

**EXAMINING STRATEGIES FOR ENHANCED INNER CITY TRAFFIC
MANAGEMENT AND HEALTH IMPACTS: A CASE STUDY OF A MUMBAI
STREET**

by

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Dedication

I would like to dedicate this thesis to my late mother Mrs. Manju Shetty, who has always inspired me to work hard through all opportunities and challenges life throws at me. She was always proud of all my achievements, both professional and academic, and I hope to continue making her proud. I feel immensely grateful and honoured to have had her as my mother, who was so positive, and she made a profound impact on my life and forever inspired me to work hard with complete sincerity, do my best and always stay humble.

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ABSTRACT

EXAMINING STRATEGIES FOR ENHANCED INNER CITY TRAFFIC MANAGEMENT AND HEALTH IMPACTS: A CASE STUDY OF A MUMBAI STREET

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2025

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This case study discusses the problem of inner-city traffic management and how it relates to health issues by using as an example one specific precinct of Mumbai, which is globally recognized as the city with the highest density of population and severe traffic jams. The aim of the study is to find not only the causes of traffic difficulties but also to find the ways of estimation of consequences and make decisions. The study analyses the traffic congestion issue from the viewpoint of physical and behavioural aspects of health and describes the social consequences of the problem of urban congestion both in the economy and the environment. In a combined method, the data was obtained by personal observations, interviews with the residents and commuters, and interviews with the healthcare professionals. The research points to the central factors of weak infrastructure, illegal intrusions, the phenomenon of seasonal flaunting during monsoons, and the continual growth of private vehicle ownership, that have resulted in congestion.

The study also underscores the negative health effects of road traffic pollution on nearby residents, including respiratory diseases, high stress, and lower quality of life due to noise pollution. This study is looking to be part of a larger conversation about sustainable urban development. For this, it will be dealing with the existing problems of traffic congestion and public health. The findings are of special importance for cities such as Mumbai, among others. They have to face up to rapid urbanization and come up with quick, multifaceted as well as innovative solutions.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AML	Acute Myeloid Leukaemia
AQI	Quality Index
AR	Arterial Road
ATC	Advance Traffic Control
CCTV	Closed Circuit Television
CO.	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
DE	Diesel Exhaust
DM	Doctorate Of Medicine
ERP	Uses The Electronic Road Pricing System
EVs	Electric Vehicles
FMCG	Fast Moving Consumer Goods
GHG	Greenhouse Gas
GPS	Global Positioning System
HCPs	Healthcare Providers
HRQOL	Health-Related Quality Of Life
ITS	Implement Intelligent Transportation Systems
KOL	Key Opinion Leaders
MD	Doctor Of Medicine

NIHL Noise-Induced Hearing Loss

NO₂ Nitrogen Dioxide

NR Not Located To Any Road

OR Other Roads

PB Lead

PM Particulate Matter

PTSD Post-Traumatic Stress Disorder

QOL Quality Of Life

RQ Research Question

RSPM Respirable Suspended Particulate Matter

RTAs Road Traffic Accidents

SME Subject Matter Experts

SO₂ Sulphur Dioxide

SOB Shortness Of Breath

UFPM Ultra-Fine Particulate Matter

WHO World Health Organization

CHAPTER I: INTRODUCTION

1.1 Introduction

Traffic is an ever-present problem, across several major urban cities throughout the world and is one that has been continuously expanding burden for both the health and well-being of its citizens and the economy alike. Mumbai, which has recently come into the limelight for being Asia's billionaire capital, was already well known as the 'city that never sleeps.' Besides being known for the aforementioned positives, Mumbai is also renowned for its gridlock problems. This problem expands multi-fold during seasonal variations and rush hours. Given the geography of this city, the continuous inflow of new populace and the fast-paced lives of its inhabitants, Mumbai's traffic problems only seem to grow. The quantity of vehicles is exponentially increasing; nonetheless, roadways cannot be increased at the same ratio, which is the chief reason for traffic congestion (Dubey and Borkar, 2015).

To contribute further to these issues, there are additional aspects such as illegal encroachment by street hawkers, bottle-neck situations caused by civil constructions of metros, bridges and highways, roadway repairs, and unauthorized parked vehicles. While these advancements in constructions and repairs seem rather promising for the future, it at times seems to be progressing at a snail's pace.

As the city continues to promise glorious offers to job-seekers with vast career advancement opportunities, with multinational companies spread across the city, enticing in people from other parts of the country to migrate to Mumbai to seize the golden

opportunities it has to offer, the size and capacity of the roadways, public transports and other modes of commute continues to stay the same.

In addition to civil development, there seems to be a rapid rise in the residential and commercial complexes, to accommodate the influx of people that come in, in vast numbers.

The city is diverting tremendous efforts to provide housing for all. This is being achieved by utilizing the vertical spaces, by demolishing down old small buildings and re-developing them into sky-rise structures.

However, while doing so, these underway redevelopment projects, that are booming all over the city, bring along with it the problem of traffic, as the cement mixing trucks are often parked off-site on adjacent roadways and heavy vehicles carrying construction materials and debris of the demolished buildings, to and fro, are responsible to block roads, and eventually cause bottle necks and hamper the free flow of traffic.

Post constructions of these towering buildings, the traffic of the adjoining areas would only worsen, as there will be an increased number of residents, which by extension would imply more automobiles. In megapolises with a prevalent number of people and businesses, there is an escalated demand for transport requirements, which to a greater extent are fulfilled by road transport (Koźlak and Wach, 2018).

A recent development that has seen a boom is digitally mediated mobility services and their arrival in the city, which was well accepted (Kuttler, 2024). All these additionally are only adding to the burden of the traffic problem.

Taking a look at the recently completed civil developments, notwithstanding the escalation in road length, newly built highways, and enhanced connectivity, the issue of traffic gridlock continues to persist (Koshy, 2019). Furthermore, India is a multilingual country where people from all cultures come to live in major metropolitan cities, bringing along with them their rich, diverse cultures and various festive celebration traditions.

During numerous festivities and processions that take place to celebrate and honor several Gods and Goddesses, a significant impact can be observed on road traffic as devotees come to offer their prayers during the celebrations, and this occasionally leads to narrowed roads, as these processions do not always use the pavement but utilize the main roads too.

India is also famously known for its ‘big fat Indian weddings’, and during the wedding seasons there is a surge in traffic as the processions of the bride and groom, referred to as ‘baraat’, which often occurs with musicians being part of this extravagant procession, playing live music alongside, and as the crowd proceeds, along with the groom, sitting on a white horse, leads to significant road traffic caused by narrowing the available roads for vehicles to pass through.

Then another contributory factor to the road traffic is the infamous rainy season, which often drenches and submerges the city, as Mumbai receives extreme rainstorms. Mumbai's monsoons often intensify the traffic situation, leading to a surge in travel time by 8-140% for both the roads of Greater Mumbai included in the study. Furthermore, the time taken to commute during evening rush hours was reported to be almost 10% higher than morning peak hours (Soni and Chandel, 2020). An incident that occurred in 2017 further illustrates the dire consequences of monsoons.

A doctor who was driving back home exhausted on a rainy day that saw a significant downpour, his vehicle was stationed due to flooded streets and traffic, he therefore abandoned his vehicle in an attempt to walk through the flooded roads in knee deep water, and subsequently fell through a manhole, which he could not see, his body was discovered several days after his death (Solomon, 2021).

Another challenge that comes alongside Mumbai's heavy rains is the damage to roads due to potholes, which are caused by cascading effects of environmental changes such as heavy rainfall and humidity (Borgalli, 2020).

These potholes have several adverse effects on traffic. It was reported that, because of potholes, traffic police are compelled to divert vehicular traffic, place barricades and stop signs in an attempt to elude accidents and fatalities; however, these eventually cause traffic congestion.

Furthermore, another factor that excessively contributes to the traffic chaos in Mumbai, at an alarming rate, would be the three-wheeler auto rickshaws used by the inhabitants as a form of transport for swift inter-city commute. Although convenient, they are rapidly becoming a cause of concern by contributing drastically to traffic.

A news report by Singh (2015) pointed out that the auto rickshaw drivers stop their vehicles anywhere, creating chaos on the roads. Traffic problems are typically caused due to auto rickshaw drivers who keep their vehicles parked on the roadways while waiting for commuters.

While auto rickshaw drivers wait for passengers, the traffic mess on the main road remains a problem throughout the day. It takes about 20 minutes to cross the traffic intersection (Gill, 2018).

Another contributory factor for traffic congestion and accidents could be attributed to poor driving habits, based on estimates approximately 90% to 95% of road crashes are results of human driving behaviours and not due to technical malfunctions of the automobile, thus making it imperative to then focus on the factors of driver's behaviours to understand traffic accidents (Abdoli et al., 2015).

A common problem in the city of Mumbai, is the ‘me first attitude’ when driving in peak hours, where the traffic congestion stalls commuters, everyone in their desperation to reach home as quickly as possible, mainly due to mounting frustration, opts to fast driving, lane cutting, signal jumping and wrong lane usage, eventually contributing to traffic by creating bottleneck situations. These poor driving practices subsequently slow down the flow of overall traffic, cause breakdowns in the system and increase traffic volumes.

A stimulation study was performed to replicate the scenario, with an interest in investigating multiple driver traits, such as anger, aggression and risk-taking behaviours in slow traffic, and it concluded driving in slow traffic provoked anger and stress(Emo et al., 2016).

While performing secondary task while driving is considered dangerous, due to very slow-moving traffic, one virtual stimulation study found that those that involved themselves in passive tasks such as listening to music or active task such as having a conversation with a passenger or completion of a quiz perceived time to pass by quickly instead of do-nothing drivers, that perceived time to go by slowly and also reportedly felt more stress and drowsiness (Hatoyama et al., 2019). This could be a strategy that could help drivers to combat traffic-caused downtimes.

In the pursuit of a better and more developed smart city, we are currently only experiencing an increased impact on health and well-being. The impacts on both physical and mental health of citizens due to traffic are tremendous.

The consequences of traffic congestion extend far beyond mere inconvenience, and its repercussions can now be felt. A survey revealed that traffic has significant health implications, particularly on respiratory health.

The symptoms, including cough, cold, pneumonia, and tonsillitis, are often a direct result of particulate matter emissions from vehicles in traffic congestion, underscoring the alarming health risks associated with this issue. Another study also found an association that, in an area with good quality air, proximity to roadway traffic had an association notably on children's respiratory health (Kim 2008).

It's not just the physical health that suffers due to traffic. A study concluded that time expended in traffic only decreases happiness (Hays et al., 2016). Ranking as the second in the list of the world's most burnt-out cities (Bloom, 2020), the perils of traffic are a chief social apprehension for this city (Bhide, 2021).

One such aspect that may be contributing extensively to this burnout may be the time it takes to commute to and from the workplace. The distance travelled and time of commuting between home and office vary significantly, and it is due to the growing demand for housing near workspaces; commuting longer routes is the only way for people, as they cannot afford high housing prices or rents in affluent neighbourhoods (Kim and Jin, 2023).

While the effects on physical health are a given, the adverse effects on mental health and emotional wellness of traffic are undeniable. Those who are significantly impacted by it on their daily commute experience insufferable lethargy, irritability and frustration.

Traffic congestion also causes emotional disturbances, predominantly stress and hostility, also triggering adverse physical, psychological, and social repercussions on the quality of life (Bhide, 2021). A study found that drivers in big cities, on working weekdays, at prime rush-hour, mainly between 5 pm to 6 pm, were in a less positive mood, attributing this finding primarily to congestion caused by traffic (Morris and Hirsch, 2016).

Another study reported a positive causal association, thereby linking high road-traffic noise exposure to depressed mood in residential settings (Leijssen et al., 2019). Specifically, urban cities are impacted greatly by noise contributed by vehicular traffic and scientific literature and law regulations attribute vehicular traffic as a chief noise source within urban areas, in addition to railways, industrial areas and airports (Quartieri et al., 2010). It is noteworthy that, due to slow-moving traffic, there is a significant loss of fuel, which is already a precious, exhausting resource that is sharply depleting.

A study carried out at a signal point of a very busy city, where the movement of vehicular traffic was excruciatingly slow, an observation was that, automobile drivers left their car engines idling, so as to make any available advancements to move forward at the slightest chance, thereby contributing tremendously to immense fuel wastage and additionally health hazards that were associated with exhaust fumes (Bansal et al., 2010). Traffic jams thus eventually cause huge economic losses due to the consumption of fuel, when the automobiles are awaiting their turn to clear the crossroads. It is the practice of drivers to habitually keep the vehicular engines on, and this leads primarily to extra fuel consumption. These small amounts of wastage of fuel, ultimately, cumulatively turn out to be a huge quantity (Parida and Gangopadhyay, 2008).

A study found that air pollution deteriorates people's mental health and exacerbates people's emotions, and that impact grows stronger with the increase in duration of air pollution, a causative factor of the air pollution inter-city, which can be attributed to the traffic congestion (Cao et al., 2023).

The rise of traffic density is leading to an upsurge in the emission levels of combustible products within the environment, which is posing a continuous threat to ambient air quality (Ali et al., 2008). Out of the top twenty highest polluted cities in the world, fifteen belong to India (Koshy, 2019). An imperative basis of ambient particulate matter (PM) and ultra-fine particulate matter (UFPM) is exemplified by traffic-related air pollution, mainly diesel exhaust (DE) (Costa et al., 2017).

Annually, air pollution is responsible for premature deaths due to particulate matter (PM) pollutants, which can lead to cardiovascular, infectious, and carcinogenic diseases. While the major causality of lung cancers is attributed to smoking, exposures other than tobacco may play a role in lung cancer in non-smokers, who may be exposed to several constituents of traffic-related air pollution (National Cancer Institute, n.d.).

A higher association has been established between nitrogen dioxide (NO₂) and respirable suspended particulate matter (RSPM) and respiratory problems, and moreover, a modest correlation with cough and asthma, which signifies both nitrogen dioxide and RSPM are of noteworthy concern (Kumar et al., 2023).

The International Agency for Research on Cancer has included ambient outdoor pollution, comprising fine particulate matter, as a human carcinogen [Group 1], and some studies have also been done that have established links between ultrafine particulate matter (UFP) and cancer.

Another study found links between road traffic noise and increased risk of breast cancer (Thacher et al., 2024). Likewise, one study highlighted an involvement between exposure to greater levels of particulate matter (PM₁₀) and nitrogen dioxide (NO₂) and the risk of kidney cancer (Dahman et al., 2024).

Overall, it is crucial to address the problem of traffic as it is critically impacting general health and well-being.

