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Effectiveness of 30 km/h zones in urban areas

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Abstract

This thesis assesses the effectiveness of implementing 30 km/h zones in urban areas, focusing on their impact on road safety, noise and air pollution, and overall quality of life. Using a mixed-methods approach that includes a literature review and a survey conducted amongst Dutch residents, this thesis seeks to provide a comprehensive - evaluation of these slow zones. The literature review revealed that several European cities like Bilbao, Brussels, London, and Paris have successfully implemented slow zones, reducing traffic accidents and fatalities, decreasing noise and air pollution, and enhancing the overall quality of life. However, the results from the survey presented a more nuanced picture. While most respondents (59.4%) expressed to believe that the 30 km/h zones improve road safety, the results on the overall implementation and effectiveness were divided. Key findings include an observed lack of adequate enforcement, a significant majority indicated to not observing an improvement in air and noise pollution (83.3% and 69.4% respectively), and it was also revealed that only a small fraction of respondents noticed an improvement in traffic congestion (3 out of 31 respondents). The study emphasizes the importance of effective enforcement, public awareness and clear communication in the successful implementation of speed limits in urban environments. Limitations of the research include the relatively small sample size and reliance on perception-based statements gathered form the survey. Future research should focus on including longitudinal studies and comparative analyses in the cities that have already implemented slow zones, to better assess the long-term effects of 30 km/h zones in urban environments.

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1. Introduction

Every week, around fifteen people are injured or involved in traffic accidents on the streets of Amsterdam (Gemeente Amsterdam, 2023). This is one of the main reasons for Amsterdam becoming the first city in the Netherlands to implement the 30 km/h zones on a large scale. Whilst there were already certain streets with the 30 km/h speed limit, in December of 2023 the city implemented the slow zones in 80% of the city.

In recent years, the implementation of 30 km/h zones in and around urban areas has increased significantly as a measure to improve the quality of life through enhanced road safety, protecting pedestrians and cyclists, and decreasing noise and air pollution. Various other cities in other countries have already implemented 30 km/h (slow-)zones. Several cities in the UK embraced these slow zones (20 mph roads) and reported decreases in traffic collisions, however, no clear evidence has been found that indicates higher rates of walking and cycling, or less pollution in the city centers (Cleland et al., 2020; Grundy et al., 2009). In Spain, Bilbao became the first major city to implement a city-wide 30 km/h speed limit in 2020. This resulted in fewer accidents and increased walking and cycling among residents (Yannis & Michelaraki, 2024). In 2021, Paris expanded its 30 km/h zones, resulting in fewer traffic accidents and attracting more people to social settings. Salazar-Miranda et al. (2022) argue that implementing 30 km/h zones has made Parisian streets feel safer and more comfortable. Brussels implemented the 30 km/h speed limits in its entire region at the start of 2021, apart from certain roads. Brussels stated that the main benefits would be improved road safety, less traffic, and reduced noise pollution (Yannis & Michelaraki, 2024; Times, 2023). The lower speed limits are intended to decrease the chances and severity of traffic accidents, specifically in highly and densely populated areas where vehicles, cyclists, and pedestrians interact with each other frequently. The slow zones are also meant to decrease noise- and air pollution from traffic, and to create a virtually car-free city. The reduced speed is thus meant to create a safer and more livable environment, contributing to the overall quality of life in cities.

The objective of this thesis research is to assess the effectiveness of implementing 30 km/h speed limits in urban environments. The assessment will be based on two methods of research. The first method is a literature review of available papers and articles about cities that have already implemented slow zones in urban areas. In the literature review, there will be a focus on several European cities. The cities will be Brussels, Paris, Bilbao, and London. These cities have implemented slow zones in their streets for a couple of years already and have had extensive and sufficient research and analyses done regarding the effectiveness. In the literature review, the focus will be on several determinants of the effectiveness of slow zones. The main determinants of the effectiveness are split up into four categories, the number and severity of road/traffic accidents, the noise and air pollution, the overall quality of life, and the change in distribution of mode of transport. In most cities that proposed to

implement slow zones, the first three categories are the most important drivers of the initiative. In a review of 30 km/h speed limit benefits in Europe, results from 40 different cities showed that a reduction in speed limits improved road safety by decreasing the chances of road accidents and the severity of the injuries (Yannis & Michelaraki, 2024). The implementation of slow zones in these cities resulted in a 23% decrease in road crashes, a 37% decrease in fatalities of road accidents, and a 38% reduction in injuries.

Implementing slow zones often is reported to reduce noise pollution in urban areas by up to 5 dB (Bühlmann and Egger 2017; Gemeente Amsterdam, 2023). The main reasoning used to explain this is that introducing a 30 km/h speed limit will discourage unsteady driving behavior, meaning less erratic braking and accelerating. A study on road traffic noise in Gothenburg, Sweden, showed opposing results (Ögren, 2018). The paper uses the Nordic prediction method to predict the noise from road traffic at different speeds. The results from the prediction show that there is a slight decrease in noise of 1.1 dB when vehicles drive at 50 km/h as opposed to 30 km/h. This is explained by the authors to be because of the vehicles using a gear that gives higher engine speed, and because vehicles accelerate and decelerate more often while driving at low speeds.

The second method will be an analysis of a survey among Dutch citizens, who live and/or move in and around the 30 km/h zones in their daily lives. The survey interprets their perception of the newly introduced 30 km/h zones in the Netherlands. The survey portrays the views of two groups of people, the first group being people who live on a 30 km/h street, and the second group of respondents also includes people who do not. Group one was assigned more questions regarding their personal experiences living in the slow zones. Group two was only asked questions about their experience when using/traveling in the slow zones.

The remainder of the thesis is structured as follows. In section 2 the following will be discussed: the background of slow zones worldwide and a literature review that expands on the risks posed by speeding vehicles. Section 3 explains the methodology of the research. In section 4, the results from the survey will be analyzed and compared to the findings of existing literature, while sections 5 and 6 provide a discussion and conclusion respectively.

2. Background and Literature review

2.1 Introduction

Urban areas nowadays are complex environments where vehicles, cyclists, and pedestrians coexist. This coexistence has become more prominent through the years as the population density in these urban areas keeps growing. Effective management of vehicle speeds in these areas, thus becomes more crucial for road safety and the quality of urban life. This chapter will briefly discuss the history of urban speed limits, delve into the importance of managing vehicle speeds, the risks associated with speeding vehicles, some international guidelines and recommendations on vehicle speeds, and a comprehensive literature review of previous studies on the subject of slow zones (30 km/h zones).

2.2 Historical Development of Urban Speed Limits

The first gasoline-fueled automobile (car) was invented by Karl Friederich Benz, in 1885. A three-wheeled motor car that could reach speeds of up to 21 km/h (13 mph). However, the origins of speed limits can be dated back to way before the first motorized vehicles were invented; almost 200 years before the first car was invented, in Newport, Rhode Island, a form of speed limit was put into work. The city restricted horses to gallop (the fastest form of gait of the horse) on major streets. The reason being to prevent pedestrians from being trampled to death by the horses (Speed Management, n.d.).

The English Parliament introduced the world's first speed limit for mechanically propelled vehicles in 1861, the Locomotive Act. The Locomotive Act initially limited the speed of all road vehicles on public highways to 16 km/h (10 mph), and 8 km/h (5 mph) through cities, towns, or villages (The Locomotive Act, 1861). Changes to the speed limits were made throughout the years to address new changes in vehicle technology, road infrastructure, and traffic management philosophies.

In the 20th century, after the invention of the first car, the concern over road safety began to become more significant. The notion of the 30 km/h speed limit specifically emerged in the late 20th century. This notion was mainly driven by the concerns in residential areas and zones with large amounts of pedestrian activity. Over time, this approach gained global traction, with multiple cities in Europe, Asia, and America adopting 30 km/h (20 mph) zones as a part of traffic calming and urban planning strategies.

As stated before, the main reason for implementing speed limits was to increase safety for both vehicle drivers and pedestrians. One exception to the safety objective occurred during the oil crisis in the 1970's. During this period, a lot of countries lowered the speed limit to conserve the fuel used by cars and this was seen as the first nationwide

strategy for oil conservation (“Editorial: Cap U.S. Speed Limit at 55 Mph to Save Gas,” 2008). In 2011, the Spanish government revived this method and lowered its maximum speed limit from 120 km/h to 110 km/h in an attempt to lower fuel consumption as the oil prices were rising (The Guardian, 2011).

2.3 Importance of Managing Vehicle Speeds in Urban Areas

In urban areas, it is crucial to manage vehicle speeds for several reasons. Driving at higher speeds significantly increases the chance and the severity of crashes and fatalities. Urban areas are densely populated, with large amounts of pedestrians and cyclists, which makes speed management more critical to ensure safety for all road users. Through managing speed, the overall livability of the urban spaces is enhanced, and non-car drivers will be more comfortable moving around the area. Besides road safety, some research proposes that driving at lower speeds also reduces noise and air pollution, thereby contributing to healthier and more sustainable cities.

Speed management is a form of traffic calming. Traffic calming refers to a set of strategies to reduce vehicle speeds to improve safety for all road users. The underlying principle is to encourage safer driving behavior through implementing measures and road design. Some examples of traffic calming techniques are the installation of speed humps, narrowed roads, and lower speed limits on busy urban roads.

