studies from the decade 1989–1999; 10 studies from 2000 to 2009; 27 studies from 2010 to 2019; and 18 most recent studies from 2020 to 2024, ensuring the inclusion of the most recent data and research on the 30 km/h speed limit assessment. This notable increase in research activity on the effectiveness of speed limit reductions since 1989 can be observed.

Publications from peer-reviewed English language scientific journals, conference papers and articles, websites and scientific reports, were considered for inclusion. Additional search terms were also added. Eventually, 60 publications were thoroughly screened, with the literature predominantly focusing on 30 km/h speed limits.

3.2. The PRISMA Procedure

This review was conducted in January 2024 and adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) steps in order to identify relevant research articles (Moher et al., 2009). The preparation of articles and studies included four phases: identification, screening, eligibility, and inclusion. The methodology was recently updated to incorporate conceptual and practical advances in selecting, identifying, assessing, and synthesizing studies (Page et al., 2021). The initial search was performed in March 2023 and all databases were last accessed in May 2024.

The search resulted in a total of 284 papers, with 77 duplicates. Two reviewers independently screened all papers utilizing a general inclusion/exclusion assessment similar to the approach followed by Hawker et al. (2002). The remaining 207 articles were examined in detail to ensure they meet the criteria set by the researchers. The selected papers needed to fit the standards and pass the inclusion criteria, such as the type of literature, language and period. During the screening stage, the articles were re-evaluated for their suitability based on the title and abstract and 123 records were excluded. Excluded items included books, book series, chapters in books, non-English language articles, and those published before 1989 in order to obtain accurate and high-quality data. A total of 84 articles were selected for full-text review, including full papers, reports and websites suggested by a subject matter expert. After the full paper review, 24 articles and reports were excluded for not meeting the inclusion criteria (i.e., the articled did not focus on the effectiveness of 30 km/h speed limit). In total, 60 scientific papers were included in the final review.

As the review focused on mixed research designs (both quantitative and qualitative assessments along with mixed methods), the quality of the selected publications was assessed using the Mixed Methods Appraisal Tool (MMAT), as presented by Hong et al. (2018). The quality of the selected articles was evaluated based on the clarity of the research questions, confidence in the assessment of these research questions, data collection methods and the suitability of the statistical analysis performed to achieve the objective. Moreover, two reviewers examined how the data in the included studies were interpreted, as well as the presentation of results, discussion, and conclusions. The MMAT guidelines were used to determine the quality, with 100% representing for high-quality articles, 75% above average, 50% average, and 25% low. The reviewers classified 41 articles as having high quality, while the remaining 19 were above average. An overview of the PRISMA flowchart and the search strategy is presented in Fig. 1.

4. Effectiveness of 30 km/h speed limits

As urbanization and motorization continue to grow, a speed limit of 30 km/h should be standard in all areas where cars, cyclists, and pedestrians interact. Setting a speed limit of 30 km/h where people and traffic mix, make streets safer, healthier, greener, and more livable. To date, numerous studies have investigated the effect of reduced speed limits. A detailed description of the significant benefits of speed limit reduction is presented below.

4.1. Safety: Road crashes, fatalities, and injuries reduction

One of the most significant effects of reduced speed limits is the reduction in collisions and serious injuries or fatalities. Several studies have investigated the impact of a 30 km/h speed limit reduction on traffic safety. For example, Abohassan et al. (2024) evaluated the impact of speed limit reduction on traffic safety and driver behavior. Collision and speed data before and after the implementation period were collected and analyzed. Specifically, speed surveys were conducted on 219 road segments before and after the speed limit change. The study utilized a before-and-after with a comparison group approach, using 50 km/h roads that maintained their speed limit throughout as the comparison group. A significant reduction in the overall number of collisions and the number of injuries and fatalities resulting from collisions was observed, with decreases of 25% and 31%, respectively.

Similarly, Uijtdewilligen et al. (2022) conducted a case study from a Dutch cycling capital, employing an hourly temporal resolution in exposure and bicycle safety. Additionally, network-wide bicycle and motorized vehicle volumes were estimated. The results indicated that after the introduction of 30 km/h speed limit, the injury risk of bicyclists reduced by 21%. For car crashes, a majority (75%) of car-to-bicycle crashes occurred on roads with speed limits between 50 and 70 km/h. Therefore, cyclists' safety can be improved by reducing vehicle speeds. Results from 40 different cities across Europe, including Brussels, Paris, and Zurich, indicated that the implementation of 30 km/h speed limits led to an average 23%, 37%, and 38% reduction in road crashes, fatalities, and injuries, respectively (Yannis and Michelaraki, 2024). Lower speed limits also yielded environmental benefits, with emissions decreasing on average by 18%, noise pollution levels by 2.5 dB, and fuel consumption by 7%, indicating enhanced fuel efficiency and reduced environmental impact.

Moreover, an interesting work conducted by Cleland et al. (2020) implemented a *meta*-narrative evidence synthesis, identifying 11 studies reporting nine 20 mph 'zone' and two 20 mph 'limit' interventions. It was revealed that in cities where speed limit reductions were applied, the number of collisions decreased by 24% to 45%, the number of injuries decreased by 42% to 49% and the number of serious injuries, including fatalities decreased by 24% to 63%. At the same time, collisions involving cyclists were reduced by 17%, while the relevant percentage for pedestrians ranged between 21% and 32%. It should be clarified that the exact reductions likely depend on how much actual driving speeds were decreased, how dangerous the street design was in general, as well as the number of "vulnerable" street users.