1.2 Research Problem

Traffic congestion has developed as a severe issue in countless cities around the world, and it is a challenge that is not easy to manage (Koźlak and Wach, 2018). A flourishing Mumbai has an ever-present traffic problem, which only multiplies and intensifies with the passage of time and brings along with it some grave health consequences, both physical and mental ones, that require urgent attention and intervention.

The effects of traffic have proven to set off commuters in a state of fight-or-flight responses, effects of which could last for hours and subsequently have derogatory effects on life and work (Liya et al., 2024). A study pointed out behavioural modifications caused due to traffic (Anciaes et al., 2017). All this has brought about a renewed interest in finding solutions for traffic management.

1.3 Purpose of Research

This research will contribute to the body of knowledge, of factors that cause and contribute to traffic in Mumbai city, its direct impacts on several aspects such as health, well-being and quality of life (QOL) of its citizens and opinions, insights and viewpoints of the healthcare providers on the subject and further investigate and suggest ways and means to combat the traffic problems, the city grapples by offering tailor made innovative solutions.

1.4 Significance of the Study

Traffic gridlock is a crucial issue in congested cities (Marve et al., 2016).

While, congested city such as Mumbai cannot be expanded horizontally, the efficiency of the transportation systems and road traffic management can surely be enhanced by exploring innovative resolutions to the multidimensional problems, thereby it can positively contribute to the improvement of health and overall well-being and quality of life of its citizens. The city faces tremendous traffic problems impairing the health and quality of life of its citizens (QOL), and furthermore, it leads to a handbrake on the growth of the city. Its citizens from all walks of life face the consequences of this traffic problem without an iota of doubt. A thorough research of the various factors contributing to this cumulative problem, and its impact analysis on health and well-being, will help to gain clarity of the conundrum and will eventually aid in bridging this gap.

1.5 Research Purpose and Questions

RQ1. What underlying factors contribute to traffic congestion on the specified street in Mumbai? The sub-questions (a, b, c, and d) for RQ1 are given as follows:

- a) What are the major contributory factors of traffic?
- b) How can we quantify these factors?
- c) How do seasonal variations, such as monsoons, influence traffic congestion on the specified street?
- d) What role do urban infrastructure and road design play in exacerbating or alleviating traffic congestion in this area?

RQ2. How does traffic congestion on the specified street in Mumbai impact the health and well-being of residents and commuters? The sub-questions (a, b, c, and d) for RQ2 are given as follows:

- a) How does traffic impact the physical health of the citizens?
- b) How does traffic impact mental health and well-being?
- c) What impacts are seen on the quality of life (QOL) of the citizens?
- d) Impact on the familial and social life of citizens

RQ3. What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai? The sub-questions (a, b, c, and d) for RQ3 are given as follows:

- a) What measures can be taken to combat the problems pertaining to health and well-being?
- b) What solutions can be implemented to mitigate the challenges and reduce traffic?
- c) How can the use of technology, such as smart traffic management systems, improve traffic flow and reduce congestion?
- d) What role can public transportation and alternative mobility options, such as cycling and walking infrastructure, play in alleviating traffic on the specified street?

CHAPTER II: REVIEW OF LITERATURE

2.1 Theoretical Framework

The goal of management of traffic will most optimally be achieved whilst theory and theoreticians work diligently with those stakeholders involved in its management (May, 1994). Over the course of the years, several theories have been cited and some of which find their application in the current setting of traffic management.

The theoretical framework offers frameworks for guiding organizational change and overcoming resistance to innovative initiatives. This may be applied in traffic management to navigate the complexities of implementing new policies, technologies, and infrastructure upgrades. By comprehending the barriers to change and addressing stakeholders' apprehensions, researchers may deploy strategies to facilitate the implementation of innovative traffic management solutions, thereby overcoming resistance to change among affected stakeholders (Srivastava and Maity, 2023).

Community-based traffic management, which this research case-study envisages, places its emphasis on involving local communities and stakeholders, highlighting the importance of their role in decision-making. With regards to traffic management, this approach involves endowing all relevant stakeholders, such as residents, businesses, and civic organizations, to enthusiastically participate in recognizing problems, setting priorities, and working on effective solutions (Edwards Jr, 2019).

By fostering collaboration and collective action, researchers can leverage their knowledge, resources, and social capital to address traffic-related challenges effectively and sustainably on the specified street in Mumbai (Edwards Jr, 2019).

This research case-study focuses on the contingency theoretical framework planning process, with its understanding that there is no one-size-fits-all approach to management, emphasizes the adaptability of strategies to the specific context and circumstances. In the context of traffic management, this framework emphasizes the importance of tailoring strategies to the unique characteristics of the specified street in Mumbai city, such as its infrastructure, population density, and traffic patterns. By considering these factors, researchers can develop customized traffic management strategies that are not only well-suited to the specific challenges and opportunities present in the study area but also to your specific needs and circumstances (Araral, 2020).

From the standpoint of this research/case study, traffic management is regarded as a complex system comprising several interconnected components, for instance, road infrastructure, modes of transportation, and vehicular flow of traffic (Sony and Naik, 2020). It stresses on the significance of gaining clarity on ways these elements interact and impact each other to cope with traffic congestion meritoriously(Sony and Naik, 2020). In exploring strategies for an improved inner city traffic management in a Mumbai street, this theory would contribute to factoring in the interdependencies amongst innumerable factors at play leading to traffic congestion, aiding in identifying leverage points for intervention and optimization (Sony and Naik, 2020). This process investigates strategic decision making in competitive situations where the outcome relies on the choices of multiple stakeholders (Hang et al., 2020).

Applied to traffic management, this theoretical framework can aid researchers to analyse the interactions between different patrons, such as commuters, transportation authorities, and urban planners, and predict how their decisions cumulatively influence traffic flow and congestion levels. By gaining clarity on the incentives and motivations driving behaviour, researchers could develop strategies that incentivize cooperation and coordination among stakeholders to accomplish effectual traffic management outcomes (Hang et al., 2020).

The overall theoretical framework tries to look into the capability to comprehend the problem, the inclination to solve it and finally the cognizance of its presence and the strategies of problem solving (Dostál, 2015). This theory can find its application in traffic management, by firstly identifying key elements that contribute to the traffic in the city and its various hazardous repercussions on a variety of aspects of life of the residents and finally, the strategies that can be deployed to enhance the management of intercity traffic.

2.2 Theory of Reasoned Action

The theory of reasoned action explains how intentions and attitudes of people influence their actions (Hale et al., 2002). Basis this theory it can be understood that if we can modify people's behaviours, attitudes and intentions, researchers can bring about a change in the actions of individuals, which would help facilitate better management of traffic.

Traffic congestion in Mumbai is a persistent and pressing issue with severe economic repercussions. It is revealed that the city suffers an estimated financial loss of INR 410 billion annually due to traffic jams, with commuters wasting an average of 121 hours each year in congestion (Patil and Sharma, 2022).

The geographical constraints posed by Mumbai's proximity to the Arabian Sea further exacerbate the challenges of urban expansion and population growth (Patil and Sharma, 2022).

With urbanization burgeoning in developing countries, including India, as rural residents seek better economic prospects in metropolitan areas, the pressure on Mumbai's transportation infrastructure continues to mount (Patil and Sharma, 2022). This is reflected in the city's staggering car density, with Mumbai boasting 510 cars per kilometre, making it the most car-congested city in India (Mahajan and Mahajan, 2022).

The consequences of congestion are starkly evident in the significant increase in travel time during peak congestion periods, with journeys taking 53% longer than usual (Mahajan and Mahajan, 2022).

Throughout the twentieth century, cities around the world have expanded expeditiously, which has resulted in significant urban spatial expansion (Haider et al., 2013); with this vertical expansion of the city comes an influx of migrated inhabitants in their pursuit of better opportunities and, in the process, greater demand for commuters and transportation. Among the bustling cities of India, Mumbai, often hailed as 'the city of dreams,' stands out for a less glamorous reason: its infamous traffic. The city's unique blend of traffic gridlock, diverse experiences, and abundant opportunities has become a defining characteristic, painting a vivid picture of the severity of the issue.

Since then, there has been a revolution in the automobile industry, which has vastly liberalised the economy. This has eventually led to a tremendous increase in vehicle ownership levels, which has resulted in changing traffic characteristics on road networks (Jalihal et al., 2005).

The number of vehicles is increasing exponentially; however, roads cannot be increased in the same ratio, which is the primary reason for traffic congestion (Dubey and Borkar, 2015).

The Observer Research Foundation (2023) stated that Mumbai has one of the world's worst road traffic and is ranked the fifth most congested city. Researchers have tried to study and address traffic accidents to reduce the number of catastrophes and alleviate their hazardous consequences on society, but the traffic problem persists (Mohammed et al., 2019).

One of the most precious resources we have is time, and Mumbai's traffic often robs commuters of this valuable asset. A study revealed that respondents went to great lengths to avoid traffic, even altering their destinations or rescheduling their trips (Lesteven, 2016). To compound the problem, Mumbai's monsoons often exacerbate the traffic situation, leading to an increase in travel time by 8-140% for both the roads of Greater Mumbai included in the study. Moreover, travel time during evening rush hours was reported to be approximately 10% higher than morning peak hours (Soni and Chandel, 2020).

It was correctly highlighted by Mascarenhas and Suri (2018) that typically, street design guidelines cover only standard cases, such as 4-arm intersections at perfect right-angles or 3-arm Y-intersections or T-intersections; however, in Indian cities, one often faces situations that defer from these templates and poor intersection geometry can be a significant factor contributing to crash risk.

Another factor contributing to the chaos at an alarming rate would be the three-wheeler auto rickshaws used by the citizens as a form of transport.

While these auto rickshaws help allow swift inter-city commutes, they are soon becoming an issue by contributing significantly to the traffic (Soni and Chandel, 2020).

A news report by Singh (2015) pointed out that the auto rickshaw drivers stop their vehicles anywhere, creating chaos on the roads. In a bid to get passengers, they even halt in the middle of the streets, resulting in traffic jams and snarls and sometimes leading to mishaps(Singh, 2015).

Traffic problems are usually caused by auto rickshaw drivers who keep their vehicles on the road while waiting for passengers. As auto rickshaw drivers wait for passengers, the traffic mess on the main road remains a problem throughout the day.

It takes almost 20 minutes to cross the traffic intersection (Gill, 2018). Moreover, it was also highlighted that auto rickshaws contribute to increasing levels of pollution in the city (Singh, 2015). Traffic junctions are considered hot spots of air pollution, as vehicles have to wait in idling mode for signals, increasing pollution (Kale and Sawant, 2015). The traffic police set up a pilot project to assemble queues for auto rickshaws and taxis outside the bustling Andheri East railway station to eliminate unauthorized stopping and parking and with the intent to streamline the traffic. The pilot project was set up to curb the problem of haphazard auto rickshaws and taxi halts and to prevent obstruction to traffic flow(Natu and Sen, 2024).

Rise in purchase power that translates into traffic

India's automobile industry is one of the world's most significant in sales volume and production(Maheshwari et al., 2024). Automakers are free to build, and since entry-level cars cost an affordable Rs 3-4 lakh, more people continue to purchase (Sen, 2023).

Automobile loan procedures for procuring vehicles for first-time buyers have become relatively easy to pass through, translating into a significant surge in traffic.

An analysis conducted to understand consumer behaviour on the purchase of cars in Mumbai found an impact on private car ownership perception due to the COVID-19 pandemic, as there is an enhanced preference for ownership of private cars as opposed to public transport (Pawar, 2022). A study's findings concluded a direct relationship between the impact of income levels, availability of loans and consumer behaviour buying patterns on the growth of the automobile industry (Maheshwari et al., 2024).

The rapid increase in traffic in Mumbai has led to a significant shortage of space for pedestrians, with roads becoming congested and pavements and subways being underutilized. This situation poses a significant challenge for pedestrians, who often prefer to walk to their destinations. The total vehicle population in Mumbai is estimated to be 45 lakhs, with 13 lakhs being private vehicles. These numbers contribute to the perpetual traffic problems in the city, leading to long jams, pollution, and fuel wastage (Sen, 2023).

Shopping trips, the second most common type of travel in urban areas after work-related commutes, have seen a significant increase in frequency. This trend has led to a surge in vehicular traffic, particularly around shopping malls, which act as primary attraction hubs in urban areas. Mumbai, already grappling with significant traffic-related challenges, especially during peak hours, is further burdened by the presence of these popular attractions, exacerbating the transportation issues at hand (Shkera and Vaishali, 2024).

Understanding traffic conditions, historically and in real-time, may tremendously benefit transport authorities and aid in managing traffic efficiently.

With this view in mind, a hybrid integrated model was built using Twitter geo-referencing, which would classify tweets to understand where traffic-related events were occurring (Das and Purves, 2019).

The model, developed by deploying a combination of machine learning, simple rules and lists of local terms, showcased a cost-effective alternative that may be used to understand traffic conditions at locations lacking proper infrastructure and surveillance systems in Mumbai. This model could also be customized and extrapolated to use in other locations (Das and Purves, 2019).

Health implications

Traffic congestion is habitually described as episodes when traffic volume exceeds the capacity of roadways (Zhang and Batterman, 2013). The consequences of this ever-present traffic congestion extend far beyond mere inconvenience. A survey revealed that traffic has significant health implications, particularly on respiratory health. The symptoms, including cough, cold, pneumonia, and tonsillitis, are often a direct result of particulate matter emissions from vehicles in traffic congestion, underscoring the alarming health risks associated with this issue. It's not just the physical health that suffers due to traffic. A recent study found a substantial effect on the physical and psychological health of citizens due to traffic congestion (Singh and Khan, 2023).

Transportation, like motor vehicles, may have grave negative influences on health with regard to traffic load and congestion, noise pollution, burden of stress and impacted emotional well-being and subsequently affecting both the physical as well as psychological health (Curry, 2016). This literature review also underscores the urgent need to address the health impacts of traffic congestion.

Numerous studies and surveys have documented the adverse effects of prolonged exposure to traffic-related stressors, including increased risk of anxiety, depression, and respiratory ailments (Das and Purves, 2019). A study by Kale and Sawant (2017) found that road traffic noise could be linked to poorer mental health, especially among those with poor sleep.

This underscores the psychological toll that traffic can take on individuals, further highlighting the multifaceted nature of the problem (Das and Purves, 2019). Furthermore, chronic exposure to traffic noise may provoke complex stress reactions (Seidler et al., 2019). A study in Denmark that investigated the association between traffic noise annoyance and mental health concluded that there was a strong association between noise and stress; the author indicated a clear tendency towards a dose-response relationship between noise annoyance and mental health and stress, whereby people who reported to have a higher noise in multi-storey accommodations were more prone to experience poor mental health and higher levels of stress (Benz et al., 2021; Jensen et al., 2018). A systematic review that aimed to examine the relationship between exposure to noise of traffic and anxiety disorders, depression and attention deficit disorders among children found studies that demonstrated an association among excessive levels of traffic noise and hyperactivity or attention deficit in children (Seidler et al., 2019).