The 30 km/h speed limit is seen as one of the most effective traffic calming measures. This statement is based on the principle that driving at lower speeds results in several positive effects on driving behavior. When vehicles drive at a slower speed, drivers have more time to process information and it allows for braking distances to be shorter (Aarts & Van Schagen, 2006; Nilsson, 2004). According to Johansson and Rumar (1971), the median brake reaction time for drivers in unexpected traffic situations is around 0.9 seconds, with 25% having a reaction time longer than 1.2 seconds. If we were to use this median reaction time and calculate the distance traveled at different speeds, the following results are found:

- at a speed of 30 km/h, the distance traveled in 0.9 seconds is 7.5 meters
- at a speed of 50 km/h, the distance traveled in 0.9 seconds is 12.5 meters
- at a speed of 100 km/h, the distance traveled in 0.9 seconds is 25 meters

However, this only regards the distance traveled before the driver reacts to the situation on the road, also referred to as reaction distance. In addition to the reaction distance, there is also the braking distance. Braking distance is the distance a vehicle travels from the point where the brakes are fully applied to when the vehicle comes to a complete stop. The braking distance of a car depends on various factors, including the vehicle's speed, the vehicle’s weight, road conditions, and the condition of the brakes and tires. If we assume a case of a medium-sized car with good tires on a dry road, the following braking distances apply:

- at a speed of 30 km/h, the braking distance is approximately 9 meters
- at a speed of 50 km/h, the braking distance is approximately 24 meters
- at a speed of 100 km/h, the braking distance is approximately 75 meters

By combining the reaction and braking distance, the stopping distance is acquired; the total distance a vehicle travels from the moment the driver perceives a need to stop until the vehicle comes to a complete stop.

Besides the stopping distance increasing when driving at higher speeds, the severity of a collision injury is also positively related to the speed of the vehicle. Rosen et al. state, that based on 11 studies, it can be uniformly reported that fatality risk increased with car impact speed increasing (Pedestrian fatality risk, 2011). Figure 1 illustrates this statement; When increasing speed from 50 km/h to 70 km/h, an increase in fatality risk of 45% can be observed (from 15% to 50% fatality risk).

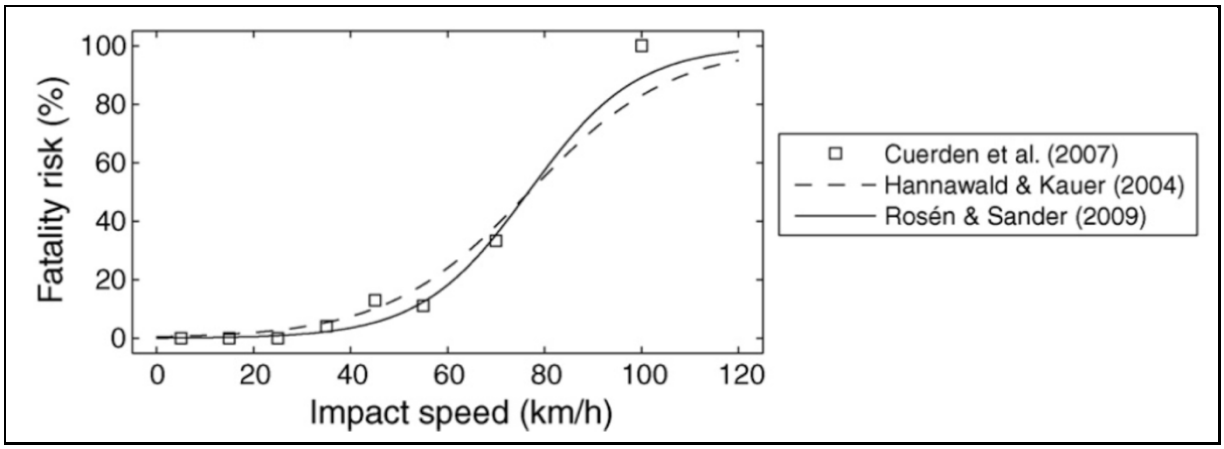

Figure 1. *The fatality rate of pedestrians in crashes with passenger cars as a function of the collision speed (Rosén et al., 2011).*

In a study on the safety impacts of raised speed limits, Kockelman (2006) used a predictive model to analyze the effect of increasing the speed limit by 10 mph (16 km/h). The analysis showed that raising the speed limit from 55 to 65 mph (89 to 105 km/h) resulted in a 24% increase in the probability of a fatality in an accident. Similarly, raising the speed limit from 65 to 75 mph (105 to 121 km/h) resulted in a 12% increase in the probability of a fatality.

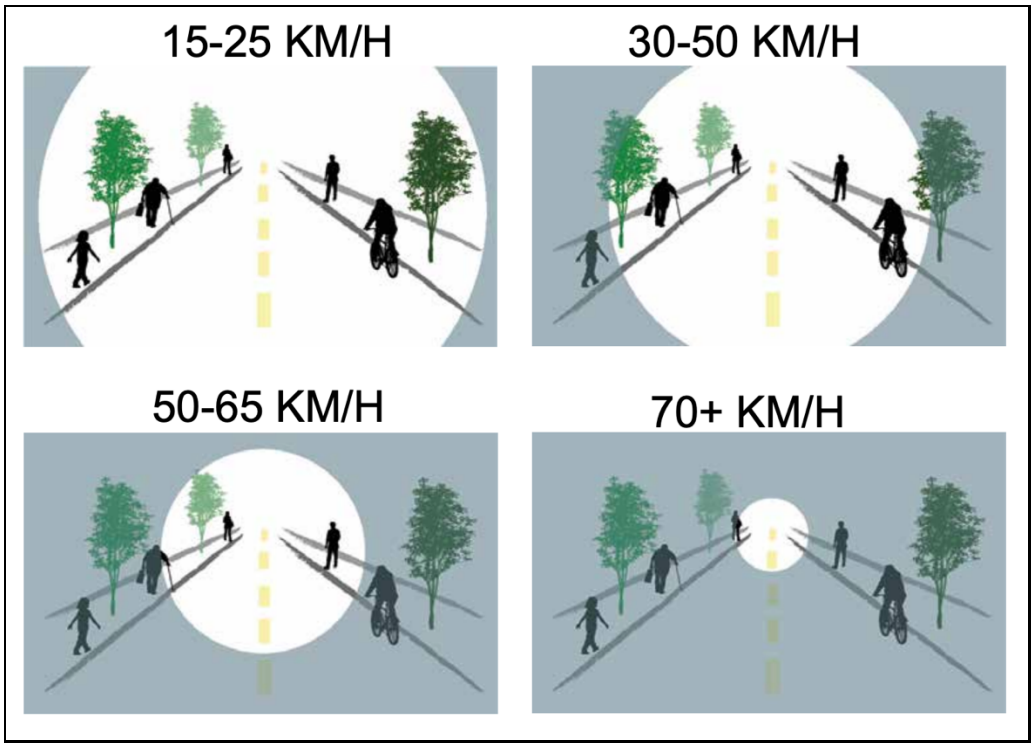

Figure 2. A visual depiction of the field of vision on the road at different speeds (Van der Berg et al., 2015).

When the speed of vehicles increases, not only the severity and chance of accidents are affected, but the visibility of the road and surrounding vehicles also changes. Figure 2 depicts that when driving at higher speeds, the driver is hindered in processing all objects in their peripheral vision. At higher speeds, the driver's vision will be centrally focused and become a tunnel-like field of vision. This decrease in visibility is more dangerous in urban areas as more unexpected events occur in these areas, think of cyclists making unexpected turns or pedestrians crossing the road.

After analyzing the effect of vehicle speed on the chance and severity of accidents, and on the visibility of the driver, there is also the effect of driving at high speeds on the environment. Based on several studies (Andre & Rapone, 2009; Yannis & Michelaraki, 2024) it has been proven that driving at higher speeds and unsteady driving increases the emissions of pollutants and greenhouse gasses. At lower speeds, vehicles tend to produce less exhaust emissions. Therefore, driving at lower speeds and implementing a speed limit in turn should also improve the air quality in urban areas. Additionally, the encouragement of cycling and walking as viable modes of transport in safer, lower-speed environments supports the general goals of urban sustainability and reduced reliance on fossil fuels. Besides lowering greenhouse gas emissions, Yannis & Michelaraki (2024) state that when vehicles drive at lower speeds, it also decreases the noise created by these vehicles. The reduction of noise at lower speeds can be explained by four different factors, namely: At lower speeds, the noise an engine makes, the noise of rolling tires, the noise of wind resistance against vehicles, and the noise of frequent braking are all reduced significantly. Although Yannis & Michelaraki (2024) state that this is the case, Bühlmann and

Egger (2017) argue that the opposite can be concluded in specific scenarios. They argue that vehicles on 30 km/h roads tend to show more unsteady driving behavior because of the speed limit and accompanying traffic calming measures. The traffic calming measures on 30 km/h roads can lead to erratic driving behavior causing more stopping and starting, and more slowing and speeding of vehicles. According to Bühlmann and Egger, the erratic driving behavior will cause more noise and gas emissions from traffic at speeds of 30 km/h specifically. They conclude that unsteady driving behavior at a speed of 30 km/h leads to an increase in noise levels.