Bornioli et al. (2020) examined the effect of city-wide 20 mph speed limits on road injuries based on a natural experiment conducted in Bristol, UK. The study showed that speed limit reduction was associated with a city-level decrease in fatal injuries of around 63%. There was also a general trend of a reduction in the total number of injuries at the city level and in 20 mph road. Furthermore, Fridman et al. (2020) investigated the impact of lowering speed limits from 40 km/h to 30 km/h on pedestrian motor-vehicle collisions on local roads in Toronto, Canada. A quasi-experimental, pre-post study with a comparator group was used to assess the effect of the intervention on pedestrian motor-vehicle collision rates before and after the speed limit change using repeated measures Poisson regression. Results demonstrated a 28% decrease in the pedestrian collision incidence rate. It should be noted that 30 km/h speed limits also influenced injury severity, with a 67% drop in major

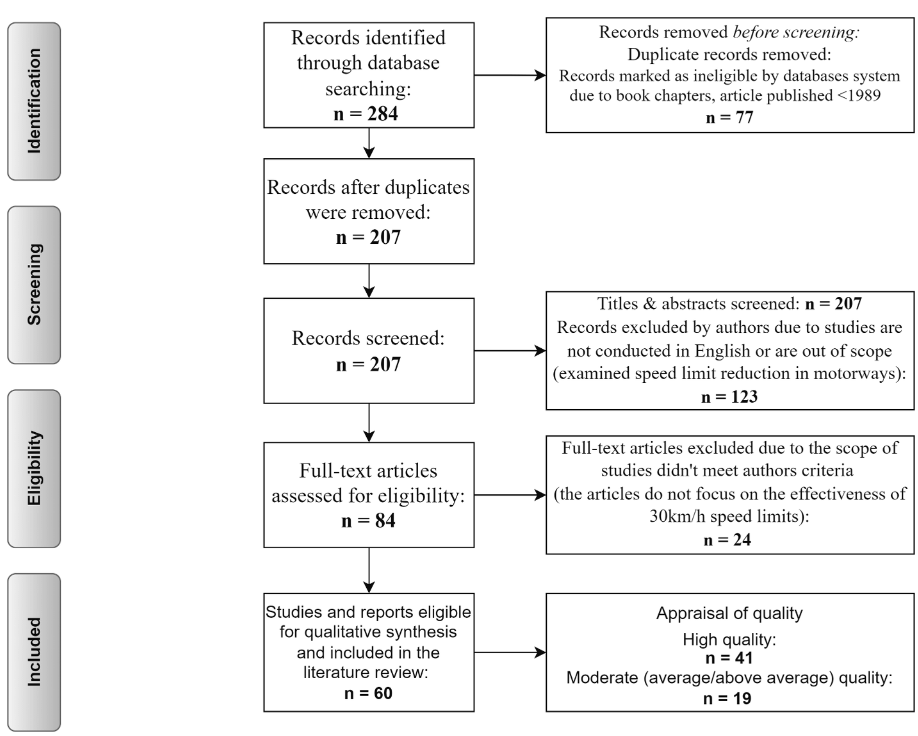

Fig. 1. PRISMA flowchart of the systematic literature review.

and fatal injuries.

Interestingly, Hu and Cicchino (2020) analyzed speed data before and after the speed limit reduction in Boston. Vehicle speeds were collected at sites in Boston where the speed limit was lowered and at control sites in Providence, Rhode Island. A log-linear regression model estimated the change in vehicle speeds associated with the speed limit reduction. Separate logistic regression models estimated changes in the odds of vehicles exceeding 25 mph, 30 mph, and 35 mph associated with the lower speed limit. A statistically significant reduction in average speeds by 0.3% was observed. Furthermore, statistically significant decreases of 2.9%, 8.5%, and 29.3% in the odds of vehicles exceeding 25 mph, 30 mph, and 35 mph, respectively, were reported. It was observed that lowering speed limits can improve road safety for all users.

Another study by Jiao et al. (2019) from New York City examined the effectiveness of neighborhood slow zones using data from the city's Department of Transportation in an interrupted time series analysis. Additionally, a cost-effectiveness analysis was conducted using a Markov model along with one-way sensitivity analyses and Monte Carlo analyses to test for errors in the model. The authors reported that road casualties decreased by 8.74% after the implementation of 20 mph speed limit areas (neighborhood slow zones). Similarly, Lu et al. (2023) proposed a comprehensive simulation-based framework to assess the potential implications of different speed limit policies in urban residential areas. The results revealed that speed limit reduction can significantly improve road safety and environmental externalities within the modeled network/area with a relatively small cost to traffic efficiency.

Hussain et al. (2019) conducted a systematic literature review and *meta*-analysis to examine the relationship between speed and the probability of pedestrian fatality during a vehicle–pedestrian crash. The *meta*-analysis included 15 studies to assess the risk of fatality for pedestrians. Results indicated that at an estimated impact speed of 30 km/h, the pedestrian fatality risk was 5%, while the risk significantly increased to 13% at an impact speed of 40 km/h and 29% at 50 km/h.

A study that examined lowering speed limits from 50 km/h to 30 km/h in school zones in Edmonton, Canada, found a 45% reduction in fatal and severe injury collisions (Sun et al., 2018). Additionally, injuries to vulnerable road users (i.e., cyclists and pedestrians) were reduced by over half (55%). It was highlighted that for every 1 km/h reduction in mean speed, injury and fatal crashes dropped by about 4%, consistent with previous research findings. Furthermore, the decrease in the risk of death for motorcycle and bicycle riders with speed reductions from 50 km/h to 30 km/h was similar to the reductions achieved for pedestrians. More specifically, Jurewicz et al. (2016) reviewed available international research on relationships between impact velocity change, impact speeds, and the probability of fatal and serious injury across a range of common crash scenarios. It was found that the risk of serious injury in a rear-end collision was more than 50% at 50 km/h compared to 30 km/h.

Other studies have found that a vehicle traveling at 50 km/h and hitting a VRU (i.e., pedestrian or cyclist), results in a mortality rate between 55% and 90%. In contrast, at a driving speed of 30 km/h, the mortality rate is equal to or less than 10% (Richards, 2010). Similarly, Grundy et al. (2009) conducted an observational time-series study based on analysis of geographically coded police data on road casualties in the UK for a 20-year timeframe. The key findings showed that 20 mph (32 km/h) zones were associated with a 42% decrease in road casualties. The percentage reduction was greatest in younger children and particularly in the category of killed or seriously injured casualties compared to minor injuries.

Findings from a qualitative study conducted by Lindenmann (2005) showed that changing the speed limit from 50 km/h to 30 km/h resulted in significant reductions in the frequency and severity of crashes on the streets. According to the World Health Organization (2004), pedestrians struck by a motor-vehicle traveling at 50 km/h were found to be eight times more likely to die compared to those struck by vehicles traveling at 30 km/h. Moreover, Webster and Layfield (2003) conducted an observational study to examine the effectiveness of 30 km/h (20 mph) zones with physical traffic calming measures. The results revealed that average annual crashes decreased by 60%, while child pedestrian and cyclist crashes decreased by 70% and 48%, respectively.