Additionally, the relentless noise pollution generated by traffic exacerbates the adverse effects on public health, with studies indicating a correlation between road traffic noise and increased risks of depression and anxiety (Hegewald et al., 2020). Long term exposure to vehicular traffic noise can increase the hazard of obesity and may also establish a pathway leading to cardiometabolic and other diseases (Foraster et al., 2018).

A study found that nocturnal traffic noise exposure in women's bedrooms was reportedly associated with them being overweight or obese, caused by sleep disturbance (Veber et al., 2023).

Findings from a study on negative effects from exposure to road traffic noise on people's well-being was found that unremitting exposure of citizens to road traffic noise caused suffering from numerous types of discomfort, therefore decreasing appreciably the amount of their well-being elements (Ouis, 2001).

Few other studies have also highlighted links between traffic noise and metabolic and cardiovascular diseases (Münzel et al., 2018). A study demonstrated that those individuals that were subjected to long term road traffic noise exposure had notably increased levels of noradrenaline with stress hormone cortisol, particularly through the nights, when compared to controls (Babisch et al., 1999). Chronic exposure to traffic-associated stress can eventually lead to more grave mental health concerns, encompassing anxiety disorders and depression (Subair et al., 2024).

A survey conducted amongst North American workers found that the frequency of traffic congestion, the fulfilment with, and the duration of the commute impacted stress levels (Tchounwou and Han, 2013). Workers who experienced traffic congestion more than three times a week reported significantly higher stress levels than those subjected to infrequent congestion. This survey also found an association between those with longer commutes and those with shorter commutes, who reported higher stress levels than those with shorter commutes and those who were satisfied with their commutes and who were least likely to be stressed (Haider et al., 2013).

A study conducted to fill the research gaps on post-congestion exposure of drivers' behaviour, using a stimulation model, concluded that traffic congestion negatively affected driver behaviour on the post-congested roads (Li et al., 2020). It was reported that Maharashtra has around 12,500 to 13,000 fatalities every year due to crashes alone. Mohammed et al. (2019) stated that around 3000 people die each day on the roads worldwide, further stating that 9,000 people per year get injured due to traffic accidents. It was further added that India is the only country in the world that incurs more than fifteen fatalities and fifty-three injuries every hour because of road crashes. Several factors contribute to this problem(Kale and Sawant, 2017).

Likewise, traffic congestion can cause drivers to become frustrated and engage in road issues (Kale and Sawant, 2017). Dubey and Borkar (2015) highlighted that traffic congestion instigates road rage. A survey on road rage established a correlation between traffic-related congestion and angriness during driving (Karim and Sharif, 2023). Furthermore, road traffic accidents (RTAs) are linked with extensive mental health problems, including post-traumatic stress disorder (PTSD) (Boelen et al., 2024). Ultimately, this results in delays, declining health of the city residents, and casualties due to road traffic accidents (RTAs) (Singh and Singh, 2021).

A study concluded that excessive evening traffic was linked to a nine percent increase in occurrences of night-time domestic violence. Another study also found the psychological impact on the commuters' well-being due to unpredictability associated with being stuck in snarls, causing helplessness(Nadrian et al., 2019).

A study undertaken to gauge the impacts of urban traffic jams on familial mental health found impacts on mental health and also diminished life quality among families of the general population and inner-city drivers. The effects noted included anxiety, stress, reduction in tolerance threshold, familial quarrels, dissatisfaction with family and lack of family cohesion (Nadrian et al., 2019).

A study comprising 100 bus conductors of Navi Mumbai concluded that there was a significant impact on their health and psychological well-being, primarily contributed to exposure to pollution, bumpy rides due to potholes, inevitable complaints from passengers, and lastly, extended hours of duty due to being stuck in traffic jams. Additionally, they also faced musculoskeletal problems due to the chronicity of their exposure to the above-stated stress factors (Dabholkar et al., 2015).

Moreover, several studies and surveys have highlighted the tremendous impacts of traffic on commuters' mental and physical health. Yet, we can benefit as a society if we add to this knowledge and seek some professional viewpoints from our research (Das and Purves, 2019).

Traffic congestion exerts a substantial economic cost in the form of the opportunity cost of time and health costs that are incurred in the form of morbidity and mortality. Its effects are being witnessed by urban residents, predominantly commuters, who are the primary sufferers of these traffic emissions (Srinivas, 2014).

The epidemiological evidence highlights a solid causal relationship between vehicular emissions and possible health impacts (Vijayalakshmi and Raj, 2020). Air pollution leads to damage and imposes risks on human health, particularly in cities, where the pollutant load is a chief concern (Silveira et al., 2024).

From the facet of health impact, when a traffic congestion occurrence has happened, there are two primary exposures potentially resulting from emissions, the first one being the in-cabin exposures for drivers in their automobiles, and the next would be the impacts to the surrounding population owed to an increase in ambient concentrations of contaminants (Levy et al., 2010).

The increased demand for automobile commutes in developing cities of India has led to complex traffic congestion, frequent accidents, and emissions of harmful substances such as carbon monoxide (CO), sulfur dioxide (SO₂), and lead (Pb) into the atmosphere. This has caused prevalent transport-related diseases in many urban cities in developing nations such as India (Srinivas, 2014).

Traffic congestion reduces the average speed, thereby cascading and increasing travel time and exposure on a per automobile basis (Zhang and Batterman, 2013). Reduced vehicle speeds can surge pollutant concentrations arising from roadway sources. Finally, congestion may alter driving patterns, ensuing in an increased number of speedups, slowdowns, stops and starts, that leads to increased emissions levels when compared to “cruise” conditions, particularly with involvement of high-power acceleration.

A survey with a sample size of 1582 conducted for street vendors, shopkeepers, and traffic police along the traffic junctions and congestion spots found that they suffered from breathing and respiratory problems. Many were even diagnosed with asthma at some time or the other (Kale and Sawant, 2015).

Commuters exposed to air pollution, especially those riding in non-air-conditioned vehicles such as cycle rickshaws, auto-rickshaws, and motorcycles, face twice the health risk than those in air-conditioned vehicles.

As blood pressure increases with increased traffic pollutants, electrocardiogram changes have demonstrated decreased blood flow to the heart. Thus, this air pollution can cause blood pressure to rise and inflame the arteries, escalating heart attack and stroke risk (Kumar et al., 2023).

As observed by Kale and Sawant (2015), which the signal lane is so lengthy that vehicles have to wait for a second turn of the signal. One of the other points also highlighted was the social impact of traffic, such as public anxiety.

Pollution that gathers inside cars stationed in traffic congestion and at red traffic lights is far greater than that found in moving cars.

It contributes to lung cancer, asthma, other respiratory diseases, heart disease, and stroke (Kumar et al., 2023). In metropolitan societies, traffic gridlock is the chief contributor of greenhouse gas (GHG) emissions and air pollution (Chor and Habibur, 2011).

A study focused on urban form along with road traffic, aimed at understanding their relationship with lung cancer incidence in high-density urban areas found a positive correlation of percentage of low-quality residential land with lung cancer incidence (Sun et al., 2021).

The perils on citizen health can be immensely felt with the rise in car density, as it is significantly contributing to several forms of pollutions that are manifesting into health concerns of the residents of the city. With every passing year, the air quality index (AQI) only seems to worsen, and the primary cited reason for this worsening is attributed to vehicular emissions (Thangavel et al., 2022).

The AQI index (a tool for the measurement of air quality, and the potential health effects of air pollution) in Mumbai is often reported to be above 200, with poor air and unhealthy air quality, which is several folds higher than what is recommended by WHO.

Vehicular emissions are responsible for the suspension of particulate matter (PM), which includes fine particulate matter and ultrafine particulate matter (UFP), which are hazardous to human health. Given their size, these can infiltrate through the pulmonary system and enter the bloodstream (Thangavel et al., 2022).

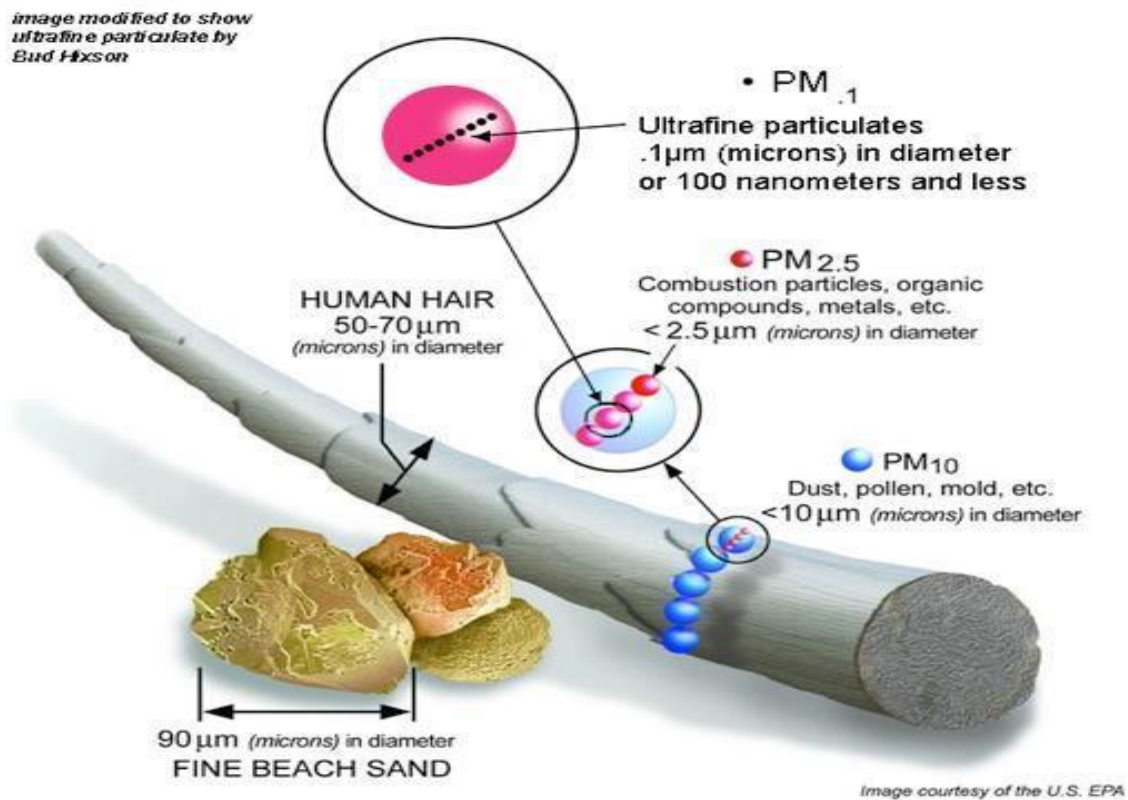


Figure 1 – Ultrafine particulate by Bud Hixson, Image courtesy of the USA EPA

The effects on health caused by exposure to air pollution include asthma attacks, respiratory infections, bronchitis, emphysema, cerebrovascular diseases, neurodegenerative diseases, and increased irritation of the eyes and respiratory system. Furthermore, air pollution has been linked to adverse outcomes in pregnancy like pre-eclampsia and hypertensive disorders (Thangavel et al., 2022).

Air pollution is carcinogenic to humans and studies have established a link between PM and risk of lung cancer (Hamra et al., 2014). A study concluded that exposure to traffic contributed air pollution was linked to an increased risk of childhood leukaemia, specifically acute myeloid leukaemia (AML)(Kreis et al., 2022).

Several other pollutant components have critical impacts, such as carbon monoxide (CO₂), which can impact cardiovascular health, primarily angina. Other pollutants include nitrogen dioxide, Sulphur dioxide, lead, benzenes and hydrocarbons. Higher lung cancer risks were associated with proximity between highways and the population, who were traffic-exposed. Furthermore, greater risks were noted between PM exposure and lung cancer cases in those countries with higher temperature and humidity (Berg et al., 2023).

While the major causality of lung cancers is attributed to smoking, exposures other than tobacco may play a role in lung cancer in non-smokers, who may be exposed to several constituents of traffic-related air pollution (National Cancer Institute, n.d.). Despite the enforcement of vehicle emission standards by law makers to combat the problems of motor vehicular exhaust, the vehicular air pollution continues to stay the primary cause of air pollution in the city (Ali et al., 2008).

Vehicular exhaust is known to contain several substances, which pose a threat to human health. The chief pollutants emitted from automobiles include carbon monoxide, unburned hydrocarbons, oxides of nitrogen, lead and other PM emissions (Ali et al., 2008).

Contributing to the exacerbation of the problem of pollution is the shrinkage of green spaces, which act as a first line of defence against pollution by absorbing carbon dioxide and converting it into oxygen and working to clean the environment, in addition to its aesthetic appearance that leads to a feeling of comfort, tranquillity and calm (Alhusinan, 2024). Health impacts from traffic congestion come are copious. A study comprising 79 of subjects, commuting through various means of transportation on a daily basis, the results demonstrated that a substantial portion of participants experienced stress, anxiety and anger problems. The study also reported impacts on physical health such as backpain and decreased productivity at work (Mushtaq and Hashmi, 2022).

While being stuck in traffic jam for hours, when the vehicle is completely stationary, this takes a toll on the driver's health, particularly the back and the spine. Additionally, those that expend more than half their work lives driving are three times more likely to suffer back issues when compared to the rest of the people (Troup, 1978).

Alhusinan (2024) specified that psychological state of the driver may also be impacted due to crowding and the accumulation of vehicles, as the driver would experience discomfort, would be disturbed and insecure, all caused by spending long hours occupied in the motor vehicle and while they see just a logjam of vehicles and hears just the commotion of car horns. Traffic and transportation are vital factors in the spectrum of economic, social and environmental dynamics, external to the health sector that is well-known to influence public well-being (Nadrian et al., 2019).

A study which interviewed participants through cellular telephones and conducted two such interviews, once while being stuck in low traffic congestion and once during a high-density congestion, found that driving in highly congested traffic resulted in higher state stress when compared to driving in low congestion.

Moreover, participants that had indicated being more predisposed to driver stress displayed even more elevated state stress as opposed to those that were lower in trait driver stress, during comparable conditions (Hennessy, 2011).

A study comprising of 26 participants who had a history of atopic dermatitis or eczema syndrome were studied by exposing them to 30 minutes of roadway heavy wheeled traffic, and experienced enhanced allergen-induced skin wheals (Kimata, 2004).