Another benefit of implementing speed limits in urban areas and making the streets safer for non-car drivers is that people may explore other viable modes of transport that are safer, lower-speed, and environmentally friendlier options that support broader goals of urban sustainability and reduced reliance on fossil fuels. Besides the direct environmental impact from vehicles, the speed limit may also encourage different modes of transport like walking and biking. According to a study done in Graz, Austria by Sammer (1994), the decision to lower the speed limit from 50 km/h to 30 km/h to reduce car dependency and promote cycling, showed that over 16% of journeys were made by bicycle after implementation.

2.4 International Guidelines and Recommendations

For the past few years, both the European Union (EU) and the United States (US) have shifted their focus on implementing lower speed limits as part of strategies to improve road safety and decrease traffic-related accidents and injuries. In the EU, the European Commission and The Organisation for Economic Co-operation and Development (OECD) advocate for the use of 30 km/h zones in urban areas, aligning with the “Vision Zero” initiative, which aims to reduce all traffic fatalities and injuries to zero by 2050 (European Commission, 2019; Speed Management, 2006). However, the EU often leaves the responsibility for setting speed limits to its members' regional authorities. Countries like Germany, the Netherlands, and Sweden have taken these principles, with nationwide implementation of 30 km/h zones in urban areas, to enhance pedestrian and cyclist safety in city centers (CROW, 2022; Yannis & Michelaraki, 2024). In the US the Vision Zero policies are also getting more attention and implementation across many cities and states. The Federal Highway Administration (FHWA) provides federal guidelines to support states to set appropriate speed limits (MUTCD, 2023). In cities like New York, Portland, and San Francisco these lower-speed zones have already been put in place in urban residential areas as part of their Vision Zero initiatives, to create safer environments for all road users. The initiatives are complemented by traffic calming measures to ensure compliance and to increase the effectiveness of the speed limits (NYC Government et al., 2020, City of Portland, 2016).

2.5 Conceptual Frameworks

Several theoretical models have been created and designed to enhance road safety in urban areas. In this part, several of the most common and influential frameworks and models will be discussed.

Starting with Vision Zero which was first introduced in Sweden in the 1990's. This approach strives to reduce all traffic deaths and severe injuries to zero by encouraging safe and healthy mobility options for everyone. The approach stresses the importance of proactive safety measures, safe road systems, and shared responsibility whilst also accounting for human mistakes and mishaps in traffic. Johansson (2009) outlines Vision Zero as a framework that "reaffirms an absolute priority to avoid death and serious injury" through safety measures. A different approach that adds to the Vision Zero approach is The Safe System Approach. The Safe System Approach (SSA) does this by designing road systems that consider and are focused on dealing with the inevitable human errors and minimizing the effects of accidents through safer roads, road users, vehicles, speeds, and post-crash care ("What Is a Safe System Approach?", 2022).

In the Netherlands, a different approach is being used to enhance road safety, namely the Sustainable Safety Vision approach. This strategy aims to create a sustainable safe traffic system that reduces accident chances and severity based on five pillars, functionality of roads, psychological, (bio)mechanics, responsibility, and learning and innovating. Schermers and Van Vliet (2001) state that the approach creates a more pedestrian and cyclist-friendly environment while keeping an efficient traffic flow. The traffic flow is kept efficient by implementing traffic calming measures where needed, but not where possible. Even Though traffic calming measures create a safer environment, they can also cause congestion when used in abundance, worsening traffic flows.

The Complete Street approach calls for streets to be planned out and maintained to allow for safe travel for all road users. This is done through integrating different modes of transport and supportive guidelines. The approach originates from the US, and its focus is to transition from roads that are mainly designed for cars, to roads that are accessible to everyone and every form of transport. The Modal Hierarchy ties into the Complete Street approach by prioritizing road users, with pedestrians, cyclists, and public transport first, followed by private vehicles. This approach should improve the overall safety and efficiency of traffic. According to Koorey (2011), the approach could significantly improve road safety and create a more controlled and predictable traffic environment.

Lastly, the Livable Street design is an approach that does not only focus on functionality but also on the quality of life for residents. The way this is accomplished is through safe pedestrian pathways, reduced speed limits, and public spaces.

Appleyard (1981), an English-American urban designer and theorist, argued that by making streets livable, an urban area can be transformed into a place where people feel safe and comfortable, creating community interaction and reducing traffic accidents.

The frameworks and theoretical concepts mentioned offer a comprehensive solution for road safety and work as guidelines for urban planning.

2.6 The results of Slow zones in different cities

Numerous studies have researched the effects of 30 km/h speed limits (slow zones) on road safety and quality of life in urban areas. In Europe, several cities have had slow zones for a sufficient number of years now. From these cities, we will now go through some of the research about the effects and discuss the most important findings of the studies. The main paper that will be used to assess the effects is the “Review of City-Wide 30 km/h Speed Limit Benefits in Europe” by Yannis & Michelaraki (2024).

We start by looking at **Brussels**, where a city-wide 30 km/h speed limit was set in January 2021. The implementation of the city-wide speed limit was called “City 30” and was part of the work of “Good Move”, which is the sustainable urban mobility plan for the Brussels-Capital region. The campaign went according to the Vision Zero guidelines and the Safe System approach, as the focus of the campaign was to prioritize reducing traffic accident fatalities and severity through road safety measures (Brussels “City 30”, 2023). From the study by Yannis & Michelaraki (2024), the effects of the City 30 campaign in Brussels were analyzed with the use of before-and-after comparisons of accident data, surveys of residents to assess perceptions and behavior differences, and noise and air quality monitoring. The results in Brussels showed a 28% decrease in road crashes and a 50% decrease in severe and fatal road crashes. A noise reduction of 2.5dB on average was measured. Based on the survey results, an improvement in air quality was noted, and a modal shift to more active modes of transport was reported. Overall, Yannis & Michelaraki concluded an improvement in the quality of life in Brussels. As the implementation of “City 30” in Brussels has only been in place for 3,5 years, the long-term effects of the city-wide speed limit are yet to be determined, but this should lead to a better comprehension of the sustained impact of city-wide implementations in future research.

Paris expanded the 30 km/h zones to almost the entire city back in August of 2021, excluding some major roads like the Champs Elysées and the Boulevard Périphérique. Paris, similarly, to Brussels, set the 30 km/h speed limits guided by the Vision Zero and Safe System Approach. The goal of the Parisian Government was to reduce accidents, pollution, and improve the overall quality of life to make the city more pedestrian-friendly (POLIS Network, 2021). To study the effects of the speed limits in Paris, again before-and-after comparisons and noise measurements were performed. However, a traffic flow analysis was also conducted to measure the changes in modal shift. The

results of driving slower in Paris showed a 40% decrease in severe road accidents and a 25% decrease in mild injuries from traffic collisions. Noise pollution also improved, with a decrease of 3dB in average noise pollution. Paris saw a significant increase in cycling, this increase was partly due to the speed limit changes in the city. The use of public spaces and perceived livability of the city improved, illustrating an increase in the quality of life in Paris since the speed limit was implemented. Paris specifically is known for its busy roads and traffic congestion; one angle of future research could be an analysis of the impact on overall traffic flow and the impact on local businesses following the 30 km/h speed limit.

In the summer of 2018, 87% of **Bilbao's** streets became 30 km/h streets. On the 8th of September, a city-wide (100% of the roads) 30 km/h speed limit was set. With the new speed limits, Bilbao was one of the frontrunners of Spain in reducing the speed in cities (Eurocities, 2021). The local authorities of Bilbao joined forces to successfully implement these speed limits according to the Strategic Road Safety guidelines and Safe Mobility Plan of Euskadi, a region in northern Spain (Municipality of Bilbao, 2021). From the before-and-after analysis in Bilbao, a 28% decrease in the number of road crashes was observed. This effect was mainly due to the implementation of the 30 km/h speed limit, however, there are doubts about the potential influence of the COVID-19 pandemic on these results. Environmentally, the effect on Bilbao's air pollution decreased by 19%. Citizens were less stressed and had fewer health problems, and the number of cycling trips in the city saw an increase from 320.000 in 2018 to almost 1.800.000 in 2022. Out of all 40 cities that were researched in this paper, Bilbao was amongst only two other cities that specifically mentioned to have improved the health of its citizens as a consequence of the speed limits.

London started with the implementation of slow zones, 20 mph (32 km/h) roads, as early as the 1990's, with large expansions in the 2000's and 2010's. What differentiates London from a lot of the other cities is that London took a Borough-by-borough approach instead of a city-wide implementation. In this paper, the effects are measured from 2016 forward. Again, a before-and-after analysis was conducted, as well as a traffic flow assessment. From these analyses, the results showed that the number of crashes decreased by 46%, the number of fatalities decreased by 25%, and the number of severe injuries also dropped by 25%. The assessment showed that there was a change in modal shift of 38% to cycling and walking in the 20 mph zones. For future research about the impact of the 20 mph zones in London, one could conduct a comparative analysis between the different boroughs and the effects on the air quality and noise pollution in the city.