Furthermore, Sammer (1994) conducted a before-and-after study investigating the benefits of a 30 km/h speed limit in the city of Graz. Regarding traffic safety, there was a 12% reduction in crashes and 20% fewer serious injuries after introducing the reduced speed limits. Another study by Vis et al. (1992) evaluated changes in crashes, traffic flows, resident opinions, and conflicts. The Ministry of Transport stimulated 15 municipalities to implement a 30 km/h zone and set up an evaluation of the safety effects of these zones. The implementation of this measure resulted in a 5% reduction in the total number of crashes and a 25% reduction in crashes with injuries. Additionally, after the initial implementation of speed limit reductions, several experimental areas in the Netherlands were chosen to determine the effects of enforcing a 30 km/h limit. An experiment conducted in the cities of Rijswijk and Eindhoven implemented different combinations of measures to enforce the 30 km/h speed limit. Results indicated a 70% decrease in the number of injury crashes (Janssen & Verhoef, 1989).

4.2. Environment: Air pollution emissions and noise reduction

In addition to road safety considerations, speed has a uniformly negative impact on the environment. Higher speeds lead to increased levels of noise and exhaust emissions. Streets that promote safe walking and cycling can reduce car dependency and harmful vehicle emissions, which contribute to climate change (World Health Organization, 2021). Specifically, 30 km/h speed limits can reduce carbon dioxide and nitrous oxide emissions from diesel cars, as well as particulate matter emissions from both diesel and petrol cars, thereby reducing air pollution.

Previous studies have shown that the reduction in noise emissions is dependent on the specific location. For instance, Borowska-Stefańska et al. (2023) investigated the effect of speed limits introduced to curb road noise on urban transport system performance in Lodz. It was highlighted that in several zones with 30 km/h speed limits established in urban areas, a reduction of noise pollution was achieved. In a recent study (Brink et al., 2022), the impact of the reduced speed limit on noise levels was evaluated in the city of Zurich. It was found that after the implementation of 30 km/h speed limit, road traffic noise dropped by an average of 1.6 dB during day and 1.7 dB at night.

According to Transport & Environment (2021), 30 km/h speed limits make streets quieter, reducing noise by 3 dB. This reduction is equivalent to halving the source of traffic noise; 10 cars traveling at 30 km/h produce as much noise as only five cars traveling at 50 km/h. Cleland et al. (2020) indicated that after the installation of a 30 km/h speed limit, noise emissions decreased by 1.5 to 4.8 dB (dB), with average values around 3 dB. This was equivalent to a reduction of about 50% in car traffic volumes. However, on roads where the speed limit was not decreased, noise levels could actually rise due to increased car traffic volumes.

Another study showed that substantial noise reduction can be achieved with 30 km/h speed limits, as noise levels can be reduced by approximately 1 to 5 dB, depending on various influencing factors (Müller-BBM, 2019). What's more, Stoecklin et al. (2019) evaluated the effectiveness of 30 km/h speed limits in reducing noise levels and improving the quality of life. Their study demonstrated that by lowering speed limits, noise reductions of 1 to 4–5 dB can be achieved.

Similarly, according to Bühlmann and Egger (2017), the potential noise reduction from implementing a 30 km/h speed limit in place of a 50 km/h limit can be up to 5 dB, depending on the share of heavy vehicles, street design, and driver compliance with the new speed limits. Sorrentino et al. (2015) quantified the effect of various urban traffic mitigation measures on cities' noise levels. It was revealed that speed limit reduction led to an improved quality of life through reduced cut-through traffic and noise, with noise reductions of 3.6 dB from light vehicles and 2.7 dB from heavy vehicles. Additionally, Annecke et al. (2008) found that noise can be reduced by 2.7 dB if the speed is reduced from 40 km/h to 30 km/h.

Regarding air pollution, such as carbon dioxide (CO_2), nitrogen oxide (NO_x), hydrocarbons (HC) and Particulate Matter (PM), it has been demonstrated that reducing the maximum speed limit from 50 km/h to 30 km/h can be beneficial to the environment. To date, scientific research has revealed that 30 km/h speed limits can result in a remarkable decrease in a significant decrease in polluting emissions: 15% in CO_2, 40% in NO_x and 45% in carbon monoxide (CO). The only exception was hydrocarbons, which saw a negligible rise of 4% (Transport & Environment, 2021). On the other hand, Gressai et al. (2021) provided a more nuanced analysis, arguing that the impact of reduced speed limits on traffic can vary depending on network topology, emphasizing the need for careful planning and analysis before implementing speed limit reductions. Moreover, Tang et al. (2019) examined the impact of reducing speed limit from 50 to 30 km/h. Their results showed that emissions of NO_x and PM increased due to the speed limit reduction, though the extent of the increase depended on the type of network and traffic characteristics.

An interesting study conducted by Williams and North (2013) revealed that 30 km/h zones can reduce nitrogen oxide and carbon dioxide emissions from diesel cars and particulate matter emission from both petrol and diesel cars, thereby reducing air pollution. According to Panis et al. (2011), the amount of PM emissions significantly decreased when driving 30 km/h instead of 50 km/h and the exact reductions of NO_x strongly depended on the composition of vehicles and their emission characteristics (e.g. emission class or motor type). In a case study implemented by Madireddy et al. (2011), it was found that 30 km/h speed limits resulted in reductions of approximately 25% in CO_2 and NO_X emissions.

Another important finding from the impact assessment of speed limit reduction (i.e., from 50 km/h to 30 km/h) was that noise levels and NO_x emissions dropped by 2.5 dB and 25%, respectively (Sammer, 1994). Moreover, Litman (1999) studied the cost and benefit of traffic calming measures, such as the implementation of a 30 km/h speed limit in urban areas. It was found that environmental savings in CO, HC, and NO_x, in the range of 13%, 22%, and 48%, respectively, were achievable.