Whilst being stuck in traffic snarls, commuters are refrained from use of restrooms to void their bladder if needed, which leads to holding of urine for long intervals of time that can cause urinary infections (Kumar et al., 2023).

These infections can sometimes be so severe that it can further lead to acute urinary retention. If this transpires with an elderly individual, it might lead to psychotic behaviour(Kumar et al., 2023).

Strategies to mitigate traffic

Research by Dubey and Borkar (2015) has provided a promising solution to our traffic congestion woes. The GPS technique, it suggests, could be a game-changer. Not only is it cost-effective, but it also has the capacity to monitor the entire road network, thereby helping us avoid congestion through careful analysis. Moreover, it can be seamlessly integrated with other congestion-avoiding techniques, offering a comprehensive solution to our traffic woes (Dubey and Borkar, 2015).

Another research by Badami and Haider (2007) suggested that change would be to encourage the use of public transport. Cities in India rely mainly on buses for public transport for commuting. However, public bus transit services must be more adequate and affordable for the urban poor (Badami and Haider, 2007).

While Mumbai offers several options in regards to public transport, such as buses and local trains, these are often always busting at the seams during the peak hours to accommodate the vast population of the city commuting to and fro.

While writing this document, about three metro lines are operational, while more than half of the planned metro lines are currently under construction. An observation is that while the metro lines are under construction, the space occupied in the centre of the roads has further narrowed the roads to a great extent, causing a bottleneck-like situation and hampering the flow of traffic (van Westen et al., 2023).

Eventually, after construction is completed for all these planned metro lines, it is assumed that it will allow for a larger part of the city to cross-connect, and thus, the hope would be that a vast majority of office-goers leave behind their vehicle and commute comfortably in air-conditioned metro-trains saving both time and fuel (van Westen et al., 2023).

The literature review shows that several factors contribute to traffic congestion. Mumbai's current traffic surveillance system heavily relies on static sensors and the traffic police, who are constrained by limited resources (Das and Purves, 2019).

Singh et al. (2019) points out that monitoring an enormous number of CCTV traffic cameras manually is a cumbersome, mundane and tedious process and suggests instead making use of state-of-the-art deep learning algorithms and computer vision to detect objects, vehicles, people and their activities and thereby proposes a system to automate the task of detecting traffic violations. This is in conjunction with other strategies and policies that would need to be implemented to help curb the challenges the citizens of Mumbai face during commuting.

This review also highlights the potential of emerging technologies to transform traffic management in Mumbai. Singh et al. (2019) advocates for adopting advanced deep-learning algorithms and computer vision techniques to automate the detection of traffic violations, thereby reducing the need for manual monitoring. This technological advancement could significantly enhance the efficiency and accuracy of traffic surveillance, leading to more effective enforcement of traffic regulations and improved traffic flow in Mumbai's streets.

This information from the literature review highlights the importance of adopting holistic approaches to traffic management that prioritize public health and well-being. By integrating health considerations into transportation planning and policy-making processes, policymakers can develop strategies that not only alleviate traffic congestion but also promote healthier and more liveable urban environments for all residents (Das and Purves, 2019).

Furthermore, while the literature review provides valuable insights into the factors contributing to traffic congestion and its health impacts, there remains a need for further research and professional viewpoints to inform evidence-based decision-making (Moreno, 2023). By engaging with experts in urban planning, transportation engineering, public health, and environmental science, researchers can gain deeper insights into the complex dynamics of traffic management and identify innovative solutions tailored to the specific context of the specified street in Mumbai city (van Westen et al., 2023). Through interdisciplinary collaboration and knowledge sharing, we can develop comprehensive strategies for enhanced inner-city traffic management that address urban communities' diverse needs and challenges in Mumbai and beyond (Das and Purves, 2019).

A preliminary literature review reveals that the first recorded traffic jam incident was in August 1969 in Bethel, New York, in the United States of America (Mala, 2023). It is observed that most urbanisation is concentrated in existing cities. In most developing countries, the existing cities are now experiencing narrowed roads that are incapable of accommodating the increasing traffic capacity and have insufficient provision for parking, loading, and unloading facilities (Singh and Singh, 2021).

Despite recent developments, urban mobility in the city is characterised by traffic jams, delays, and a need for integrated and inclusionary transportation systems. These negatively impact economic efficiency through loss of labour time, delayed deliveries of goods and services, environmental pollution, and healthcare costs (Shaban and Sattar, 2023). Mumbai vehicles have exceeded 25 lakhs, with most registered within the past decade (Jain, 2021).

Space constraints are a huge issue, mainly due to an increase in privately owned vehicles. Furthermore, due to a shortage of parking spaces, people ultimately park their vehicles on the roads, thereby occupying a considerable portion of road space that is required for traffic movement. This eventually leads to inconvenience of vehicular flow and reduced road capacity (Jain, 2021).

Beyond the menace of unauthorised road parking issues, the city faces the issue of illegal encroachments by hawkers at road intersections, which is a minor inconvenience and a persistent bottleneck to traffic flow in Mumbai (Singh and Singh, 2021). Despite attempts to widen roads, these encroachments disrupt smooth vehicular movement and worsen congestion, as Shivatare et al. (2017) pointed out. Traffic congestion results from numerous factors, such as road incidents, bottlenecks, and erratic traffic patterns (Agarwal et al., 2024).

While the snowballing motorisation of developing nations is a testament to their economic growth and their citizens' aspirations for speedier and more comfortable travel, nevertheless, the steady increase in congestion on already crowded roads is threatening to isolate workers from employers and to turn off the bus transport systems that numerous middle- to low-income commuters primarily rely on (Kutzbach, 2010).

While efficient public transport and successful urban planning may remedy the situation to alleviate traffic congestion, reducing traffic is a multipart problem that does not come with an uncomplicated solution. Research cited that transport infrastructure development in Mumbai has not kept up with its demand (Shaban and Sattar, 2023).

In addition to the already present issues concerning vehicular traffic, the problem is exacerbated during the monsoon season when heavy rainfall transforms streets into veritable rivers and exacerbates mobility challenges. For the city's residents, navigating Mumbai's traffic-choked arteries has become a daily ordeal, with commute times stretching well beyond the norm and bringing about the suffering of quality of life (Gowda and Thenambigai, 2020).

Seasonal factors, such as the monsoon rains, further compound the traffic congestion challenges in Mumbai. Heavy rainfall reduces traffic speed and volume and it leads to road waterlogging, particularly in areas with inadequate stormwater drainage systems (Hu et al., 2018). The catastrophic deluge experienced by Mumbai on 26th July 2005 serves as a poignant reminder of the city's vulnerability to extreme weather events, which can bring transportation networks to a grinding halt (Gupta, 2007).

The staggering effects due to traffic congestion hamper individual productivity and erode the city's economic efficiency and competitiveness (Hu et al., 2018).

As Patil and Sharma (2022) emphasised, transportation is crucial for accessing opportunities and enhancing the quality of life (QoL). Nevertheless, more comprehensive studies are needed to assess its impact on QoL. Seasonal factors, such as the monsoon rains, further compound the traffic congestion challenges in Mumbai. Heavy rainfall reduces traffic speed and volume and it leads to road waterlogging, particularly in areas with inadequate stormwater drainage systems (Hu et al., 2018).

To effectively manage these issues, it is imperative to comprehensively delineate the sources of traffic congestion and assess their multifaceted impacts on urban citizens' lives, health, and well-being (Mahajan and Mahajan, 2022). This understanding is a foundational step towards devising targeted interventions and implementing a sustainable traffic management model tailored to Mumbai's unique context.

Importantly, seeking expert opinion and leveraging evidence-based strategies are crucial for mitigating risks and improving the overall health outcomes of affected individuals (Jain, 2021). Short-term solutions may include:

- optimising traffic signal timings,
- implementing congestion pricing schemes and
- enhancing enforcement of traffic regulations to alleviate immediate congestion hotspots.

Additionally, leveraging technology-driven solutions such as real-time traffic monitoring systems and intelligent transportation systems can enhance the efficiency of traffic flow management (Kheder and Mohammed, 2024). By fostering a participatory approach that incorporates diverse perspectives and engages stakeholders at every stage of the decision-making process, it is possible to cultivate ownership and support for sustainable traffic management initiatives (Kheder and Mohammed, 2024). The citizens' role in this collaboration is not just important but indispensable.

In parallel, long-term strategic planning efforts should focus on enhancing the resilience and adaptability of Mumbai's transportation infrastructure to future challenges, including population growth, urbanisation, and climate change impacts (Mahajan and Mahajan, 2022). This may involve investing in infrastructure upgrades, expanding public transportation networks, and promoting alternative modes of transportation, such as cycling and walking (Mahajan and Mahajan, 2022).

2.3 Human Society Theory

Human society theory advocates that human behaviour and interactions are dictated through multifaceted, fostered social norms, cultural practices, and shared values that cumulatively influence the functioning of an organized community (Rahma and Wantini, 2024). This theory finds its application in traffic management in the metropolitan city of Mumbai, by highlighting the importance of society's etiquette and requirements in the maintenance of safety and order on the roads. The overall demonstrated traffic behaviour is simply not governed by an individual but is in fact a result of the societal expectation alongside regulatory frameworks. Successful traffic management will chiefly depend on the esteemed efforts of stakeholders, such as authorities and community, undertaking joint responsibility of the roads, complying with traffic rules and burgeoning respect for all road users and commuters. In summary, application of human society theory to management of traffic in Mumbai would necessitate models that would not only rely on lawmakers to enforce regulations but in tandem also embolden the citizens autonomous participation through means of awareness and education.

In the context of examining strategies for enhanced inner city traffic management in a Mumbai street, the theme of "our road - our pride" highlights the need for a holistic approach that considers the diverse needs and priorities of stakeholders.

This includes actively engaging with local communities and businesses, who are the most affected by traffic congestion, transportation authorities, and city planners to develop strategies that not only alleviate traffic congestion but also enhance the overall liveability and sustainability of the urban environment. By fostering a sense of ownership and pride in the condition of Mumbai's streets, researchers can mobilize collective action and support for initiatives aimed at improving traffic flow, reducing pollution, and enhancing safety on the specified street (Gowda and Thenambigai, 2020).

Moreover, embracing the theme of "our road - our pride" can catalyse innovation and collaboration in traffic management practices. By recognizing roads as shared public assets that contribute to the collective identity and prosperity of Mumbai City, stakeholders can work together to develop and implement innovative solutions that address the unique challenges and opportunities present in the specified street (Gowda and Thenambigai, 2020).

This may include integrating technology-driven solutions, promoting sustainable transportation modes, and prioritizing investments in infrastructure upgrades that enhance Mumbai's roads' functionality and aesthetic appeal. Through a shared commitment to preserving and strengthening the city's streets, Mumbai can reinforce its reputation as a vibrant, dynamic, and liveable urban centre for residents and visitors alike (Gowda and Thenambigai, 2020).

In metropolitan areas, all the roads are unlikely to have the same traffic volume and thus, in order to prioritise management actions of congestion mitigation for different roads with different operating conditions, a study proposed to assess the performance of different roads based on a comparable quantitative metrics (Maitra et al., 2004).

By observing the after-effects, the insights gathered have the ability to improve the efficiency of cities and reduce congestion. These insights conveyed that only one uniquely tailored solution can exist for each of the city's roads (Sharma et al., 2024).

By embracing a holistic and integrated approach that combines short-term interventions with long-term strategic planning efforts, this specific street in Mumbai can transform its inner-city traffic management and facilitate a more sustainable and liveable urban environment for its residents (Siva Raju and Ahire, 2018).

2.4 Summary

In summary, vehicular traffic has only grown over the years in the city of Mumbai, and there are multiple factors that are contributing to its continuous growth all at once. An upsurge in population along with an increased demand for transportation ultimately contributes to the increasing number of automobiles on the road that will eventually lead to traffic congestion (Ghazali and Tahar, 2024).

Transportation system comes with their limits where the vehicular flow is disrupted owing to the narrow roadway width, limited vehicular parking spaces and traffic signals collectively known as congestion (Harriet et al., 2013).

The effects of traffic congestion have long been a concern in most metropolitan areas. By increasing travel times, traffic congestion increases the costs of travel and reduces accessibility (Weber and Kwan, 2002).

Furthermore, traffic congestion can have dire consequences for the health and well-being of individuals and the ecology alike. It can manifest into many various short term and long-term adverse effects, which require immediate interventions and solutions to curb the issue from expediting further.

The execution of traffic regulations is a crucial aspect of maintaining road safety. Conventional methods of traffic law enforcement have mainly relied on manual intervention, eventually resulting in inefficiencies, inaccuracies, and resource-intensive processes (Jadhav and Ansari, 2024). Transportation systems in metropolitan spaces of India, including Mumbai, are remarkably intricate, primarily due to the system frameworks, the immense number of destinations, and the hotchpotch of traffic (Jain, 2021).

For instance, at the crossing of four roads, it has been witnessed that allotting an equal amount of time for the green light to all roads is insignificant since the traffic volumes on different lanes are different. Thus, the arrival rate is eventually responsible for all traffic gridlocks, long queues, and increased waiting intervals (Dimri et al., 2024).

A research study has proposed the design and execution of an adaptive traffic signal timer system that utilises real-time automobile detection along with an intelligent Signal Switching Algorithm. This system can improve the flow of vehicular traffic at junctions, thereby improving waiting time (Amarnath et al., 2024). Furthermore, leveraging technology and data-driven solutions can be pivotal in optimising traffic management strategies (Gowda and Thenambigai, 2020).

Advanced traffic monitoring systems with real-time data analytics capabilities can enable authorities to identify congestion hotspots and deploy targeted interventions to alleviate bottlenecks (Gowda and Thenambigai, 2020). Additionally, the implementation of intelligent transportation systems, including adaptive traffic signal control and dynamic routing algorithms, can help optimise traffic flow and minimise commuter travel times. By harnessing the power of innovation and collaboration, Mumbai can chart a course towards a more efficient, resilient, and sustainable urban transportation ecosystem (Mahajan and Mahajan, 2022).

Although the correlation linking traffic congestion and road accidents is an under-researched area, a research study concluded that in the analysis of accident frequency, traffic congestion increases the frequency of severe and fatal injury accidents (Wang, 2010). As cited by Bloomberg Philanthropies Initiative for Global Road Safety, road safety is a persistent public health challenge that needs more attention and more resources to address the problem (Gowda and Thenambigai, 2020).

Traffic in Mumbai is a problem that is notably taking a major toll on the health and well-being of the citizens residing in the city, along with loss of time and productivity. With every passing day, the problem only seems to extrapolate at a great magnitude. In order to reach on time, commuters need to leave hours prior to the usual estimated time as the commute is not simply a mere car ride away but the time estimated to be lost in traffic needs to be delicately factored in for ensuing timely arrivals to destination, even so on regular commute trips such as home to office and vice versa.