Overall, based on the research done, the benefits of the implementation of slow zones are clear. However, there is still a lot of criticism on the speed limits in urban areas; One challenge is the public acceptance and compliance. In the survey that was created for this research, several questions regard the respondents' acceptance and compliance with the 30 km/h speed limit. The results from these questions are quite

polarizing and opinions on the matter vary a lot. This shows that there needs to be extensive public awareness initiatives and education on the subject.

2.7 Summary

In conclusion, the importance of managing vehicle speeds is explained by the effect on reducing accidents and improving the quality of life in urban areas through decreases in noise and air pollution. The implementation of slow zones (30 km/h or 20 mph) creates safety by providing drivers with more time to react to unexpected events and lowering the severity of potential accidents. The implementation of these zones has also been shown to encourage more sustainable modes of transportation that contribute to improving the environment and health of the residents, although some think differently about this and believe that slow zones lead to erratic driving behavior, which results in opposite results.

3. Methodology

3.1 Introduction

In this research, a mixed-methods study is conducted through a literature review and a qualitative survey on the effects of 30 km/h zones in urban areas. This form of a mixed-method study was needed to understand and analyze the effectiveness of speed limits in urban environments, not only in numerical values, but also from the perspective and interpretation of the individuals who are living, working, or traveling in the slow zones daily. Conducting a qualitative survey allows for an inside-out view of the implementation of slow zones from the respondents. From the responses, the perception of the road users can be analyzed.

This section will discuss the research design of both the literature review and the survey, the sample selection and data collection of the survey, and the analysis of the data.

3.2 Research Design

This research starts with a comprehensive literature review of speed limits in urban environments. To get a better understanding of the subject at hand, background information about speed limits was necessary, that is why the literature review gives context on the origins of speed limits, the importance of managing speeds in urban environments, international guidelines, and some of the most influential and used frameworks and models that are used to successfully implement slow zones in cities. After the context is given, the results of slow zones in several cities can be assessed based on different aspects of effectiveness.

For the literature review, the papers and articles were largely acquired through Google Scholar, Consensus, an AI-powered academic search engine, and through regular Google searches on the subject and sub-themes of the thesis. The most relevant keywords and search terms used to find papers consisted of combinations of the following words:

- 30 km/h zones, 20 mph zones, slow zones
- Road Safety
- Environmental benefits of speed limits
- Urban quality of life
- Traffic accident fatalities and severity
- Effects of driving at high speeds
- Changes in modal shift

The key themes and findings of the papers are the effects of the implementation of speed limits in urban areas on the number of accidents, the severity, the fatality rate,

noise and air pollution, and the overall quality of life in urban environments. Besides the effects of implementation, papers on frameworks and models with guidelines, and traffic calming measures were frequent and relevant for the review.

The survey from Appendix 1 was made with Qualtrics, an online survey-building tool where users can create, distribute questions, and collect and analyze responses. The objective of the survey is to gather qualitative information on the perception of newly introduced 30 km/h zones all over Amsterdam. The survey consists of 17 closed-ended questions and one open-ended question. The closed-ended questions are split up into the following categories: "Safety Concerns", "Impact on Traffic Flow", "Environmental Benefits", and "Public Awareness". The open-ended question leaves space for any additional comments or suggestions on the survey or regarding the 30 km/h zones. The closed-ended questions retrieve demographic data on the respondents and responses to questions answerable by all respondents. Respondents who indicate living in a 30 km/h street are asked specific questions about their experience with the effects of the speed limit on the quality of life in their neighborhood.

3.3 Sample Selection and Data Collection

The survey has been distributed via social media platforms like WhatsApp, Facebook, and LinkedIn. The target population is Dutch citizens living or interacting with 30 km/h zones. In total, there were 72 survey responses of which 64 were fully answered responses. For the research, only the fully completed surveys will be included to increase the quality and reliability of the retrieved data.

A thematic analysis approach is used for the analysis of the open-ended responses, whilst descriptive statistics are used for the analysis of the closed-ended questions. For the closed-ended responses, charts, graphs, and tables are used to present the data.

3.4 Research Approach Overview

In this research, a mixed-method study is needed to assess the effectiveness of speed limits in urban environments extensively. The effectiveness of implementing speed limits in urban environments can not only be based on the numerical changes, but the experiences of residents are also crucial to measure the complete effects of initiatives to improve the urban environment in cities. The responses to the survey give an insight into the perceptions of Dutch residents of urban areas. Combining the survey results with the literature review data gives a complete understanding of the effectiveness of implementing speed limits in cities. Potential limitations of this research design can be assigned to the sample size and representativeness of the survey, and the potential biases in the responses of the survey.

4. Survey results

4.1 Introduction

From the 64 included responses, a distribution of age and gender is shown in Table 1. The distribution between male and female respondents is almost equal.

		What is your gender?			
		Male	Female	Prefer not to say	**Total**
What is your age?	Total Count	33	28	1	62
	Under 18	0	0	0	0
	18 - 24	15	5	0	20
	25 - 34	3	3	0	6
	35 - 44	1	2	0	3
	45 - 54	2	5	1	8
	55 - 64	6	9	0	15
	65 or older	6	4	0	10

Table 1. Distribution of Age and Gender of Respondents

The distribution of age is shown in Table 1. The sample consists mainly of respondents between the ages of 18 to 24, and respondents from the age of 55 and up. None of the respondents are under the age of 18.

The distribution of the respondents' most used mode of transport is shown in Figure 3. From the responses, it can be seen that most respondents are active participants of the 30 km/h zones as 26 out of 59 (44%) of the respondents indicate using the car most in their daily lives, and 22 (37%) indicate using a bicycle most.

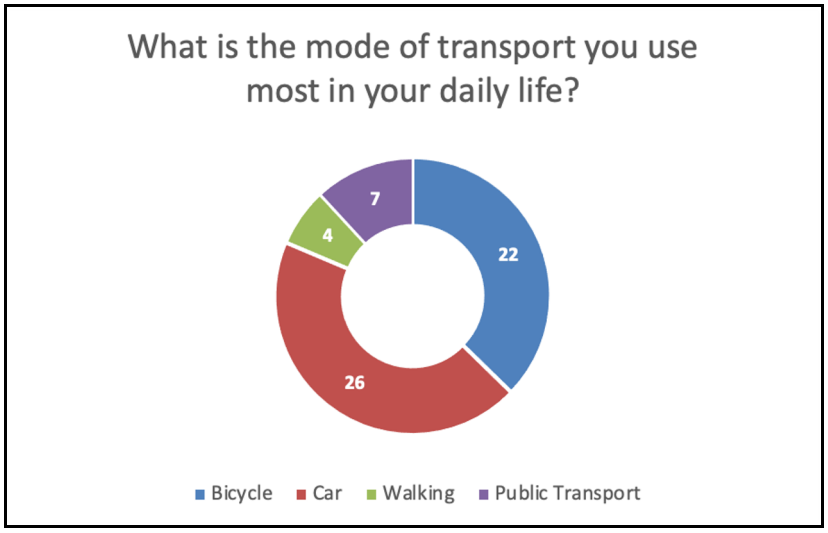

Figure 3. Distribution of Most Used Mode of Transport.

The survey data collection period started on the 12th of June and was open until the 30th of June. Before starting the survey, some ethical considerations were taken into account by asking for consent from the respondents and informing respondents of anonymity, confidentiality, and data protection measures.

4.2 Closed-Ended Questions

As stated in the previous section, the survey consists mostly of closed-ended qualitative questions. The questions are divided into themes regarding the different categories to measure and assess the effectiveness of a 30 km/h speed limit in urban areas.

The first category aims to gauge the awareness of the respondents on 30 km/h zones and their general opinion on the city-wide implementation of the speed limits. From the 64 responses that are included in the analysis, 63 respondents indicated to be aware of the 30 km/h zones in the city where they live. The respondents were asked if they support the implementation of 30 km/h zones in the city where they live, the results are shown in Figure 4.