4.3. Energy: Fuel consumption reduction

Previous studies have shown significant benefits in terms of energy and fuel consumption resulting from the introduction of a 30 km/h speed limit. According to the literature findings, lower speeds lead to reduced fuel consumption while smoother traffic flow contributes to additional fuel economy through eco-driving (Salgueiredo et al., 2017). Similarly, Rowland and McLeod (2017) revealed that decreasing maximum speed by 20% (i.e., from 50 km/h to 40 km/h) resulted in a 3.4% reduction in fuel consumption. However, these effects are relatively small and are greatly offset by a more continuous traffic flow (i.e., fewer accelerations) and less car traffic, likely due to reduced capacity and the attractiveness of other modes of transportation (Jones & Brunt, 2017).

In addition, Ahn and Rakha (2009) investigated the environmental and energy impacts of traffic calming measures, such as the implementation of 30 km/h speed limit in urban areas. It was revealed that designs requiring drivers to maintain a more consistent low speed, rather than rapidly accelerating and decelerating, were not only better for road safety but also for fuel consumption and emissions. A survey conducted by Haworth and Symmons (2001) found that lowering speed limits and modifying driving styles improved fuel economy and other environmental outcomes in addition to enhancing safety. Specifically, the results demonstrated that with speed limit reduction, fuel consumption declined by 11%. Additionally, Litman (1999) attempted to quantify the energy and environmental impact of 30 km/h speed limits, finding that reducing vehicle speeds from 50 km/h to 30 km/h led to a 7% decrease in fuel consumption.

Nevertheless, it should be noted that there are some concerns about the positive effect of 30 km/h speed limits on fuel consumption. Arguments are often raised against low-speed zones, claiming that vehicles have less efficient fuel consumption at lower speeds and can also generate more emissions, reducing air quality (Taylor, 2000). For instance, Woolley et al. (2002) argued that fuel consumption may increase under lower speed limits, although this result may have been biased by the specific fuel models available in the study. This concern stems from the common understanding that traditionally, motor vehicles were designed to maximize fuel efficiency when operating at around 50 km/h. However, urban areas with such speed limits typically generate patterns of harsh acceleration and braking due to intersections, turns, or traffic congestion. Research has found that this type of travel pattern is worse for fuel consumption and emissions than traveling at a slower but more consistent operating speed, which reduces the amount of acceleration and braking between stops.

4.4. Traffic: Traffic flow improvement

It is worth mentioning that the establishment of 30 km/h speed limits can be beneficial in improving traffic flow and reducing congestion. Interestingly, at lower speed limits, the following distance among vehicles can be shorter (as cars need less distance to stop than at higher travel speeds), and, thus, there is improved merging of vehicles from the side streets. This allows the road to accommodate a larger number of vehicles traveling at a constant speed, thereby reducing traffic congestion and improving travel times (Global Road Safety Facility, 2023).

After the implementation of city-wide 30 km/h speed limit, a remarkable reduction in traffic volumes was identified. Citywide small reductions can be expected, while specific roads can see a decrease of up to 30% in traffic volumes. This is caused by changes in the decisions of car users, such as changes in mode of transport, routes, or trip frequency (Beek, 2022). It is also important to highlight that crash reduction benefits of lower speed limits improve traffic congestion by reducing the temporary disruptions in traffic caused by road crashes. Additionally, Nightingale et al. (2021) evaluated the effects of a 20 mph speed limit intervention on speed and traffic volumes in the city of Edinburgh. Results indicated an overall 5.7% reduction in average speed and a 2.4% reduction in traffic volumes, though the direction of the effect was uncertain.

Job and Mbugua (2020) found that reductions in speed limits as vehicles reach congested conditions result in smoother traffic flow with fewer stop/start movements. Regarding travel times, there is a general and often misleading assumption among drivers that increasing their driving speed will proportionally reduce overall travel time. It is worth noting that travel times would not be significantly affected by the 30 km/h speed limit change, while delays during off-peak times would decrease by 10% (Abdulghani, 2020). Research has revealed that there is no significant change in travel times, even for bus journeys, due to speed limit reductions in urban areas.

Maher (2018) investigated the impact of speed limit reduction on travel times and found that travel times increased by between 3% and 5%. This slight increase in travel time is usually far lower than most people intuitively assume. These findings are in contrast with those presented by Svensson et al. (2014), who indicated that reduced speed limits can result in a decline in traffic volumes on the specified roads. This is likely due to the fact that in dense urban areas, the proportion of time that can be driven at speeds significantly higher than the 30 km/h limit is quite low, especially during the times of day when most car journeys take place. For example, if drivers travel at 65 km/h instead of 60 km/h, the time saved is a maximum of 46 s over a 10-kilometer distance. However, the risk of being involved in a crash with casualties is doubled (Transport Roads & Traffic Authority, 2011).

Interestingly, Haworth et al. (2001) modeled the travel time costs associated with a national decrease in the general urban speed limit.

They found that reducing the default urban speed limit on arterial and collector roads or local streets by an assumed 5 km/h reduction in average travel speed would prevent an estimated 3,000 casualty crashes per year, with an increase in average travel time per trip of less than 10 s. Furthermore, a 10 km/h reduction in average travel speed would prevent over 8,000 casualty crashes per year while increasing average travel time by less than 26 s per trip.

In fact, in most town and cities, average speeds are less than 30 km/h due to traffic congestion and other factors, such as junctions and traffic lights. In a survey conducted in Australia by Cairney and Donald (1996), it was suggested that any increase in journey time due to lowered speed limits was negligible. Drivers can travel at lower speeds with smaller spacings, maintaining a stable and relatively high throughput (e.g., with less "stop/start" traffic or "shock waves"), especially at the onset of congestion and during congested traffic conditions and times. This not only positively impacts traffic congestion but also road safety. Similarly, Vis et al. (1992) demonstrated that the implementation of a 30 km/h speed limit on specific streets in the Netherlands contributed to a 5–30% decrease in traffic volumes.

4.5. Livability: Sustainable, physical, and mental health improvement

Within this context, motor-traffic volumes decrease as slower speeds encourage active, sustainable, and shared travel. Specifically, 30 km/h speed limits facilitate and promote environmentally friendly and more active transport modes, such as walking, cycling, and public transport, freeing up more space for urban recreation, commerce, and outdoor activities. This improves physical and mental health and creates vibrant cities with better livability (Karndacharuk & McTiernan, 2019a). Reducing speed limits in urban areas provides substantial cost savings and health benefits (Neki et al., 2021). Furthermore, Cleland et al. (2021) demonstrated that the widespread implementation of 30 km/h speed limits in cities can improve public health through reduced emissions and increased physical activity related to walking and cycling.