Given the geography, the unique presentation of the populace, and the worsening health impacts, Mumbai is a standalone case, which requires its own unique tailored solution to address the problem. In order to reach some consensus amongst the stakeholders and policymakers, to manage the problem, offering just a single solution will not be beneficial nor will it suffice to address the complex multifactorial problem and in order to tackle it, it is crucial to first identify the multiple causative reasons of the city's traffic by an in-dept study of all factors cumulatively contributing to it and scrutinize the cascading health implications.

The review of the literature of similar studies may help in suggesting solutions that can be implemented to aid traffic problem, by understanding the similarities and subsequently drawing nuances.

However, in order to address the gap, it is imperative to recognise that the presentation of Mumbai's traffic problem is unique in terms of the causative factors and also the impacts that are observed on citizens health individually and as a community. By distinguishing the challenges faced, both from the standpoint of health and quality of life, we can better navigate the solutions, which are not just important to address but have also assumed an urgency. Arriving on time and living a healthy life should not be a matter of happenstance; rather, it should be an outcome of a robust action plan, integrating all the measures which are put in place to make the city a well-managed one.

CHAPTER III: METHODOLOGY

3.1 Overview of the Research Problem

An exponential and ever-increasing traffic in the city of Mumbai, is chiefly contributing to the deteriorated health of its citizens, grave impacts on the quality of life and well-being. With every passing year, the issue of vehicular traffic only seems to mount and worsen, and measures which are taken to remedy the situation, such as infrastructure development, etc, are proving to be futile (Anand, 2006). The impacts of this traffic are proving to be far beyond mere inconvenience, and it is cascading and manifesting into even bigger problems and economic loss. To remedy the situation, it is important to find and analyse the causes, deeply understand its impacts on all aspects and suggest measures that can help in curbing the issue (Anand, 2006).

3.2 Operationalization of Theoretical Constructs

The operationalization of theoretical constructs exemplifies a mode of quantifying and qualifying tangible, intangible and abstract concepts, which allow them to be measured and analysed in such a way that they can be defined and analysed. With a view to operationalize theoretical constructs, it is imperative to characterize observable variables that were associated with it so that it could be quantified and qualified effectively (Amarnath et al., 2024).

As this research case-study focuses on the causative factors of the traffic congestions, the impacts it has on health of its citizens, the opinions of the healthcare providers (HCPs) and residents in a specific street of Mumbai city, the views and

observations and finally the goal to suggest remedies that could be arrayed to alleviate the multifaceted issues.

It is imperative to understand the interdependencies of the aforementioned variables and how these will eventually become the cornerstone of this research (Amarnath et al., 2024).

The insights obtained from healthcare providers (HCPs) and residents of a specific street of Mumbai city, from interview questionnaires, were analysed using qualitative research methodologies to understand common variables and themes. The qualitative data were examined further to better understand how it correlates to help improve the overall health and well-being of its residents in a particular street of Mumbai city, by putting in place remedial measures pertaining to griddle lock problems that the city faces (Boelen et al., 2024).

3.3 Research Purpose and Questions

The purpose of this research is to analyse factors contributing to traffic congestion and its health impacts on a specific street in Mumbai city, and to propose strategic interventions for improved urban traffic management and well-being.

RQ1. What underlying factors contribute to traffic congestion on the specified street in Mumbai? The sub-questions (a, b, c, and d) for RQ1 are given as follows:

- a) What are the major contributory factors of traffic in the specific street?
- b) How can we qualify & quantify these factors for qualitative research purposes in the specific street?
- c) How do seasonal variations, such as monsoons, influence traffic congestion in the specified street?

d) What role do urban infrastructure and road design play in exacerbating or alleviating traffic congestion in this area of the specific street in Mumbai city, used for this research purpose?

Research question one (RQ1) was adopted from literature articles by Rahman et al., (2022) *"Traffic congestion and its urban scale factors: 'Empirical evidence from American urban areas'";* and Aftabuzzaman et al. (2011), *'Exploring the underlying dimensions of elements affecting traffic congestion relief impact of transit.'*

RQ2. How does traffic congestion on the specified street in Mumbai impact the health and well-being of residents and commuters? The sub-questions (a, b, c, and d) for RQ2 are given as follows:

- a) How does traffic impact the physical health of the citizens, in the specific street?
- b) How does traffic impact the mental health and well-being, in the specific street?
- c) What impacts are seen on the quality of life (QOL) of the citizens in the specific street?
- d) Impact on the familial and social life of citizens, in the specific street

Research question two (RQ2) was adopted from multiple literature articles used as references to broaden the understanding of the health impacts of traffic to address the gap. The articles that served as reference are as follows, Novaco and Gonzalez, (2009), *'Commuting and well-being';* Stokols and Novaco (1981), *'Transportation and well-being: An ecological perspective';* Haider et al., (2013), *'Does commuting cause stress? The public health implications of traffic congestion';* and Clark et al., (2020) *'How commuting affects subjective wellbeing'.*

RQ3. What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai? The sub-questions (a, b, c, and d) for RQ3 are given as follows:

- a) What measures can be taken to combat the problems pertaining to health and well-being, in the specific street?
- b) What solutions can be implemented to mitigate the challenges and reduce the traffic, in the specific street?
- c) How can the use of technology, such as smart traffic management systems, improve traffic flow and reduce congestion, in the specific street?
- d) What role can public transportation and alternative mobility options, such as cycling and walking infrastructure, play in alleviating traffic on the specified street?

Research question three (RQ3) was adapted from, Cheng et al. (2024). '*What interventions are effective in reducing congestion?*' and De Nazelle et al. (2011), '*Improving health through policies that promote active travel: a review of evidence to support integrated health impact assessment.*'

3.4 Research Design

The research is being carried out by collecting and analysing data from below mentioned four sources (figure 2).

The data collection was performed using quantitative approaches, wherein the interviews and open-ended questions will be asked and additionally followed up to seek various perspectives. Qualitative methodologies encompass diverse research techniques to explore and understand the complexities of human experiences, perceptions, and behaviours (Boelen et al., 2024).

- a) Interviews of medical professionals, subject matter experts (SME)
- b) Interviews of selected residents of a specific street in a Mumbai city suburb
- c) Content analysis of existing literature from various sources
- d) And personal observations of the researcher regarding the specific street of Mumbai city.

Methods of Data collection

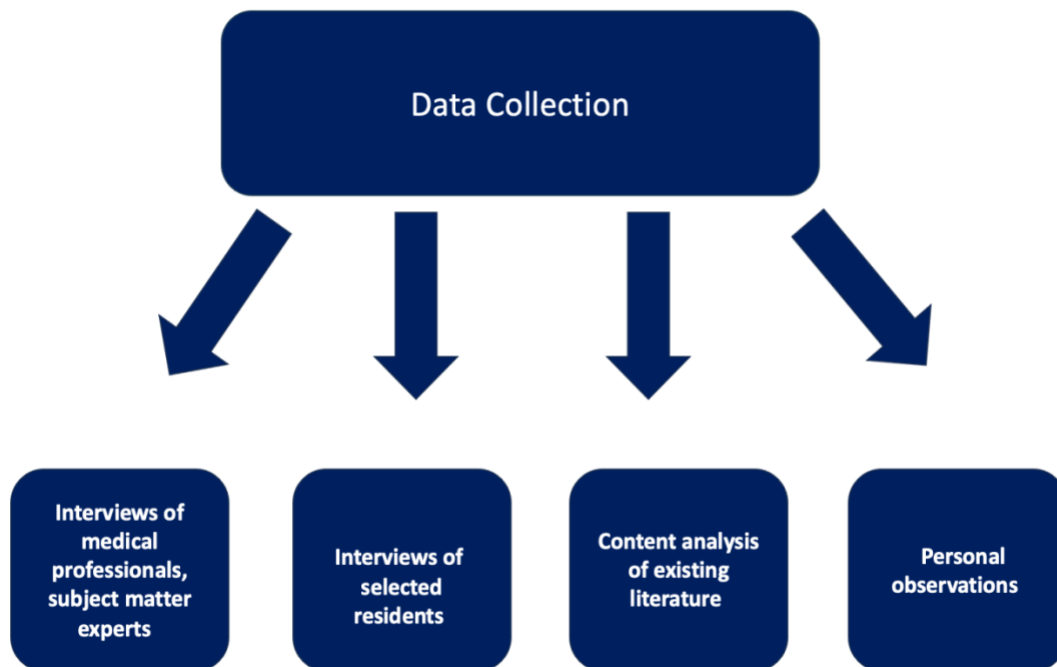


Figure: 2 – Data collection methods (Source: Author’s own work)

Interviews were conducted with subject matter experts (SME) who are highly esteemed medical professionals practicing medicine and/or are industry experts to obtain expert opinions on the health impacts of traffic congestion and potential cautionary measures and solutions that can be implemented.

By soliciting opinions and recommendations from these respected healthcare providers (HCPs), specializing in relevant fields such as public health, pharmacology medicine, and respiratory health, oncology the research aimed to augment understanding of the health implications associated with traffic congestion (Dimri et al., 2024).

Additionally, these interviews aimed to seek valuable perspectives on strategies to alleviate the health risks posed by traffic congestion and promote overall well-being, specifically focusing on the specified street in Mumbai(Dimri et al., 2024).

Another important piece of this research focuses on gathering opinions of those who are primarily impacted by this traffic, in their day-to-day life, to understand how effects of traffic is peculating and gravely impacting the life of the citizens from not just the perspective of health but from an overall aspect (Hegewald et al., 2020).

The research case-study also deep dives to collect nuances from other studies conducted on similar topics, to understand and provide a framework and guidelines for how the problems were addressed and research gaps were addressed (Jain, 2021).

Finally, the researcher's own personal observations and opinions have been shared on the matter, and potential solutions will be documented based on the learnings from the research.

3.5 Population and Sample

The research/case study is focused on a specific street of Mumbai city with a population size that is more than 200 and less than 500, depending on the floating population (Jain, 2021).

The interview questionnaire was administered to about six healthcare professionals/providers (HCPs), who are prolific in their respective medical fields, and who can provide detailed insights on the matter that are being observed in the real-time.

The researcher envisages that data saturation might be achieved with these many numbers of participants (Jain, 2021).

Additionally, the interviews were also be conducted with around 12-15 citizens who reside or travel regularly across the specific street of Mumbai city, who are impacted with inter-city traffic on a regular basis.

With a view to achieving data saturation in qualitative research, a sample size of around 12-15 is considered to be practical and ideal, in a standardized population of residents or commuters of the specific street in Mumbai city. Further sample studies are conducted where necessary, based on the requirement of primary data for the qualitative research.

Data saturation was thought to be achieved when the inputs and perceptions we get from further interviews no longer add any further merit to the information, even when additional surveys may be conducted with several more stakeholders.

3.6 Participant Selection

The healthcare professionals (HCPs) from multiple domains were requested to provide insights and expert opinions, chiefly to understand the impacts on the health and well-being of citizens (Khreis, 2020).

These healthcare professionals (HCPs) were those who have specializations in medical fields, may be industry experts, key opinion leaders (KOL) and published authors, that are practicing medicine (Khreis, 2020).

The sampling method for healthcare professionals used in the study was purposive sampling.

This method of sampling was chosen as the study would benefit tremendously from gaining insights from medical professionals, respondents who are subject matter experts (SME) having immense knowledge and experience in the healthcare setting (Khreis, 2020).

Selection of citizens who reside in a specific street in the City of Mumbai will be from a subset of those who meet the following inclusion criteria,

- a) Are adults of ages 18 and above
- b) Those who are residing in the specific street of Mumbai for, atleast, a year
- c) Are commuting on a daily basis during weekdays by roadways or a mix of roadways and an additional mode of transportation
- d) Are willing to consent and participate in this research case-study

The method of homogenous sampling is deployed for citizens selection for participation, meeting the aforementioned inclusion criteria.

3.7 Instrumentation

Two semi-structured questionnaires comprising of interview schedules were used in this case-study and will be mailed out or handed over to the participants of the research. The first one will be the ‘Set A’ interview questionnaire, which comprised of questions to the healthcare professionals (HCPs) such as medical doctors, which were mainly be directed towards, gaining perspective and insights on the health impacts that the citizens are predisposed to as an after math of the traffic impacts (Kutzbach, 2010).

The second set of interview questionnaire ‘Set B’ was for the residents and/or commuters of the street to mainly probe questions and gain clarity on how the traffic impacts the quality of life, overall health and well-being of the individuals.

The interview questionnaires were semi-structured and have open-ended questions where a participant can answer requested information in great detail (Kutzbach, 2010).

Validation process

The validation of the questions (Set A and Set B), were first pilot tested, and interviews were conducted with a healthcare professional (Set A) and a resident (B), who were not part of the study, but fit the inclusion criteria were interviewed with a semi-structured interview schedule.

Personal interview is extensively accepted for qualitative research to gain perspectives of individuals that have had experienced the phenomenon (Collingridge and Gantt, 2008; Wimpenny and Gass, 2000).

Prior to the interview, the informed consent process was completed and the purpose of the study was explained in detail. The participants were also involved in the validation process and were aware of how their participation contributed to this validation. This validation was done as a pilot testing method, to get responses, and to understand if all the questions which were asked, were correctly understood and received appropriate responses. The step of pilot study was mainly performed with an intent to scrutinize the appropriateness of the interview questions that would be asked in the main study, to gain information on the context of the study as it affords the researcher with an opportunity to first rehearse the interviewing methods and then make needed modifications, as deemed appropriate, resulting from insights that arise from experiences while interviewing (Majid et al., 2017). Post this step of validation, the researcher went ahead with the actual interviews.

3.8 Data Collection Procedures

The interview questionnaires noted in the above section were used to collect primary qualitative data.

There were two primary sampling methods deployed for the data collection process. The 'Set A' interview segment of the study greatly benefited from the purposive sampling method and thus was chosen to gain valuable perspectives and insights of healthcare professionals (HCPs) on the various health impacts of vehicular traffic. The second sampling method which was used to conduct interviews and insights is the homogenous sampling method primarily for residents of a specific street of the Mumbai city to weigh in on the impacts of their regular commute, overall quality of life (QoL) and well-being (Mala, 2023). 'Set A', which comprised mainly questions pertaining to health impact, was handed to healthcare professionals (HCPs). 'Set B' was be given to citizens of the specific street of Mumbai city who meet the selection criteria (Mala, 2023). The interviews were be conducted face to face, in person or via phone or using other modes of telecommunications or social-media tools. For each completed interview questionnaire, the source of the completion was also be noted (such as face to face, via phone, via email, WhatsApp, Facebook, Zoom calls, etc).