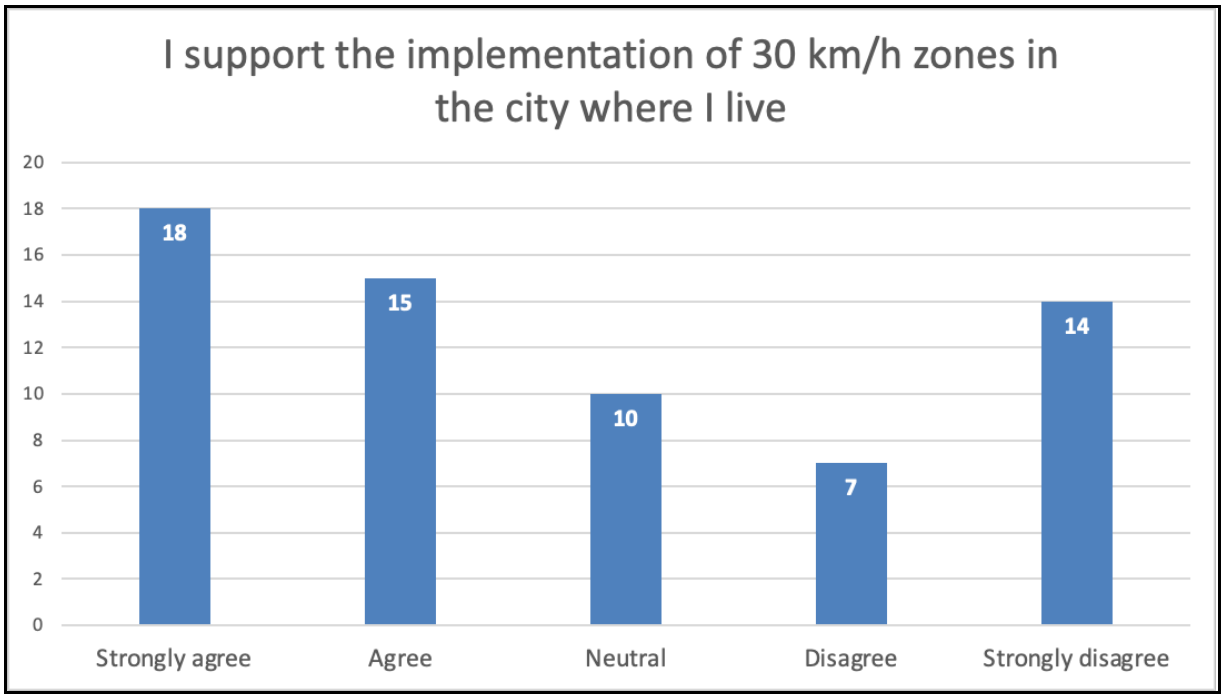

Figure 4. Distribution of Opinions on the Implementation of 30 km/h Zones.

The results show that the opinions on the 30 km/h zones are divided. Over half (33) of the respondents either agree or strongly agree with the statement. This suggests a majority support the implementation of the 30 km/h zones. However, 21 (32.8%) of the respondents also disagree or strongly disagree, indicating a lack of unity on the matter.

The survey then asked whether the respondents believe that the implementation of 30 km/h zones enhance road safety. The results shown in Figure 5 indicate that the

majority of the respondents (38 out of 64, or 59.4%) think that 30 km/h zones make the roads safer. Compared to the distributions from Figure 4, we observe that a significant part of the respondents (21 out of 64, or 32.8%) do not support the 30 km/h zones. However, only 14 respondents think that the 30 km/h zones do not make the roads safer. This suggests that some respondents may acknowledge the safety benefits of the 30 km/h zones but still are opposed to them. This could be because they prioritize driving at higher speeds over road safety.

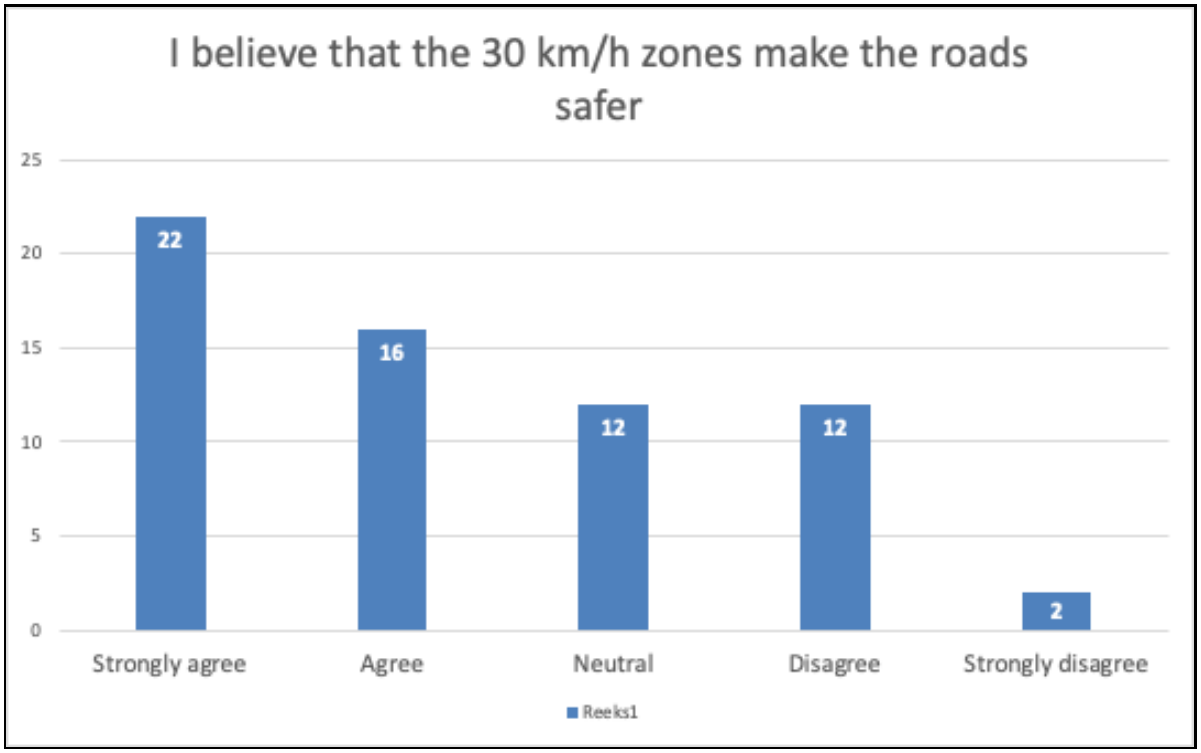

Figure 5. Results on Respondents' Perceptions of Road Safety in 30 km/h Zones.

The last question of the awareness and perception category asked whether the respondents noticed an improvement in the environment in their street. The results in Figure 6 indicate that, again, a majority (34 out of 64, or 53.1%) observe an improvement in air quality and/or a reduction in noise pollution as a consequence of the 30 km/h zones. However, the minority who are either neutral (14), disagree (10), or strongly disagree (6) with the statement, highlight that there is some level of skepticism about the environmental effects of the implementation of the speed limits.

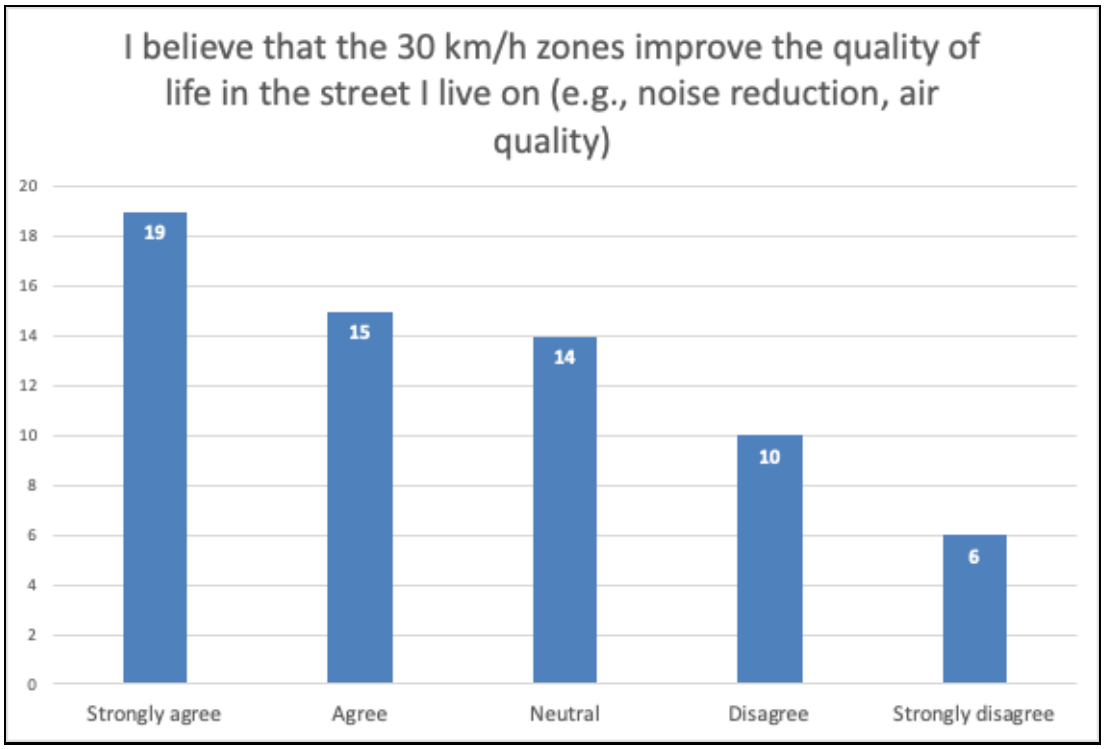

Figure 6. Results on Respondents' Perceptions of Quality of Life Improvements from 30 km/h Zones

The second category of survey questions regards Safety and Traffic Flow. The statements in this category, and the fourth and fifth categories (Environmental Impact and Public Perception and Community), were only presented to those respondents who indicated to live on a 30 km/h street. When asked if these respondents have noticed a reduction in the number of traffic accidents since the implementation of the 30 km/h zones, a large majority of 27 out of 37 (approximately 73%) have not noticed a reduction. Only 10 out of 37 (approximately 27%) observed a reduction in the number of accidents since 30 km/h zones were introduced in their street. The implementation of 30 km/h zones may be perceived to not be as successful in reducing traffic accidents according to these results, however, a reason for the large majority could be that the respondents did not have a clear reference/memory to compare the current situation to the situation before implementation of the slow zones.