As already mentioned, the improvements due to reduced noise are substantial. Findings from a study conducted by Rossi et al. (2020) revealed that noise reduction had a greater impact on public health improvements than the reduction in collisions. This was likely due to reduced stress levels and better sleep, which positively impacted the prevalence of cardiovascular diseases and diabetes. Similarly, the effects of decreased air pollution due to less car traffic could prevent a significant number of years of life lost (Cepeda et al., 2017). Moreover, Brown et al. (2017) indicated that increased active travel modes provide substantial health benefits due to more physical activity. The overall health effects from the large decrease in road crash injuries are probably relatively small compared to the possible extents of increased health due to less noise, less air pollution, and more physical activity.

According to Pilkington et al. (2018), lower speed limits enhance safety by reducing the risk and severity of crashes, making roads more pedestrian- and cyclist-friendly. It was observed that with the introduction of 20 mph speed limits, walking and cycling across Bristol increased, both among children travelling to school and adults commuting to work. Vulnerable road users (VRUs), such as pedestrians and cyclists, feel safer with lower speed limits, further promoting these active travel modes. Additionally, lower speeds can create a more pleasant and less stressful environment, motivating residents to engage in healthier, more environmentally friendly modes of transport. The perception of safer streets directly correlates with the rise in active travel activities like walking and cycling.

It should be noted that safety on the roads is paramount. Drivers tend to choose the modes of transport by which they and those around them will be safest. Research has shown that most road crashes are caused by vehicles, with the driver being often at fault (Salmon et al., 2011; Staubach, 2009). Therefore, if users feel safer by other transport modes, they are more likely to prefer these alternatives and reduce their car usage. In addition, simulation studies demonstrated significant subsequent increase of active travelling (pedestrians, cyclists and e-scooters) and Public Transport passengers, as mobility conditions become more user friendly to the vulnerable road users (Van Erpecum et al., 2024).

Moreover, perceived safety is a significant factor. When speed limits are reduced, VRUs feel more secure on the roads. This increased sense of safety encourages more people to walk or cycle instead of driving. As more individuals choose these active modes of travel, the streets become more vibrant and accommodating to non-motorized users, further promoting walking and cycling. Furthermore, a shift in travel modes occurs. As active travel modes become more appealing and widely adopted, the reliance on cars decreases. This transition not only alleviates traffic congestion but also reduces the overall attractiveness of car usage.

At the same time, Cairns et al. (2015) revealed that 20 mph zones and limits were effective means of improving public health through reduced road crashes and injuries. Calm driving at lower speeds contributes to healthier living for drivers. All road users, especially children and the elderly, are more likely to walk and feel more confident venturing outside their homes and crossing the street. Furthermore, the implementation of 30 km/h speed limits in urban areas increases opportunities for work and friendship and reduces health inequalities by improving accessibility for road users with restricted mobility, hearing, vision, or mental health, as well as for children, the elderly, pedestrians, cyclists, youth, and commuters (Pickett et al., 2014).

Concerning different transport modes, the effect of implementing 30 km/h speed limits is multifaceted. Firstly, it is easier for motorists to merge with traffic traveling at 20 mph rather than 30 mph. Additionally, buses operate more efficiently. The reduced length of traffic queues can decrease bus journey times, increase reliability, and make buses more attractive compared to cars. According to Turley (2013), a 30 km/h speed limit in urban areas can lead to increased physical activity due to improved comfort for people using active modes. Furthermore, children are more likely to walk or cycle to school on their own, and older people are more confident in venturing outside their homes, crossing the street, or driving their own cars at a more reasonable (i.e., slower) speed rather than always at 30 mph.

Lastly, it should be noted that 30 km/h speed limits can save lives, reduce economic costs and positively contribute to the economic growth of each country. According to a Welsh Government report published by Davis and Jones (2022), the direct estimated cost of introducing the 30 km/h default will be £32.3 million. In the first year, it is estimated that the road crash casualty savings at 20mph will be just over £92 million; nearly three times higher than the implementation cost. Over a three-year period, the benefits are estimated to be between 8–9 times higher than the implementation cost (£275.8 million). Reduced speed limits were also associated with cost-savings of $15 USD per resident to the healthcare system (Jiao et al., 2019). An interesting finding by Jones and Brunt (2017) estimated that if all current 30 mph limit roads in Wales became 20 mph limits, 1,200 to 2,000 casualties would be avoided and 6 to 10 lives would be saved each year.

5. Discussion

All in all, this study addressed a gap in the existing literature by evaluating the impact of reducing the speed limit from 50 km/h to 30 km/h. While the effectiveness of speed limit reductions has been studied in different contexts, assessing their impact on an urban environment using a multi-parameter approach (i.e., safety, emissions, energy, traffic, livability, and health) is a novel undertaking. This work presented a comprehensive framework for evaluating the benefits of a default speed limit reduction, which can be replicated by other cities worldwide. Additionally, the key results derived from this study contribute to a more comprehensive understanding of the effectiveness of a 30 km/h speed limit. These findings can also influence future actions and policies, fostering a safer road environment for all users globally.

Previous studies have shown that speed limit reduction serves multiple purposes, including fuel savings, noise and emissions reduction, and, most importantly, enhancing road safety. Higher speeds have been consistently linked to longer reaction times, increased stopping distances, and a greater risk of crashes, fatalities, and serious injuries. Higher vehicle speeds contribute to increased greenhouse gas emissions and fuel consumption, adversely impacting the quality of life, especially for people living in urban areas. Speed has significant impacts on the environment as it is strongly related to the emissions of greenhouse gases (mainly NO_x) and local pollutants (CO, NOx, PM, HC).

Speed significantly affects the exterior noise emitted by vehicles, thereby influencing overall levels of traffic noise, a major concern particularly in urban areas and at night. Travel speed, both actual and perceived, also shapes people's perceptions of their surroundings and amenities. Increased mobility, faster travel times, and enhanced access to facilities generally improve quality of life assessments. However, the adverse impacts on the environment, such as increased emissions, detract from overall quality of life. Some impacts, like injuries or noise pollution, can be quantified, whereas disruptions to local communities or fear caused by fast-moving vehicles can't be easily measured but still have significant effects. In these instances, the social costs of speed are primarily borne by those outside of moving vehicles.