The interview process with healthcare professionals to understand the health impacts of traffic, deploying the methods described in the literature by (Næss, 2020), consisted of the below described steps,

1. Preparation for interviews

By choosing the topic for theoretical considerations, which in case for this current study, would be traffic management and its health impacts on the citizens. For the healthcare segment of the interview, emphasis was placed mainly on the health impacts of traffic. Topics from the forefront, taking into consideration specific health issues such as respiratory, cardiovascular diseases, stress and mental disorders that might be linked to traffic-related factors, will be included in the interviews.

An interview guide comprising of main questions as noted in Set A and Set B and potential follow up questions, that may arise as a part of the expected responses. A few examples and samples of the questions that would be asked are as follows,

In your experience, what are the primary health issues you observe that seem to be related to traffic?

How does traffic noise and air pollution, in your opinion, affect the health of residents?

What are the specific health concerns of that arise in relation to traffic?

Follow-up questions were asked to gain clarity, such as,

What are the long-term health implications of these traffic-related factors?

What are some preventive steps, which the residents can take to prevent the health impacts of traffic.

Already available information, which was received from the interviewee, will be reviewed prior to the interview to avoid redundancy. As the questionnaires (Set A) were previously emailed to the healthcare professionals and responses were received, these will be thoroughly reviewed first to save time during the formal interview and will help the researcher to tailor the questions and also avoid asking for information already available.

2. Conducting the Interviews

Starting the interviews with broad open-ended questions, to gain overall perspectives and insights on the subject, from the particular set, and researcher jotted down field notes from these interviews, accurately make a note of the discussion and prevent loss of important points and to ensure nothing is lost in transcription, and to avoid any potential for misinterpretation or misunderstanding.

3. Interpretation of Interview Material

Written text was used as the primary basis for interpretation, and context analysis will be used to interpret the results.

The researcher used an interpretation scheme, by involving sub-questions, to deep dive into the interview materials and its analysis. For instance, *What detailed respiratory conditions are mentioned by healthcare professionals as being linked to traffic pollution?*

Causal mechanisms, will be further explored, such as *investigation of the potential causal mechanisms through which traffic affects health, how does air pollution arising due to traffic hotspots, cause respiratory problems? How do healthcare professionals perceive the impact of traffic noise on mental health and stress levels?*

Analysis of the field notes were done, mainly to determine the emerging key themes, patterns, and evidence related to the health impacts of traffic.

Similarly, for the residents' interview, the above steps stayed the same, except the questions were from the standpoint of their personal experiences on living on the studied specific street, the challenges they faced and how multiple factors come into inter-play.

4. Analysis from interviews and synthesis

This step involved, grouping sub questions and received responses into broader categories to facilitate cross-interview analysis to with an intent to identify and group common themes and variations. For instance, impacts noted on respiratory health, mental health, cardiovascular health, etc. and this information will then comprehensively be reviewed and synthesised in the further sections.

Secondary sources of literature will also be vastly evaluated to understand the causes and impacts of the traffic and what measures and solutions have researches prescribed to alleviate the issues (Mala, 2023). Lastly, with personal observations of the researcher on the various causative factors of the vehicular traffic will be documented and studied using root cause analysis, and solutions will then be planned and suggested to help ameliorate the situation.

3.9 Data Analysis

Data from the completed interviews of both ‘Set A’ and ‘Set B’ were analysed to understand the insights and narratives which are provided by the participants and further summarized to draw inferences and gain clarity on the research questions thereby bridging the gaps in the research. Qualitative data analysis methodologies were used, comprising of conceptual context analysis, wherein, analysis of presences and meanings of various concepts driven from verbatim insights will be identified within the semi-structured interviews and coding and grouping of similar concepts were done, until there are emergence of specific themes and frequency of concepts that come out of this coding of data and thematic analysis, which will focus primarily on emergence of themes, from the data being analysed. Finally, the researcher will analyse and interpret these findings. In addition to qualitative analysis, quantitative analysis was also be used for data analysis. Pictorial representations such as bar charts, and line graphs were used to decipher and present the data (Nallathiga, 2006).

Qualitative methodologies used for data analysis

Qualitative data analysis deep-dives into the multifaceted nature of human experiences, observations and perceptions. Context analysis and thematic analysis were the methodologies that were used for analysis of interviews for both questionnaire A and B, which were semis-structured and open ended, to fully understand and grasp the context being discussed.

And to identify themes and patterns within the data collected, decipher its meanings and implications from the standpoint of the research questions being discussed and understanding its true perspectives and factors involved.

Conceptual Context Analysis

Analysis of presence and meanings of concepts within the interviews where mined for, by deploying focus and attention to details on the key concept being discussed, coding was performed on the data to understand the emergence of frequency of a concept being discussed and the themes and patterns that surfaces out of it, finally interpreting the meanings and concepts from the context within the data (Figure 3).



Figure 3- Conceptual Context Analysis method (Source: Author's own work)

2. Thematic Analysis

Thematic analysis, will be performed as per steps described by Castleberry and Nolen, (2018), where the researcher will collate and compile the data in an organized fashion and will need to familiarize oneself with it by reading and rereading the data in a holistic way, the step that follows will be disassembling, which would require, fragmenting data into separate meaningful groups, by coding. Coding mainly involves the identification of what is similar or different within the captured data.

This step then follows, reassembling the coded data, which involves mapping of the codes and subsequently placing them into context to create themes and granularly analysing the reassembled data to gain insights on thematic views. Next step would be interpreting the

data, which should be complete, comprehensive and can be replicated and be a true representation of raw data, which can then be represented as a thematic map.

Application of Conceptual Context Analysis and Thematic Analysis in current research study.

In this research, thematic and context analysis qualitative methodology was applied across all the interview and on email responses that were received from the healthcare professionals. Steps below were followed.

Questions were first emailed to all the participating healthcare professionals prior to conducting interviews, and responses were also received via email. Post this the researcher thoroughly read through all the responses in order to familiarize what was already been answered to prevent any redundancy during the in-person or telephonic interview.

In case of ‘residents’ interview’ segments, the researcher directly approached the participants for an interview after seeking and receiving appropriate consents.

During and after the completion of each of the scheduled interviews with all the participants, notes and transcripts were written down to ensure that no information was missed out.

After all the interviews of both Set A (Healthcare providers) and Set B (residents) were completed, the gathered interviews excerpts were then thoroughly read together cumulatively to delve through all the information and the responses were compared for understanding the context that were being discussed.

These were re-read several times in conjunction with the email responses received to analyse, and codes were created by systematically grouping similar excerpts together to find out what the key elements were that were being highlighted.

This activity was performed on Microsoft Word software, and each code was highlighted with either a font colour or a specific-colour highlights in order to group them. Next, the codes, which were colour coded, were collated and grouped together under various themes.

In order to interpret, comprehend and articulate its meaning, the arranged coded excerpts were further organized in a systematic fashion to make sequential sense and granularity.

These collated excerpts were then again reviewed to pick up various repetitive words, context, themes and patterns that were emerging from the data.

Ad-hoc follow-ups were made in just two cases to gain additional clarity from the healthcare professional participant especially to deeply understand medical information that was discussed during the healthcare segment of interview, via a telephonic connect.

After all the information was correctly comprehended, the narratives were then written for each of the research questions (RQ) and sub-questions, to cohesively summarise all the information.

The narratives were carefully aligned with the study's overarching aim of exploring traffic management strategies and their associated health impacts on the selected street in Mumbai.

Each narrative not only addressed the specific research questions but also highlighted any unique insights or unexpected findings that surfaced during the interviews. Throughout the process, particular attention was given to maintaining the reliability and credibility of the findings.

Cross-verification of responses was conducted wherever possible to ensure consistency, especially for observations related to traffic conditions, air pollution exposure, and reported health issues.

The final thematic summaries were further refined to draw meaningful connections between traffic management challenges and public health outcomes, providing a robust foundation for the discussion and recommendations chapters that follow.

The application of qualitative research methodology in the current research involves using non-numerical data to explore and understand complex phenomena within the study's context. This approach emphasizes collecting rich, detailed insights through methods such as interviews and observations allowing for in-depth analysis of participants' experiences, perceptions, and motivation

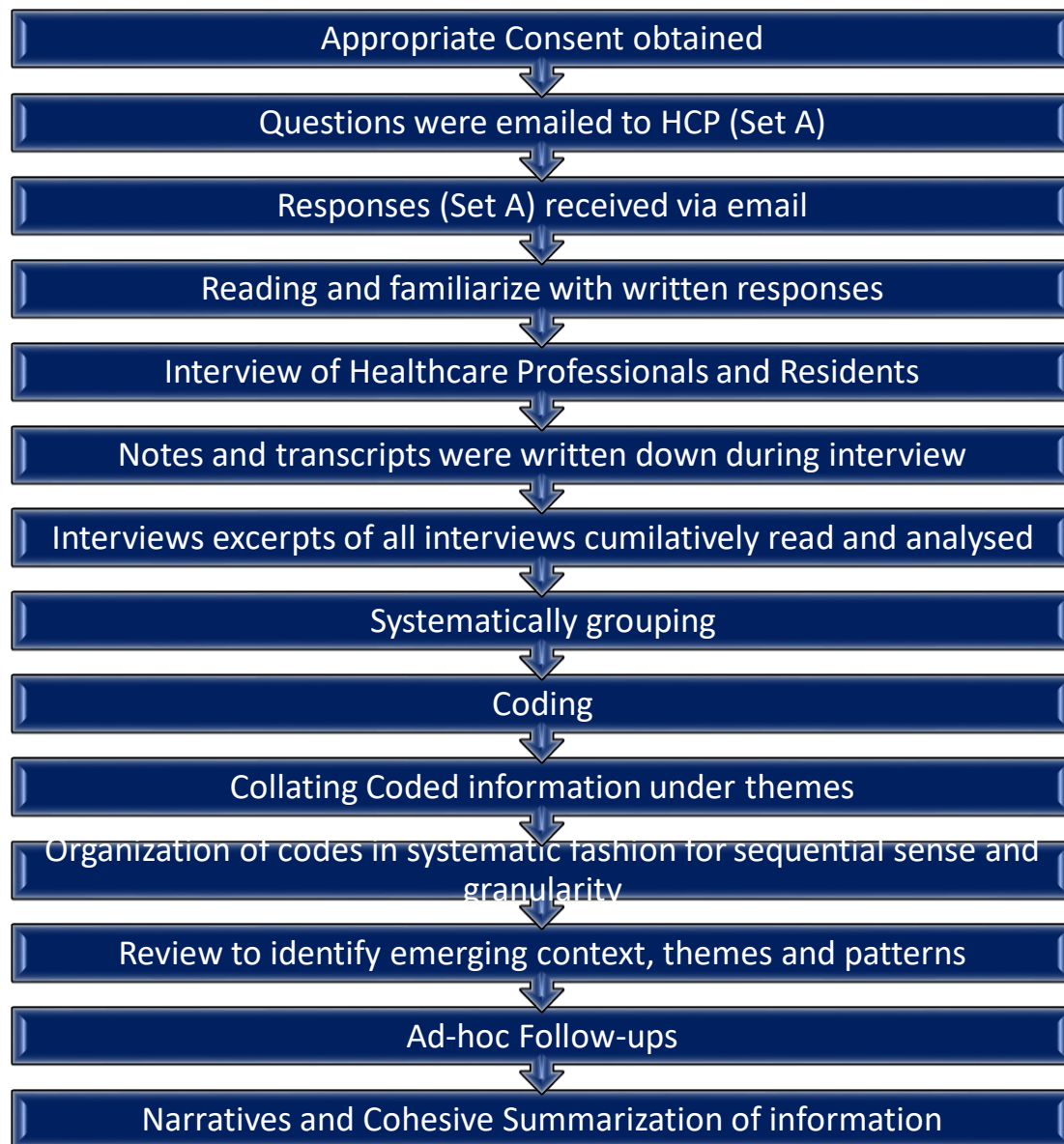


Figure-4 Application of qualitative research methodology in current research (Source: Author's own work)

3.10 Research Design Limitations

As the data collection is qualitative, which comprises of interviewing six healthcare professionals and 12-15 residents who are residents and/or commuters of a specific street of Mumbai city, to gain insights (Nallathiga, 2006). However, the sample size is significantly smaller in comparison to the population of the entire city of Mumbai. Hence, this study has further scope of being repeated with suitable modifications and replicated on a similar or a bit larger population & sample size and thus opens up avenues for future studies (Nallathiga, 2006).

3.11 Conclusion

The research/case study used qualitative methodologies, analysis of secondary data and observational approaches for data collection, analysis and reporting its findings. The homogenous sampling method was deployed for residents of the specific street of Mumbai city to participate in the interview and the purposive sampling method was chosen in case of healthcare professionals/providers (HCPs), taking into account the qualitative nature of the data collection. The insights and perspectives gained from the interviews were then summarized and analysed, which helped to provide the backbone of the research and further build possible solutions to remedy the research problems (Sharma et al., 2024).

CHAPTER IV:

RESULTS

In order to systematically compile and summarize the results of the qualitative data collected, a structured approach was adopted. The responses obtained from both Profile A (residents) and Profile B (healthcare professionals) of the interview questionnaire were carefully analysed. A combination of statistical analysis, context analysis, and thematic analysis was employed to recognize recurring themes, contextual patterns, and key insights from the participants' responses (Daniels and Minot, 2025). Additionally, the researcher's personal observations, based on interactions and field experiences, have been integrated at relevant points throughout this chapter to enrich the understanding of the data and to provide nuanced interpretations. This comprehensive methodology ensures that the findings presented are thorough, reflective of diverse perspectives, and aligned with the overall research objectives (Daniels and Minot, 2025).

The demographic profile of the residents (Profile A respondents) from the specified street in Mumbai comprised a total of 15 participants, including 9 females and 6 males. The age of the respondents ranged from 28 to 48 years, representing a broad adult age group. Educational qualifications among the participants were diverse and reflected a high level of academic achievement. Among the females, qualifications included a Master of Business Administration (MBA), Bachelor of Commerce (BCom), Diploma in Computer Science, Bachelor of Arts (BA), Master of Arts (MA), Bachelor of Legislative Law (LLB).

Other candidates had Engineering in Information Technology, Bachelor of Dental Surgery (BDS), and Master of Science (MSc) (Pham Xuan, 2025).