Figure 7 shows the results of the statement if the 30 km/h zones have reduced traffic congestion. The results show a clear indication that 30 km/h zones are perceived to be ineffective in reducing traffic congestion with 28 out of 31 responses expressing no significant change in traffic conditions in their street. This is in line with Jang et al. (2022) and Tassinari (2024) who both indicate that lowering the speed limit does not show significant effects on reducing traffic congestion.

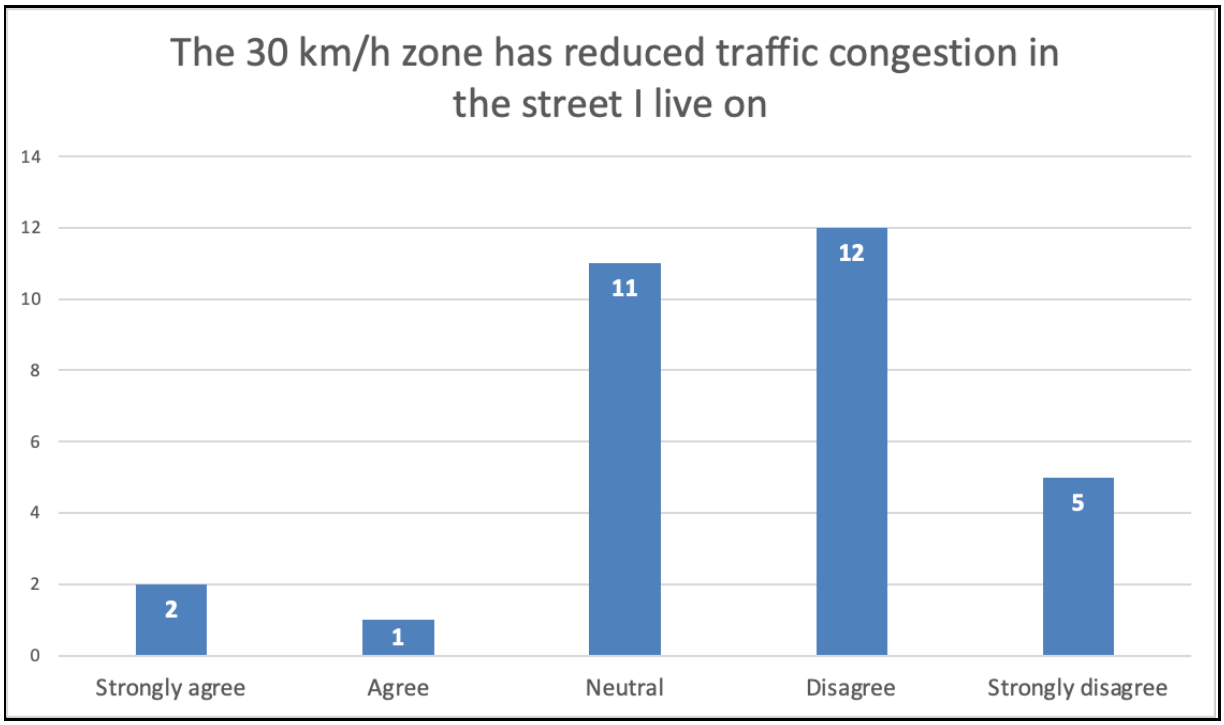

Figure 7. Results on Respondents' Perceptions of Effect on Traffic Congestions from 30 km/h Zones

The third segment of the survey aims to assess the compliance of respondents and their perception of the enforcement of 30 km/h zones in the city. To the statement "When I drive on a 30 km/h road, I always comply with the speed limit", 37 out of 59 (62.7%) respondents answered to comply "always" and "most of the time", 11 and 26 times respectively. 13 respondents indicated to "rarely comply" and 2 respondents indicated to "never" comply.

Following the question regarding the respondents' compliance, two statements about enforcement were posed; "In my opinion, the 30 km/h speed limit is adequately enforced" and "I have been fined or warned for exceeding the 30 km/h speed limit in the past 12 months". In the second statement, all 61 respondents stated never to have been warned or fined for exceeding the speed limit in the past 12 months. The results of the first statement tie into the second statement. The results shown in Figure 8 depict that half (31 out of 62) of the respondents think that the speed limit is not enforced sufficiently. These opinions are not unfounded because there has been virtually no enforcement on these roads (Gemeente Amsterdam, 2023). From July 1st, 2024, that will change; Speed cameras will be placed in parts of Amsterdam to enforce the speed limit NL Times (2024).

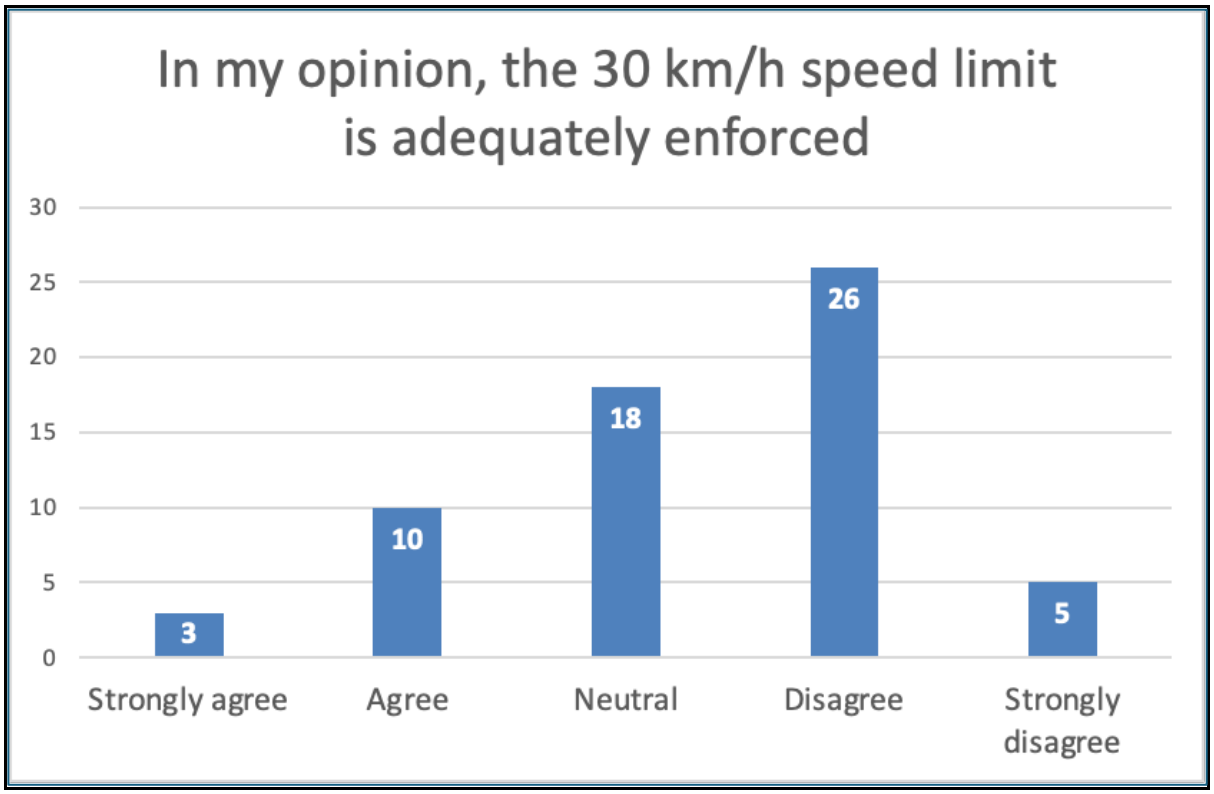

Figure 8. Results on Respondents' Perceptions of the Level of Enforcement

In the fourth category, Environmental Impact, the respondents who live on 30 km/h streets were asked if they observed positive changes in both the air quality and noise levels after the implementation of the 30 km/h zones. The results for both statements showed clear results that indicated that a majority observed no significant change in either aspect. Table 2 shows the responses to both statements. For the first statement, 30 out of 36 (83.3%) respondents indicated not observing an improvement in air quality and only 6 (16.7%) respondents did observe an improvement. The second statement had a slight convergence of responses, with 11 respondents (30.6%) observing reductions in noise levels and 25 respondents (69.4%) indicating not noticing a reduction in noise levels. These results differ from the results from Yannis & Michelaraki (2024), this may imply that the argument made by Bühlmann and Egger (2017) is correct; The 30 km/h speed limit may cause more unsteady driving leading to more noise and air pollution.

Statements	Options	Count	Distribution in %
I have noticed an improvement in air quality since the implementation of 30 km/h zones.	Yes	6	16,7%
	No	30	83,3%
		36	100%
I have noticed a reduction in noise levels in the street I live on since the implementation of 30 km/h zones.	Yes	11	30,6%
	No	25	69,4%
		36	100%

Table 2. Distribution on the Environmental Impact of 30 km/h Zones of Respondents Perception

The last category of closed-ended questions assesses the Public Perception of the 30 km/h zones in the Community, specifically for the respondents living on a 30 km/h street. Figure 9 depicts the respondents' opinions on the impact the 30 km/h zones had on their community/neighborhood. Overall, the largest group of respondents are neither positive nor negative about the impact of the 30 km/h zones. The other respondents are quite equally divided when it comes to agreeing (10 respondents) or disagreeing (8 respondents) with the statement that slow zones have had a positive impact on their community.