Taking all the aforementioned aspects into consideration, the implementation of 30 km/h speed limits will not only improve road safety, but also provide significant cost savings and health benefits delivered by transport noise and air pollution reduction or increased pedestrian and cyclist active mobility.

Table 2 provides an overview of the studies assessing the benefits of 30 km/h speed limits, while the maximum and average values of the quantitative effect of 30 km/h speed limit in terms of safety (i.e., crashes, fatalities, injuries), emissions, fuel consumption, traffic volumes and travel times are presented in Table 3.

Based on Table 2, it can be observed that 52% (31 out of 60) of the studies included were quantitative, encompassing experiments, observational research, or time series analyses. Additionally, 37% (22 out of 60) were qualitative, consisting of systematic literature reviews and *meta*-analyses. Notably, 12% (7 out of 60) of the studies employed mixed methodologies, incorporating various research approaches.

It should be explicitly stated that Table 3 contains the maximum and average values extracted from the aforementioned 60 studies for which information was available. It is worth highlighting that each study examined varied in its characteristics, such as the extent of the 30 km/h implementation area (e.g., 75% of the road network, 65% of urban roads, or the entire city center), population size, or the duration over which the assessment was conducted. Taking into account these diverse factors, interpreting the results within the context of population disparities posed challenges. Therefore, a cautious approach was adopted by focusing solely on presenting the average observed changes.

The implementation of 30 km/h speed limit has profound positive effects on both road safety and environmental factors. As summarized in Table 3, crashes decreased on average by 30%, with pedestrian-involved crashes showing an even more substantial reduction of 43%. Fatalities and injuries also significantly decreased, with average reductions of 45% and 40%, respectively, while the most significant reductions were observed in incidents involving pedestrians. Moreover, there were substantial decreases in CO_2 emissions (20%), NO_x emissions (35%), and PM emissions (20%), contributing to improved air quality. Additionally, noise levels decreased by an average of 3.7 dB, and fuel consumption dropped by 7%, indicating not only safer roads but also environmental benefits.

Furthermore, the impact of speed limit reductions extended beyond safety and environmental aspects to traffic management. Despite an average reduction in traffic volumes of 16%, there was no substantial increase in travel times, suggesting that the benefits of speed limit reductions do not lead to increased congestion. These findings highlight the multifaceted advantages of implementing lower speed limits, emphasizing not only the importance of road safety but also the significant positive impacts on public health and environmental sustainability. Therefore, policymakers and urban planners should consider speed limit reductions as a comprehensive strategy for creating safer, healthier, and more sustainable communities.

Table 4 presents a comprehensive overview of findings from previous research on the benefits of 30 km/h speed limits, encompassing reductions in crashes, fatalities, injuries, emissions, fuel consumption, traffic, and noise. It was revealed that 11% of studies indicated that city-wide 30 km/h speed limit could result in a 0–5% reduction in crashes, while 22% reported reductions of 5–20%, another 22% found reductions of 20–35%, 11% reported reductions of 35–50%, and 33% observed reductions of more than 50%. With regards to fatalities, researchers were evenly split; 33% of them reported a reduction in fatalities by 20–35%, 35–50%, and more than 50%. At the same context, 11% of researchers reported a 5–20% reduction in injury risk, 33% found a 20–35% reduction, 22% found a 35–50% reduction, and 33% found a reduction of more than 50%.

With respect to emissions, 22% of researchers observed a 5–20% decrease in pollutant emissions, while 44% reported a 20–35% reduction and 33% noted a 35–50% drop. In terms of fuel consumption, 33% of researchers found a 0–5% reduction and 67% reported a 5–20% reduction. Interestingly, 10% of researchers reported a noise reduction of 0–2 dB, 50% found a reduction of 2–4 dB, and 40% stated a reduction of more than 4 dB. Lastly, concerning traffic volumes, 25% of researchers revealed a 0–5% decrease in traffic, 50% reported reductions of 20–35%, and 25% found reductions of 35–50%.

The results were grouped around the values reported in previous research, as presented in Table 4.

5.1. Limitations

This study has several limitations worth noting. Firstly, while all studies included in the *meta*-analysis reported significant reductions in crashes following speed limit reductions, they did not compare these streets to others where speed limits remained unchanged. Specifically, the roads evaluated at 50 km/h for crash analysis were primarily arterials, while those at 30 km/h were predominantly local streets. Although both types of roads exhibited similar collision trends prior to the speed limit change, the generalizability of the results to other road types may be limited. Furthermore, there was limited available data to investigate the operational effects of speed limit reductions. Altering speed limits on specific roads is likely to change speeding patterns and traffic flow within the adjacent road network, potentially leading to collision migration.

The impact of reduced speed limits on several aspects remains poorly studied, including livability, the significance and usage of public space, social interactions, social cohesion, life satisfaction, sense of belonging, and sense of street ownership. Furthermore, the exact effects on mental and physical health have not been directly measured.

Based on a comprehensive review of scientific literature, mixed results have emerged regarding fuel consumption, energy use, and the impact of speed limit reductions. Studies indicate that driving at 30 km/h instead of 50 km/h may lead to increased fuel consumption and CO_2/NO_x emissions in certain contexts. Opponents of 30 km/h speed limits in cities often cite a study by Cerema (2020), which found higher CO_2 emissions when vehicles maintain a constant 30 km/h compared to 50 km/h. This is attributed to increased emissions during frequent acceleration and deceleration typical in urban driving conditions. However, these effects are generally modest and can be offset by smoother traffic flow with fewer accelerations and reduced overall car traffic, which makes alternative modes of transport more appealing (Jones & Brunt, 2017).

The relationship between speed and air quality is complex, influenced by factors such as vehicle type, brake and tire wear, variability in driving speeds, and the nature of the road environment. Studies conducted elsewhere have not definitively shown either a positive or

Table 2
Overview of the studies assessing the benefits of 30 km/h speed limits.