Among the males, qualifications similarly demonstrated high educational attainment, including Bachelor of Arts (BA), MBA, MSc, Electronics Engineering, Chartered Financial Analyst (CFA), and Mechanical Engineering degrees. This demographic composition indicates that the participant group was predominantly composed of professionally qualified individuals with tertiary or postgraduate education, providing a well-informed perspective on the issues explored in the study (Pham Xuan, 2025). The profile B respondents were the healthcare professionals who were interviewed for this research were as follows. Four of the six healthcare professionals were super specialized in the domain of general and medical pharmacology.

One healthcare provider had super specialisation in pulmonary medicine, and another healthcare provider had super specialisation in oncology and haematology. The idea behind conducting interviews with healthcare professionals having several super specialisations was to get a comprehensive view and cover a broad spectrum of healthcare domains to understand the various systemic health impacts on the residing citizens and to gain clarity and deep insights (Pham Xuan, 2025).

Ethical considerations

As this study is a non-interventional one, there were no pertinent ethical issues that could arise.

However, all participants, including both healthcare professionals and residents & commuters of the specific street, were informed that their responses and opinions expressed are primarily only used for the research study, keeping their identity undisclosed and confidential. Prior to data collection, oral and written consent was obtained, and they were briefed about their autonomous participation (Jadallah, 2025).

Furthermore, the study adhered to ethical standards ensuring no harm or discomfort to participants, and the data collected was securely stored and anonymized for analysis purposes. Participants were reassured that they had the right to withdraw from the study at any time without facing any negative consequences. The study protocol aligned with the broader ethical principles outlined in international research guidelines, emphasizing respect, beneficence, and justice (Jadallah, 2025).

4.1 Research Question One

RQ1 What underlying factors contribute to traffic congestion on the specified street in Mumbai?

The demographic data of the responders which included the residents that participated in the research included, 9 females and 6 males, the data is summarized in the table below.

No.	Gender	Age	Education
1.	Female	45	Masters in business administration (MBA)
2.	Female	30	Bachelor of Commerce (BCom)
3.	Female	47	Diploma in Computers science
4.	Female	38	Bachelor of Arts

5.	Female	30	Masters in Arts
6.	Female	44	Bachelor of Legislative Law (LLB)
7.	Female	31	Engineering in Information Technology
8.	Female	43	Bachelor of Dental Surgery (BDS)
9.	Female	34	Masters in Science
10.	Male	28	Bachelor of Arts
11.	Male	33	Master's in business administration (MBA)
12.	Male	38	Masters in Science
13.	Male	44	Electronics Engineering
14.	Male	48	Chartered Financial Analyst (CFA)
15.	Male	28	Mechanical Engineering

Table 1: Demographic data of the participants (Source: Author's own work)

The sub-questions for RQ1 are given as follows:

4.1.1 What are the major contributory factors of traffic in the specific street?

When discussing these contributory factors with the residents of the street, most responders provided an understanding that while many factors directly or indirectly contributed to traffic, unauthorized parking was a major contributor. This was highlighted by multiple residents. Unauthorized parking, has caused the lane to narrow down

tremendously, which has further caused these ‘two-ways’ street to become a single lane (Raoniar and Perumal, 2025).

Vehicles coming in from two opposite sides, sometimes on a single lane, have led to a logjam situation on this street. Furthermore, a tea stall hawker and a ‘*paan*’ (betel leaf) hawker that have small stalls situated on this roadside has brought along with it multiple loyal customers, who station their two wheelers or bikes or even three wheelers autorickshaws to enjoy these delicacies, encompassing a major chunk of the roadways which is causing bottlenecks (Raoniar and Perumal, 2025).

As pointed out by a resident, the street in question also has multiple shops and a multistorey hospital, where visitors of the patients, who have come in for a brief visit, do not have a guest parking offered as a part of the building’s infrastructure, often end-up parking adjacent to the hospital, which further cascades and exacerbates the traffic conundrum. Store owners frequently have attractive offers on display that occupy a part of the pavement, which catapults the public into grabbing the excellent discounts.

Another observation noted was, as this street is located quite close to the market place which is an extensively busy area, there are barely any parking spots available, and those who come to stock up on their groceries often park on the sides of roadways, pedestrians too are seen in great numbers on this street, and as the store displays are on the footpaths, these pedestrians use the streetways to pass through as the pavements are preoccupied and this affects the free flow of traffic (Raoniar and Perumal, 2025).

The other shops and establishments on this street are a gym and a saloon. Even in the wee hours of the morning and late at night when the traffic is expected to be lower than usual, however, this is not the case with this street.

Health enthusiast often visits the gym in the early morning time or late evening and bring along with them their vehicles, as they don't want to park too far from the gym, they often end up parking their cars in double parking fashion. Even though the street has sign boards of odd and even parking system to combat the narrow road parking challenge, this is not adhered to, and people in their hubris and rush, end up parking on both sides of the road (Raoniar and Perumal, 2025).

This can be attributed to the absence of fear of their vehicles being towed away or wheel locked and being fined, as the city's towing vehicles authority has fixed timing, and thus these traffic violations often go unchecked and are not fined. This however becomes more than an inconvenience for the residential commuters who often want to get a head start and begin their work commute earlier to get to their workplaces to avoid the peak time traffic of the city (Raoniar and Perumal, 2025).

A resident highlighted that, they 'need to factor-in additional time, for commuting to work, just for making it out of this street into the main highways, as the traffic is simply too much'. Another factor that is contributing to the compounded traffic is the revolution seen in the way food and groceries are being ordered and delivered in the last few years. Three of the respondents mentioned that they no longer need to overstock their groceries, as these apps are very handy and often order from the apps.

Like in all major cities of the world, currently in the city of Mumbai too, we are seeing a boost in quick commerce, which is the food delivery apps that are also into quick commerce, delivering groceries in flat 10 minutes.

Everyone now has convenience at their fingertips, with the ability to order a hot meal or groceries by paying a very small nominal fee, thereby saving both time and effort (Ahmad et al., 2025).

These kinds of orders are completed with a small delivery fee attached to it, which can even be waived off using subscription membership on these platforms. Services are being offered by several competitive apps, offering cut-throat, lucrative prices and discounts, delivered in minutes (Ahmad et al., 2025).

However, this q-commerce is contributing to a significant rise in the rate of traffic as these deliveries are completed using motorcycles and scooters to perform delivery. The delivery which is based out on customer convenience model is a perfect fit for busy working professionals and is causing a lot of people to order their groceries from the comfort of their home, and due to the competition even small value orders are often being delivered, that is thereby increasing the cumulative traffic (Ahmad et al., 2025).

The street being studied is no exception, as residents have noted that while they find this pattern of delivery extremely convenient, the number of traffic jam events has also increased.

Previously, people would procure a monthly or weekly supply to gain good discounts on their orders and save themselves trips, however quick commerce has solved both these problems but significantly contributed to traffic, as the riders often violate the traffic laws, jumps signals etc, to make swift deliveries (Ahmad et al., 2025).

Also, it is noted that the delivery companies, to meet the promised time, station their delivery partners with their motor vehicles at the junctions that have several stores, to save time (Ahmad et al., 2025).

These stationed automobiles too occupy a proportion of the roads, and moreover it is noted that in-order to make a timely delivery, as they are often incentivized for an on-time delivery by the company, the riders often ride their vehicles faster than usual, use wrong side lanes and jump signals, further disrupting the traffic.

All these factors are overall contributing to traffic in the specific street. Upon performing an analysis of the reasons and the frequency with which these were highlighted by the residents on the specified street, the following information was obtained as given in the following graph.

The following (Figure 5) illustrates the major contributory factors of traffic congestion on the specified street as identified by residents. According to the survey data, key factors include a high volume of commercial vehicles passing through the area, frequent construction activities, and inadequate parking facilities leading to road blockages. Residents also pointed out the insufficient public transportation options, which

force many individuals to rely on personal vehicles, exacerbating congestion. Additionally, poorly maintained infrastructure, such as narrow lanes and outdated traffic signals, was highlighted as a significant contributor. These combined factors create a persistent traffic bottleneck, impacting daily commuting times and residents' quality of life.

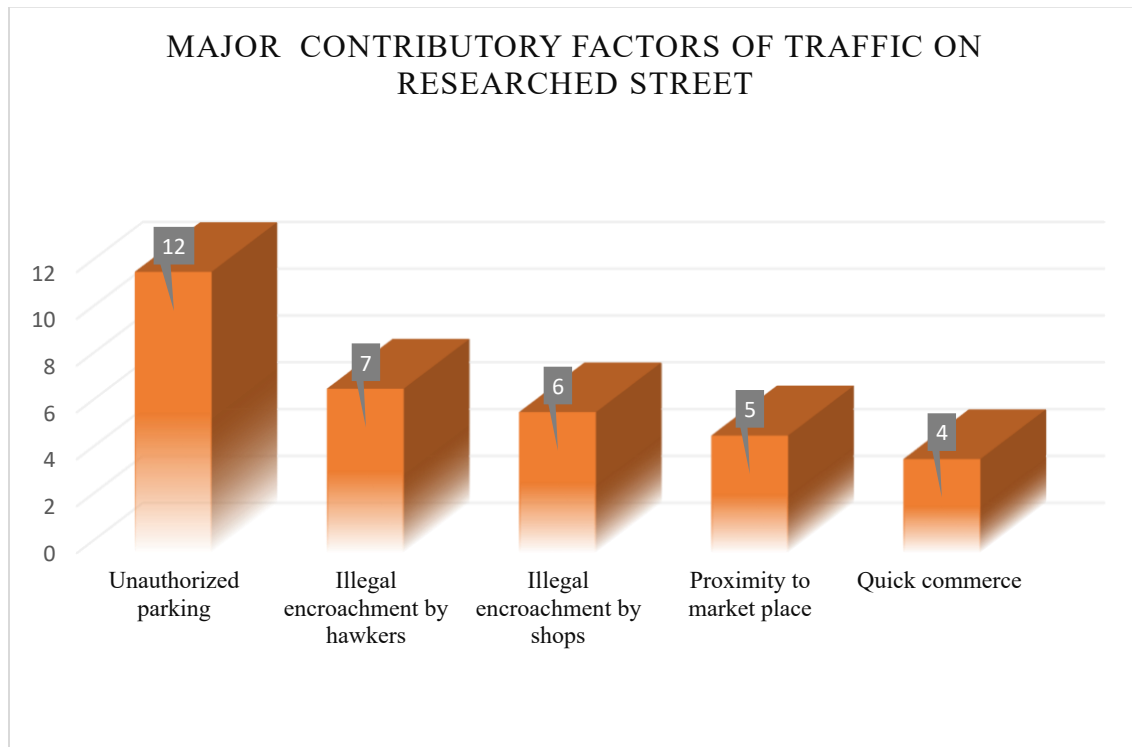


Figure 5 Major Contributory factors of traffic on the specified street cited by residents
(Source: Author's own work)

The above (figure 5) highlights the frequency of the responses noted in the interviews with the residents. It is noted that Unauthorized parking was the main

contributory factor, as this reason that was cited by 12 out of 15 respondents, followed by illegal encroachment by hawkers and shops which was highlighted by 7 and 6 responders respectively. A few respondents also stated that the main contributory factor was the street's proximity to marketplace and quick commerce deliveries.

Identification of these factors highlights that the contribution to the traffic problem on the said street is from multiple sources, and it underscores the need to find prudent solutions.

Descriptive Statistical Analysis for RQ1 – SQ1:

To better understand the major contributory factors of traffic congestion on the specified street in Mumbai, a basic descriptive statistical analysis was conducted. The responses gathered from residents regarding five key factors were analysed. The mean value across all factors was calculated as 6.8, suggesting that, on average, each factor received moderate emphasis by participants. The median value was 6.0, indicating that half of the factors scored above and half below this point. The mode was identified as 4, corresponding to 'Quick commerce', implying that this particular factor was mentioned most frequently among the lower end of reported concerns. The standard deviation was 3.11, reflecting a moderate spread of the data around the mean, suggesting that while some issues like unauthorized parking (12 mentions) were cited heavily, others were less uniformly perceived. These statistical findings help quantify the relative significance of each traffic-contributing factor according to the study participants (Daniels and Minot, 2025).

4.1.2 How can we qualify & quantify these factors for qualitative research purposes in the specific street?

The first step to qualify and quantify these factors will be to identify them. The researcher used interviews of the residents of this street, who are spectators of the daily mayhem of traffic on this street. By deploying the method of context analysis to the insights of the residents' interviews, it was understood that the majority of the traffic is caused due to double parking.

And the health and well-being of residents is chiefly hampered due to the hustle bustle of this busy street caused primarily by the stationed vehicles and likewise by the impatient honking of the passer-by cars.

A few interviewed residents also complained that they often have their allergies flare, especially around the winter season, which they attributed to the overall pollution of the city, but stated that smoke was one of the primary causes. They complained that they had to miss work due to this allergy flare-up. It was also mentioned by an interviewed resident on a lower floor that, as far as possible, the household preference has been to keep the windows closed to avoid the dust and noise from passing vehicles. Another candidate, who was interviewed mentioned that during the peak time of morning and evening, between 8 am to 9.30 am and between 6.30 pm to 8 pm, he prefers not to drive his car, as it becomes exceeding difficult and rather uncomfortable to remove private car from its parking spot and the preferred method of commute was the auto-rikshaw ride around this time, to timely reach the destination. In-order to quantify and qualify the causes, post

identification, it would be best to note the instances of log-jams in a day, in the said street, the frequency of these jams over the course of the week, particularly by identifying junction-points where traffic is stationed and the interventions, if any which was deployed to release the overall pressure on the jam. It is noteworthy that on average, the street observes traffic events at least 3 times a day.

Two out of 3 times, this is caused by peak-hour rush, as there are two schools near this street, which causes these jams at the commencement and the end of the school day.

Parents who drop and pick their children also park on this specific street, as sometimes they do not have parking spaces near to the school, and this street is just a stone throw away.

Two school buses, one from each of the two schools, also pass through this street. Given the size of the bus and the volume of the road, this, in turn, creates a log-jam as these buses pass by. As this street is also located very close to the marketplace and a public garden, the number of visitors to this street is significantly higher. People Park their cars on this street to run their errands nearby. This, in addition, compounds the traffic on the already very busy street.

Moreover, the road is currently dug up for repairs of underground pipelines, while this is not a permanent situation, it is often responsible for increasing the traffic on this street, as several pipelines pass through underground, and each time the due to breakdown

or maintenance, the roads are dug up, casing bottlenecks and collaterally inconvenience to the residents.

Other means of quantifying these factors are multifactorial approach like, data collection and analysis of weather data and traffic flow data and consequent data which could impact the traffic.