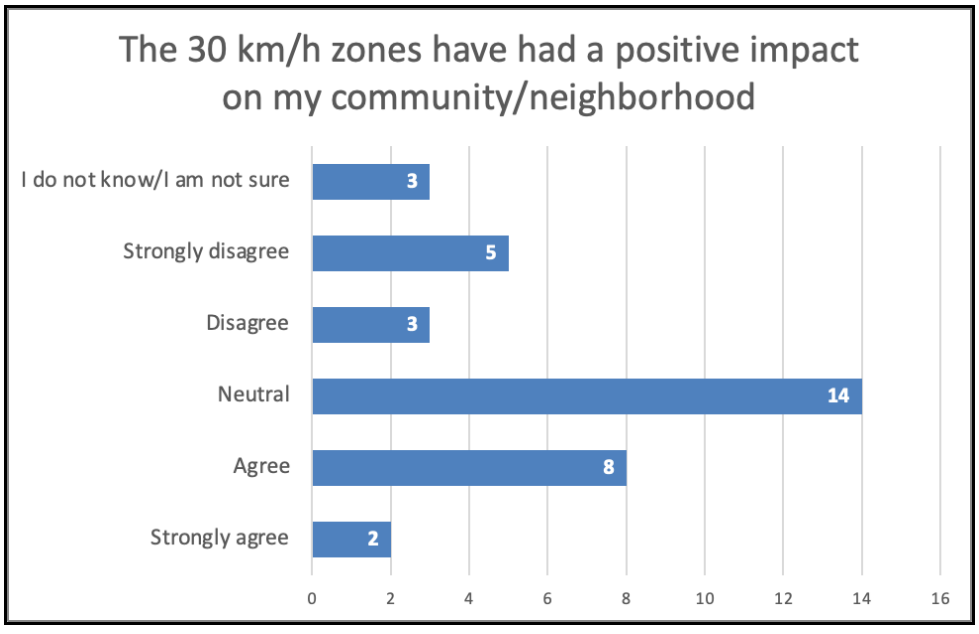

Figure 9. Results of Respondents' Opinion on the Impact of 30 km/h Roads on Their Community Since Implementation

Lastly, the respondents were asked if they feel more comfortable walking and/or cycling on roads with the 30 km/h speed limit. From Figure 10 it can be seen that almost twice as many respondents feel more comfortable on streets since the 30 km/h speed limit was introduced, 19 respondents (strongly) agree as opposed to 10 respondents who (strongly) disagree. From these results, it could be derived that the implementation of 30 km/h roads is effective for the goal of making urban areas more livable.

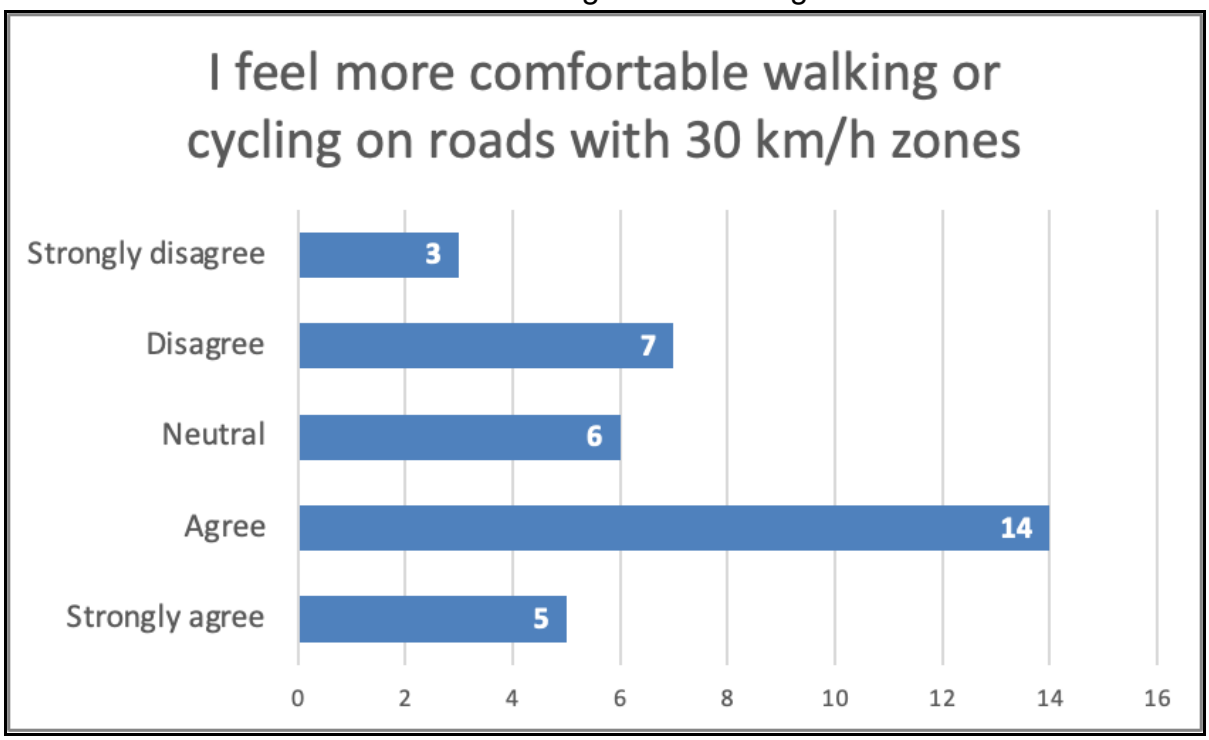

Figure 10. Results on Respondents' Feeling Towards Walking/Cycling on 30 km/h Roads Since Implementation

4.3 Open-Ended Question

The last question from the survey was an open-ended question for respondents to leave any additional comments or suggestions on the 30 km/h zones. In this section the responses will be assigned to several different themes of responses, namely, (Partially) removing the 30 km/h speed limit, not effective/Not well thought out, Supportive/Satisfied, and No/too little enforcement. In total, 22 responses were given in this section of the survey of which 9 responses were in line with (partially) removing the 30 km/h speed limit in the city. Some of the responses suggested adjusted arrangement; "it would be useful to adjust them on a time-bound basis. It doesn't always have to be 30", whilst others want to remove the speed limit as a whole.

2 responses indicated that there is not enough enforcement which causes people to not adhere to the speed limit. This again is explained by the adjustment time that has been implemented so everyone gets used to the new speed limits (NL Times, 2024).

6 of the responses mentioned that the introduction of the speed limits has not been effective and/or has not been implemented correctly. According to the responses, in some areas, it is not indicated properly which in turn creates unsafe traffic situations

and congestion. Besides, one respondent mentioned the role of public transportation and the fact that buses and trams do not have to adhere to the 30 km/h speed limit, which causes confusion: “The 30 km/h zones create unnecessary dangerous situations and congestion. The trams and buses cannot keep to the speed limit because of their timetable. The consequences of more environmental pollution due to congestion and the creation of traffic jams in major cities have not been carefully considered.”

5 out of the 22 responses indicated support and/or be satisfied with the speed limit. Some of them suggested more 30 km/h streets to reduce the number of accidents and fatalities, while others expressed not being fully satisfied with the speed limit but being understanding of the benefits of driving at lower speeds (environmental and road safety).

4.4 Discussion and Conclusion

The survey responses can give some key insights for assessing the research question; the effectiveness of implementing a 30 km/h speed limit in urban environments. In general, among the survey respondents, a small majority of 33 out of 64 respondents support the implementation of the 30 km/h speed limit in urban areas. The opinions varied quite evenly on the support of the implementation of 30 km/h zones. The observed level of enforcement shows a significant trend that can be seen in the answers of the respondents; A large majority of 79% of the respondents (strongly) disagreed or were neutral when asked if the speed limit was adequately enforced. These results are also supported by the choice of the government to have an adjustment period to the 30 km/h zones before introducing enforcement measures starting on the 1st of July. Of the respondents who indicated that they live on 30 km/h streets, the majority have not observed a positive effect on both the air quality and the levels of noise pollution since the implementation of the speed limit in their street. 83.3% expressed not observing an improvement in the air quality, and 69.4% had not noticed a reduction in noise levels. An unexpected finding was the results of the statement discussing the reduction of traffic congestion because of the 30 km/h speed limit. Only 3 out of the 31 respondents agreed with the statement that the 30 km/h zones reduced traffic congestion in their streets. The other 28 respondents observed no significant change in traffic conditions.

The consensus from the survey is that from the public point of view, the speed limits seem to not be very effective or well thought out. There is a lot of room for improvement to enhance the effectiveness and the publics’ perception of the benefits of the speed limits. Policymakers could learn from these results in that they need to inform and communicate the benefits of these zones to the community more efficiently and clearly. However, a limitation of this survey is the relatively small sample group of 60-70 respondents used for the results. Of the 60-70 who responded to the survey, only 36 respondents indicated living on a 30 km/h street. This limited the representativeness of the results. Besides the relatively small sample group, the survey was based on

perception-based statements and thus does not give clear solutions for improving the 30 km/h zones in urban areas.