No	Author	Year	Main StudyDesign	Quality	Safety Crashes	Fatalities	Injuries	Emissions CO_2, NO_x, PM	Noise	Energy Fuel	Traffic Traffic Volumes	Traffic Flow	Travel Time	Liveability	Health	Cost
1	Abohassan et al.	2024	mixed method	high	−25%	−31%	−31%									
2	Borowska-Stefańska et al.	2023	quantitative	high				↓								
3	Global Road Safety Facility	2023	qualitative	above average							improved					
4	Beek	2022	mixed method	high							−30%					
5	Brink et al.	2022	quantitative	high					−1.7 dB							
6	Uijtdewilligen et al.	2022	quantitative	high			−21%*									
7	Davis & Jones	2022	quantitative	above average												3 times higher road crash casualty savings
8	Nightingale et al.	2021	quantitative	high							−2.4%					
9	Neki et al.	2021	qualitative	high											improved	↓
10	Cleland et al.	2021	qualitative	high											improved	‘
11	Gressai et al.	2021	quantitative	high				combined effect								
12	Transport & Environment	2021	quantitative	above average				−15% CO2, −40% NOx and −45% CO,+4% HC	−3 dB							
13	Rossi et al.	2020	mixed method	high											improved	
14	Abdulghani	2020	mixed method	high								−10% delays	no impact			
15	Cleland et al.	2020	mixed method	high	−54%, −17%*, –32%**	−63%	−49%		−4.8 dB		−50%					
16	Bornioli et al.	2020	quantitative	high			−63%									
17	Fridman et al.	2020	quantitative	high	−28%**	−67%**	−67%**									
18	Job & Mbugua	2020	qualitative	above average								smoother				
19	Hu & Cicchino	2019	quantitative	high	−0.3% speed											
20	Hussain et al.	2019	qualitative	high		−24%**										
21	Jiao et al.	2019	quantitative	high	−9%											cost-savings of $15 USD per resident
22	Tang et al.	2019	quantitative	high				↑								
23	Karndacharuk & McTiernan	2019	qualitative	high										improved		
24	Stoecklin et al.	2019	qualitative	above average					−5 dB							
25	Müller-BBM	2019	qualitative	average					−5 dB							

(*continued on next page*)

Table 2 (*continued*)

No	Author	Year	Main StudyDesign	Quality	Safety Crashes	Fatalities	Injuries	Emissions CO_2, NO_x, PM	Noise	Energy Fuel	Traffic Traffic Volumes	Traffic Flow	Travel Time	Liveability	Health	Cost
26	Sun et al.	2018	quantitative	high	−45%	−45%	−55% (cyclists & pedestrians)									
27	Pilkington et al.	2018	qualitative	above average										improved		
28	Maher	2018	mixed method	average									+5%			
29	Jones & Brunt	2017	quantitative	high		2,000 less casualties (6–10 lives would be saved each year)										a value of prevention of £58 M–£94 M each year
30	Rowland & McLeod	2017	quantitative	high						−3.4%						
31	Salgueiredo et al.	2017	qualitative	high						↓		smoother				
32	Cepeda et al.	2017	qualitative	high											improved	
33	Brown et al.	2017	qualitative	high											improved	
34	Bühlmann & Egger	2017	qualitative	above average					−5 dB							
35	Jurewicz et al.	2016	quantitative	high			−50%									
36	Sorrentino et al.	2015	quantitative	high					−3.6 dB (light vehicles) and −2.7 dB (heavy vehicles)							
37	Cairns et al.	2015	qualitative	high											improved	
38	Svensson et al.	2014	qualitative	high							↓					
39	Pickett et al.	2014	qualitative	average											improved	
40	Williams & North	2013	quantitative	above average				↓								
41	Turley	2013	qualitative	average										improved		
42	Madireddy et al.	2011	quantitative	high				−25% in CO2 and NOx								
43	Panis et al.	2011	quantitative	high				↓								
44	Transport Roads & Traffic Authority	2011	quantitative	above average									+46 s over a 10-kilo-metre distance			
45	Richards	2010	quantitative	high		9 times less mortality rate										
46	Grundy et al.	2009	quantitative	high		−42%										
47	Ahn & Rakha	2009	qualitative	high				↓		↓						
48	Annecke et al.	2008	quantitative	above average					−2.7 dB							
49	Lindenmann et al.	2005	qualitative	high	↓	↓	↓									

(*continued on next page*)

Table 2 (*continued*)

No	Author	Year	Main StudyDesign	Quality	Safety Crashes	Fatalities	Injuries	Emissions CO_2, NO_x, PM	Noise	Energy Fuel	Traffic Traffic Volumes	Traffic Flow	Travel Time	Liveability	Health	Cost
50	World Health Organization	2004	quantitative	above average		8 times less mortality rate**										
51	Webster & Mackie	2003	quantitative	high	−60%, −48%*, −70%**											
52	Woolley et al.	2002	qualitative	high						↑						
53	Haworth et al.	2001	quantitative	high	8,000 less casualty crashes per year								+26 s per trip			
54	Haworth & Symmons	2001	mixed method	above average						−11%						
55	Taylor	2000	qualitative	above average						↑						
56	Litman	1999	quantitative	high				–22% HC, −48% NOx and −13% CO		−7%						
57	Cairney & Donald	1996	qualitative	average									no impact			
58	Sammer	1994	quantitative	above average	−12%		−20%	−25% NOx	−2.5 dB							
59	Vis et al.	1992	quantitative	high	−5%		−25%				−30%					
60	Janssen & Verhoef	1989	quantitative	high	−70% (injury crashes)											

* this reduction refers to cyclists.
** this reduction refers to pedestrians.
*** the symbols ↓ and ↑ indicate that the quantitative effect of this measure has not been provided; only qualitative impact is given in the relevant study.

Table 3
Maximum and average values of the quantitative effect of 30 km/h speed limits.

	Max	Average
Crashes	−60%	**−30%**
Crashes (pedestrians)	−70%	**−43%**
Crashes (cyclists)	−48%	**–33%**
Fatalities	−63%	**−45%**
Fatalities (pedestrians)	−67%	**−46%**
Injuries	−63%	**−40%**
Injuries (pedestrians)	−67%	**−61%**
Injuries (cyclists)	−55%	**−38%**
CO_2 emissions	−25%	**−20%**
NO_x emissions	−48%	**−35%**
PM emissions	−45%	**−20%**
Noise	−5 dB	**−3.7 dB**
Fuel consumption	−11%	**−7%**
Traffic volumes	−30%	**−16%**
Travel times	+5%	***no impact***

Table 4
Grouped impact of 30 km/h speed limits on several metrics around the values reported in previous research.