Further research should aim to get a larger sample population that is more representative of the Dutch population to get a better understanding of the residents' views on the matter. A long-term impact assessment could help to achieve a better understanding of the effects of 30 km/h zones on traffic accidents, air quality, and overall quality of life.

5. Discussion

This thesis assessed the effectiveness of 30 km/h zones in urban areas through a mixed methods approach of a literature review and a survey conducted among Dutch residents living and interacting with slow zones. The literature review displayed that several cities like Bilbao, Brussels, London, and Paris have successfully implemented slow zones, which resulted in reduced traffic accidents and severity of the accidents, less noise and air pollution, and an improvement of the overall quality of life. However, the results gathered from the survey expressed a different picture.

A large majority of the respondents (79%) indicated that the 30 km/h speed limit was not enforced adequately in the city, this view is supported by the decision of the government to have an adjustment period of 6 months before installing enforcement measures. The lack of enforcement amongst other factors like the lack of clarity in the regulations and the start and ending of slow zones, contributed to the perceived ineffectiveness of the respondents. From all respondents, 83.3% indicated to not have noticed any improvement in air quality. For the improvement in noise pollution 69.4% expressed the speed limit to be ineffective. These findings align with the arguments made by Bühlmann and Egger (2017), who argued that the 30 km/h speed limit could lead to more unsteady driving behavior which in turn would increase noise and air pollution. Furthermore, only 3 out of 31 respondents indicated to have noticed a reduction in traffic congestion. Contrarily, almost twice as many respondents indicated to feel safer and more comfortable walking or cycling near 30 km/h roads.

The success in other European cities highlighted in the research papers of the literature review differed significantly from the results found in the survey. While most of these studies reported significant improvements in road safety and environmental benefits, the responses of the survey did not show comparable positive effects. Based on the survey results, the comprehensiveness and good communication of enforcement strategies are needed to enhance the effectiveness of 30 km/h zones. Policymakers should consider several strategies to achieve this; Implementing stricter enforcement measures are crucial to increase compliance with the speed limits. Improving existing infrastructure like more visible signs and road design will increase drivers' compliance as well and naturally calm traffic.

Current studies mainly focus on the quantitative effects of 30 km/h zones, such as accident rates and fatalities, and pollution levels, often overlooking the qualitative perception of residents. The aim of this thesis is to fill this gap by reporting survey data on the public view. However, when conducting a survey, some biases and limitations are almost inevitable, as in this survey the small sample size and the perception-based statement limits the generalizability of the results. Future studies should aim to gather a larger, more representative sample group and conduct a mixed-method survey to gather both quantitative and qualitative insights. Besides gathering more

representative and useful survey data, using longitudinal studies on long-term effects of slow zones on road safety, air quality and overall quality of life in urban areas could provide useful data to measure the true effects.

Concluding, implementing 30 km/h speed limits can be effective in reducing the amount and severity of traffic accidents and enhancing the urban livability for all road users. However, the success largely depends on effective enforcement and public awareness and communication.

6. Conclusion

This thesis aimed to assess the effectiveness of implementing 30 km/h speed limits in urban areas. The assessment focused on the effects of the speed limit on road safety, noise and air pollution, and the quality of life in cities. Through a mixed-methods research consisting of a literature review and a survey conducted among Dutch residents, this study aimed to give a comprehensive evaluation and insights of the impact of 30 km/h zones.

From the literature review, it became apparent that cities like Bilbao, Brussels, London, and Paris have successfully implemented slow zones throughout their cities, resulting in fewer accidents and fatalities, less noise and air pollution, and a more comfortable and livable urban space. However, the conducted survey on the slow zones in the Netherlands illustrated different results based on the perception of the respondents. 79% of the respondents indicated that the enforcement of the speed limits was not sufficient. Environmentally, 83.3% expressed to not noticing an improvement in air quality and 69.4% indicated not noticing significant reductions in noise pollution. Furthermore, the speed limits were deemed ineffective to combat traffic congestion with only 3 out of 31 respondents observing an improvement of traffic congestion.

Despite the mixed findings of both the literature review and the survey, the importance of managing speed in urban environments cannot be overstated. Based on the evidence from other European cities, it can be concluded that road safety and the livability of urban areas do improve when slow zones are introduced and enforced correctly. Having these zones in cities is crucial for enhancing the safety of more vulnerable road users and could promote more sustainable mobility.

Future research should focus on conducting longitudinal studies to assess the long-term effects of slow zones on the urban environment and safety. Comparative analyses can be useful to identify successful ways of enforcement and implementations of these zones. This could be combined with analyzing behavioral and psychological factors that influence the compliance and perception of the public to create a comprehensive evaluation of 30 km/h zones in urban environments. By addressing these areas of research on this topic, deeper insights can be provided to improve and support the successful implementation of 30 km/h zones.

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Appendices

Appendix 1: Survey

Thesis Survey (Final)

Start of Block: Introduction to the Survey

Welcome and thank you for participating in this survey! We are interested in understanding the perception of 30 km/h zones in urban areas. For this study, you will be presented with questions regarding 30 km/h zones (slow zones). Your responses will be kept completely confidential.

The study should take you around 3 minutes to complete. Your participation in this research is voluntary. You have the right to withdraw at any point during the study. The Principal Investigator of this study can be contacted at 530735nb@eur.nl.

Your responses will be used strictly for academic purposes. All gathered data will be anonymous and non-sensitive. We promise that your data will not be used for any purpose other than for this research topic directly.

By clicking the button below, you acknowledge: That your participation in the study is voluntary. That you are aware that you may choose to terminate your participation at any time for any reason.

Please indicate that you understand and consent.

- ○ I consent (1)
- ○ I do not consent (4)

Skip To: End of Survey If The study should take you around 3 minutes to complete. Your participation in this research is vo... = I do not consent

End of Block: Introduction to the Survey

Start of Block: Awareness and Perception

I am aware of the existence of 30 km/h zones in the city where I live

- ○ Yes (1)
- ○ No (2)

I support the implementation of 30 km/h zones in the city where I live.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neutral (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)

I live on a 30 km/h zone street?

- ○ Yes (1)
- ○ No (2)

I believe that the 30 km/h zones make the roads safer.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neutral (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)

I believe that the 30 km/h zones improve the quality of life in the street I live on (e.g., noise reduction, air quality).

- Strongly agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)

End of Block: Awareness and Perception

Start of Block: Safety and Traffic Flow

Display This Question:

If I live on a 30 km/h zone street? = Yes

I have noticed a reduction in the number of traffic accidents since the implementation of 30 km/h zones.

- Yes (1)
- No (3)

Display This Question:

If I live on a 30 km/h zone street? = Yes

The 30 km/h zone has reduced traffic congestion in the street I live on.

- Strongly agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)
- I do not know (6)

End of Block: Safety and Traffic Flow

Start of Block: Compliance and Enforcement

When I drive on a 30 km/h road, I always comply with the speed limit.

- Always (1)
- Most of the time (2)
- Sometimes (3)
- Rarely (4)
- Never (5)
- I do not have a drivers license (6)

In my opinion, the 30 km/h speed limit is adequately enforced.

- Strongly agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)

I have been fined or warned for exceeding the 30 km/h speed limit in the past 12 months

- Yes (1)
- No (3)
- I do not remember (2)

End of Block: Compliance and Enforcement

Start of Block: Environmental Impact

Display This Question:

If I live on a 30 km/h zone street? = Yes

I have noticed an improvement in air quality since the implementation of 30 km/h zones.

- ○ Yes (1)
- ○ No (2)

Display This Question:

If I live on a 30 km/h zone street? = Yes

I have noticed a reduction in noise levels in the street I live on since the implementation of 30 km/h zones.

- ○ Yes (1)
- ○ No (2)

End of Block: Environmental Impact

Start of Block: Public Perception and Community Impact

Display This Question:

If I live on a 30 km/h zone street? = Yes

The 30 km/h zones have had a positive impact on my community/neighborhood.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neutral (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)
- ○ I do not know/I am not sure (7)

Display This Question:

If I live on a 30 km/h zone street? = Yes

I feel more comfortable walking or cycling on roads with 30 km/h zones.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neutral (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)

End of Block: Public Perception and Community Impact

Start of Block: Demographic Information

What is the mode of transport you use most in your daily life?

- ○ Car (1)
- ○ Bicycle (2)
- ○ Walking (3)
- ○ Public Transport (4)
- ○ Other (5)

What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Other (3)
- ○ Prefer not to say (4)

What is your age?

- ○ Under 18 (1)
- ○ 18 - 24 (2)
- ○ 25 - 34 (3)
- ○ 35 - 44 (4)
- ○ 45 - 54 (5)
- ○ 55 - 64 (6)
- ○ 65 or older (7)

End of Block: Demographic Information

Start of Block: Additional Comments

Do you have any additional comments or suggestions regarding the 30 km/h zones in your neighborhood?

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End of Block: Additional Comments