Reported reduction by researches	**0–5%**	**5–20%**	**20–35%**	**35–50%**	**>50%**
Crashes	11%	22%	22%	11%	33%
Fatalities			33%	33%	33%
Injuries		11%	33%	22%	33%
Emissions		22%	44%	33%	
Fuel	33%	67%			
Traffic	25%		50%	25%	
Reported reduction by researches	**0-2db**	**2-4db**	**>4db**		
Noise	10%	50%	40%		

negative effect on air quality from driving at 30 km/h speed limits; some emissions may increase slightly while others decrease under these conditions.

Lastly, it should be noted that the research findings underscored the significance of conducting context-specific analyses when adjusting speed limits, taking into account factors such as local conditions, traffic volumes, and road type. Nevertheless, it is important to recognize that careful planning and thorough analysis are essential prerequisites before implementing any modifications to speed limits, as their impact can vary significantly depending on the specific characteristics of the road network and surrounding environment.

5.2. Future research directions

To address the limitations identified in previous studies, several future research directions are proposed. Firstly, this study highlighted the positive impact of implementing lower speed limits on road safety, evidenced by significant reductions in both vehicle speeds and collisions. However, there were instances where drivers did not comply with the new speed limits, indicating the need for additional measures to ensure compliance. Overall, these findings underscore the importance of reducing speed limits to enhance road safety and stress the ongoing necessity for monitoring and assessing road conditions to inform decision-making effectively. The framework developed in this study can serve as a valuable tool for other local authorities and regions seeking to evaluate the effects of implementing lower speed limits within their own jurisdictions.

Further examination and additional data collection are essential to comprehensively assess the potential effects of 30 km/h speed limits. To effectively evaluate the impact, various types of data should be considered. These include crash data, which would encompass details such as the road speed limit, crash location, road conditions, number of people involved or injured, crash cause, and crash type. Road-specific data, such as geographic characteristics, road density, and types of roads (secondary or municipal), are also crucial for a thorough analysis. Additionally, incorporating location-specific data such as time of day and traffic levels can provide insights into how different conditions influence the effectiveness of speed limit reductions. Real-time field driving data collected through GPS devices can further enhance the analysis by quantifying the energy and environmental impact of traffic calming measures.

Further studies should incorporate average values of quantitative effects, appropriately weighted by factors such as population size or the total length of the area where 30 km/h speed limits are implemented. This approach aims to provide a more accurate representation of the overall effects observed across studies with available data. The size and characteristics of each city will be also considered, allowing readers to interpret the results within the context of population disparities. This transparency will ensure that our conclusions accurately reflect the diversity of urban settings and avoid oversimplification of the data.

Lastly, future research could indeed benefit from incorporating sociodemographic variables and analyzing multiple demographic groups, such as age and gender. This approach would enable a more comprehensive examination of the effects of speed limit reductions across diverse segments of the population.

6. Conclusions

All in all, speeding (i.e., excessive or inappropriate speed) remains a prevalent social problem and ranks as the foremost road safety issue in many countries. It is a contributing factor in approximately one-third of fatal crashes and exacerbates the severity of all types of collisions.

The aim of this paper was to evaluate the effectiveness of implementing a city-wide 30 km/h speed limit. This objective was pursued through a detailed literature review highlighting the benefits of such speed limits in urban settings. The study comprehensively assessed changes in speed, collisions, emissions, energy consumption, traffic flow, livability, and health outcomes before and after the implementation of the new speed limit.

This study aimed to address a gap in the current literature by evaluating the multifaceted impact of 30 km/h speed limits in urban areas, focusing not only on safety and environmental factors but also on broader aspects. The primary research question sought to determine the overall effect of implementing 30 km/h speed limits on safety (resulting in an average 45% reduction in fatalities), emissions (averaging a 25% reduction), energy consumption (with an average reduction of 7%), traffic flow (no significant impact), livability and health. Regarding the second research question, the findings indicated that safety outcomes were most significantly affected, with an average 40% reduction in crashes, fatalities, and injuries following the implementation of a 30 km/h speed limit.

The findings underscored that city-wide 30 km/h speed limit represents a crucial life-saving measure, significantly reducing both fatalities and severe injuries. The relationship between speed and the risk of injury or death applies universally across all road users involved in crashes. Implementing legislative, enforcement, and road engineering measures to reduce urban speed limits not only decreases injury and fatality rates in crashes but also yields substantial cost savings and health benefits. These benefits encompass reductions in transport-related noise and air pollution, alongside enhanced opportunities for active mobility among pedestrians and cyclists. Furthermore, lower urban speeds, complemented by effective urban street policies, promote public transportation, allocate less space for motorized vehicles in favor of non-motorized modes of transport, and create more room for urban recreational activities, ultimately enhancing livability and fostering vibrant cities.

Based on the principles of the Safe System Approach, which prioritizes the prevention of fatalities and serious injuries, the implementation of a 30 km/h speed limit in urban areas is deemed appropriate, especially where vulnerable road users are prevalent and conflicts with vehicular traffic are likely. Achieving effective implementation requires a comprehensive approach involving enforcement and infrastructure measures. Firstly, robust enforcement mechanisms should be established to ensure compliance with the new speed limits. This includes increased police presence, speed cameras, and public awareness campaigns to educate drivers about the importance of adhering to the lower speed limit for enhanced road safety. Simultaneously, infrastructure improvements are essential to support the 30 km/h speed limit. Urban streets should be redesigned to prioritize the safety of vulnerable road users, such as pedestrians and cyclists. Measures may include implementing traffic calming measures, establishing dedicated bicycle lanes, and enhancing pedestrian crossings to create safer environments.

In conclusion, urban planning strategies should prioritize mixed-use developments and compact urban forms that promote walking and cycling and reduce reliance on motorized transportation. Integrating public transport with pedestrian and cycling infrastructure can also encourage modal shifts away from private vehicles, further reducing the demand for higher speeds on urban roads. By adopting a comprehensive approach that combines legislative measures, rigorous enforcement actions, and infrastructure enhancements, the implementation of a 30 km/h speed limit can significantly improve road safety and create more livable and sustainable urban environments.

CRediT authorship contribution statement

George Yannis: Writing – review & editing, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Eva Michelaraki:** Writing – original draft, Visualization, Resources, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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