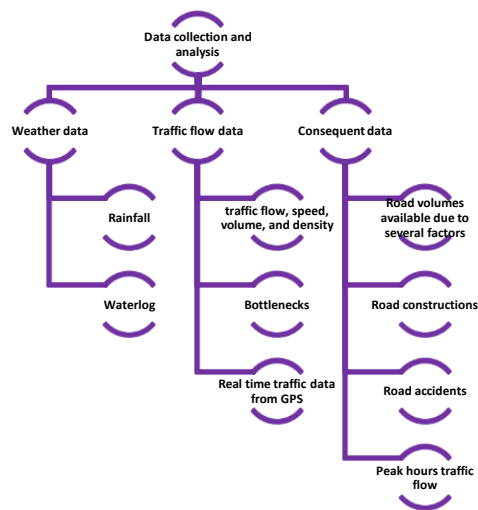


Figure-6 Quantification of factors of traffic on the specified street (Source: Author's own work)

By using statistical analysis of each of the factors and by basis its frequency that was cited by the residents as a contributory factor, on the specified street being studied, the following observations were made.

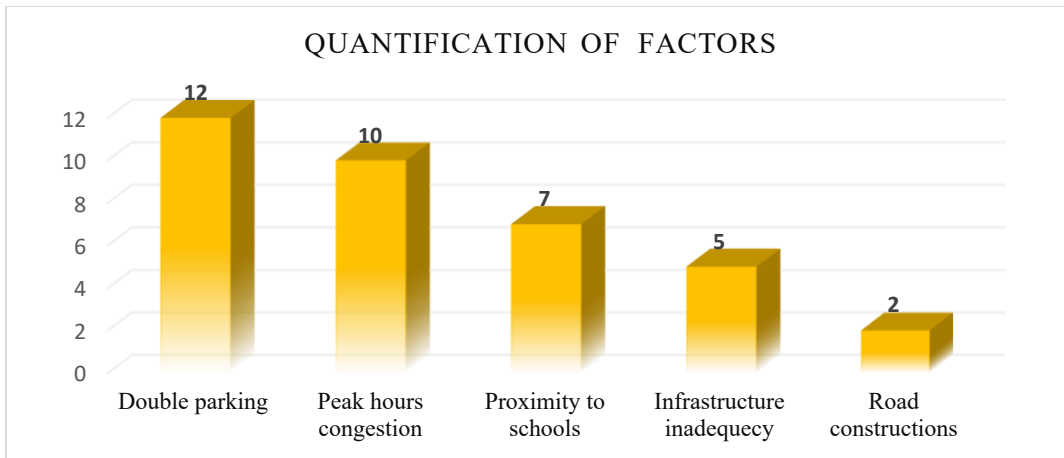


Figure-7 Frequency of factors causing traffic highlighted on specified street (Source: Author's own work)

The above figure quantifies the factors that are the primary reasons causing traffic, observed on the street. Double parking of vehicles has been highlighted by around 12 residents during the interview in a recurring fashion and is undeniably the primary problem on this street.

Peak hour congestion came as a close second, wherein 10 responders noted this to be the cause of the jam, as observed on the street. Furthermore 7 of the responders felt that the proximity of schools to this street added to jams, infrastructure inadequacy and road constructions were also pointed out by a few respondents.

These findings convey that by deploying certain metrics, such as but not limited to quantification of elements like, 'double parking', 'road constructions' events, proximity to

schools, it can help determine the traffic situation of a given street and thus it can be factored-in while determining smart innovative solutions to curb inner-city traffic jams.

Descriptive Statistical Analysis for RQ1-SQ2:

To further validate the findings shown in Figure-7, a descriptive statistical analysis was conducted on the key factors identified by residents as causes of traffic congestion. The mean value across all listed causes was 6.8, suggesting that, on average, these factors were moderately cited during interviews. The median was determined to be 7, representing the midpoint of the distribution when sorted by frequency. The mode was 12, corresponding to double parking, which emerged as the most frequently cited traffic cause.

The standard deviation of approximately 4.04 reflects a moderate dispersion in the responses, implying notable variability in how strongly different factors impacted traffic flow. These descriptive findings highlight the dominance of double parking and peak hour congestion as critical areas requiring targeted traffic management interventions on the researched street (Daniels and Minot, 2025).

4.1.3 How do seasonal variations, such as monsoons, influence traffic congestion in the specified street?

Context analysis and researcher's personal observations for RQ1-SQ3:

Monsoon wreaks havoc in the city of Mumbai, and the rainy season spans through four months. During monsoon seasons, it is witnessed that there are a lot of traffic snarls

observed at various timepoints throughout the day. This is because of waterlogging at multiple places, due to choked drainage systems, heavy intensity of the downpour and geographically low-lying areas within the city. Also, as the severity of monsoon happens to be of a greater magnitude as compared to other parts of the nation, it is frequently noted that it affects the visibility of drivers during the evening and night.

The speed of the vehicles is thus greatly reduced due to the visibility. Furthermore, in order to avoid streets which are tremendously waterlogged, it is often observed that drivers opt for lanes and streets which are not waterlogged to prevent damage to the vehicle. Another noteworthy finding is the potholes during the monsoon, which disrupt speed.

Additionally, the public transport system, mainly the local trains which are also referred to as ‘Mumbai’s lifeline’, comes fully to a standstill, during such times, even the BEST public buses stop its operations and those who opt usually for public transports, are then forced to use a private car or optionally book online cab services, adding substantially to the roadways traffic burden. Streets that are comparatively less waterlogged are of preference to the commuters, thereby concentration of traffic is observed in certain streets and also during such times, the specified street is also tremendously affected, which is being discussed.

It is noted by the residents that there are several spots where traffic starts to get affected multi-folds, this is mainly near shops of small roadside eateries and tea stalls, which see a spike in demand, as the weather changes. A street food delicacy called ‘*vada pav*’, that is potato stuffed ball, deep fired in batter and stuffed in a bread, and ‘*pakodas*’

which are deep batter fried crispy fritter served alongside piping hot tea is a staple street food that is loved by everyone from all strata of society, and it is craved for as comfort food, another favourite food item includes charcoal roasted sweet corn, and these have many buyers alike.

Three stalls of the above-mentioned street foods are already present on the specified street. Cart vendors too, stop their food vending carts during monsoons to attract customers. People halt their vehicles to buy these comfort foods during monsoons, which are often freshly prepared by the vendors who illegally encroach portions of roadways by street vendors, to make quick sales.

The items take several minutes to be delivered to the stationed vehicles, as they are being freshly roasted or fried, to serve those who park their cars or likewise two-wheelers in between streets, to enjoy the hot delicacy as it rains, which further affects the free flow of traffic. In the residents' interviews, it was highlighted that three such vendors are present on the specified street, selling tea and fried goodies on food carts. Two out of three are notably encroaching on the sides of the street, which are mainly reserved for pavement and pulling crowds that park the vehicles in an unauthorized fashion.

While the street-cart vendors boast high sales, it is very evident as understood from the perspective of the residents of the said street, that the vendor's customers are 'quiet a nuisance' as they sometimes tend to even park their vehicle carelessly in front of main entry gates, due to lack of parking spaces and even honk loudly to call the hawkers to place their orders. Thus, during monsoon's the ever-present problem of traffic gets out of hand

due to the aforementioned reasons. A recurrent theme that was observed in the interviews is that ‘halting vehicles’, ‘parking cars in an unauthorized way’ has become the primary reason for most traffic jam events on the specified street, which is further exacerbated during the heavy downpour of Mumbai’s monsoons.

Overall, the monsoon season magnifies existing structural and behavioural issues on the specified street, combining infrastructural weaknesses (such as poor drainage and potholes) with social behaviours (such as impromptu parking and encroachment) to significantly worsen traffic congestion.

These compounded effects not only slow down vehicular movement but also heighten commuter frustration, safety risks, and unpredictability in travel times.

Consequently, the street experiences critical stress points that severely impact daily commuting patterns, particularly during peak hours and intense downpours.



Figure-8 Actual picture of traffic snarls caused as an aftermath of heavy rains (Source: Author’s own work)

Summary of Key Findings for RQ1-SQ3:

To provide a clearer understanding of how monsoon-specific challenges translate into tangible traffic issues on the specified street, a brief summary table has been developed below. This table categorizes the major monsoon-related disruptions and their direct impact on traffic flow and congestion patterns observed during the study.

Key Monsoon Challenges	Impact on Traffic
Waterlogging due to poor drainage	Reduced traffic flow; vehicles divert to drier streets, concentrating congestion
Low visibility during heavy rains	Slower driving speeds; increased risk of accidents and bottlenecks
Formation of potholes	Disrupted vehicle movement; uneven road usage patterns
Standstill of public transport (local trains and buses)	Increased private car usage; higher volume of vehicles on roadways
Unauthorized parking near food vendors	Road space obstruction; traffic jams and access blockages
Street encroachments by hawkers	Narrowing of driving lanes; restricted movement leading to localized congestion

Table 2: Key Challenges faced during monsoon and its impacts on traffic (Source: Author's own work)

4.1.4 What role do urban infrastructure and road design play in exacerbating or alleviating traffic congestion in this area of the specific street in Mumbai city, used for this research purpose?

Most interview respondents felt that a lot can be achieved from the standpoint of better urban infrastructure development to aid in alleviating traffic congestion (Figure 8).

They often expressed their dissatisfaction with the way the traffic on the street was managed and stated that it would be helpful to have regular checks on unauthorized parked vehicles on the street to minimize the inconveniences.

The current street in question joins at a junction and is adjoining several roads, thus many commuters who do not reside nearby take the current roads to commute to their destination, to avoid peak-hour traffic on the main roads.

As this specific street is narrow and was not a part of the original road development plan, it is obvious that it did not take into consideration the heavy traffic flow that it currently experiences. Furthermore, in terms of infrastructure, the utility stores, chemist, hospitals, florist shops and street snacks vendors who have illegally encroached a proportion of roads, understanding that the areas sees a lot of regular customers, who commute daily through the same route, often are the leading causes of slow-moving traffic,

as the halt mid-way their journey to make their purchases of the snacks offering or other knick- knacks.

In terms of road design, the street in this research has no remainder of pavements for pedestrians, to commute on foot, as there are encroachments of shops, which display their fast-moving consumer goods (FMCG) on these pavements illegally occupying these footpaths.

And similarly, even hawkers that cause encroachments, eventually causing the residents of the street a great deal of inconvenience and discomfort, as the work-around journey will be to walk the streets which is meant for vehicles to pass-by, leading to increased honking by cars, slowing down speed to keep safe distance between pedestrians and their cars.

Overall, the inadequacy of infrastructure, illegal encroachments by hawkers, street vendors, break-journeys by commuters and the lack of urban planning have eventually exacerbated the traffic in the given street. During the interviews with the residents, the inadequacies of infrastructure were highlighted (Figures 8 and 9).

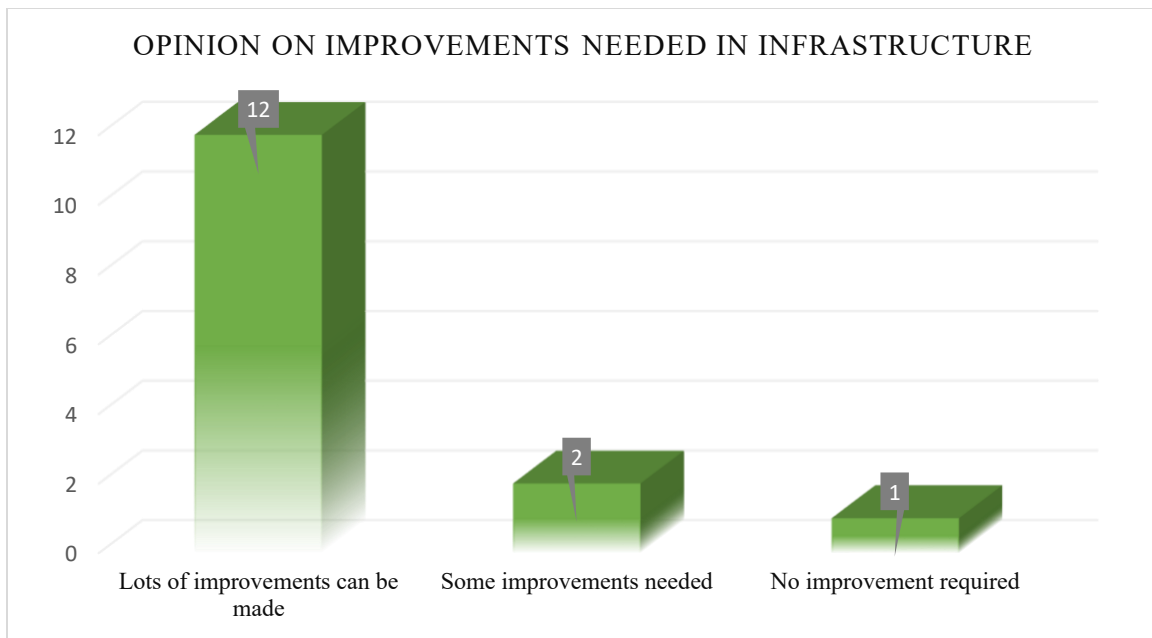


Figure-9 Opinion of residents on improvements needed in infrastructure (Source: Author's own work)

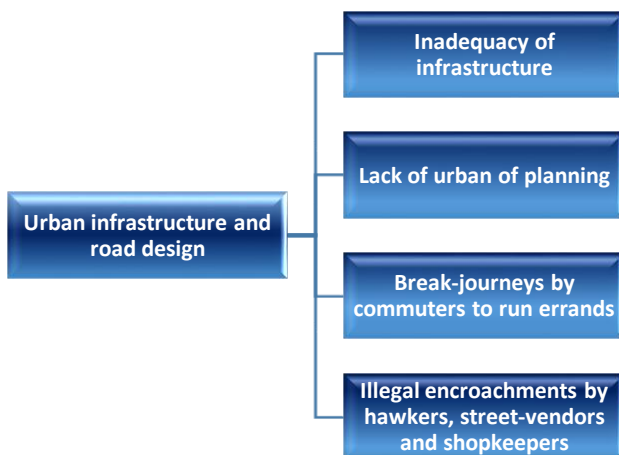


Figure-10 Role of urban infrastructure and road design on traffic congestion (Source: Author's own work)

Descriptive Statistical Analysis for RQ1-SQ4:

The descriptive statistical analysis for respondents' opinions on infrastructure improvements reveals a mean frequency of 5.33, indicating that, on average, approximately five respondents identified a specific category of opinion. The median response was 2.0, and the mode was also 2, suggesting that most respondents either believed that "some improvements" or "no improvements" were needed. However, the relatively high standard deviation of 5.77 reflects substantial variability in opinions, primarily driven by the dominant sentiment that "lots of improvements could be made," which was expressed by 12 respondents. This indicates a significant skew toward dissatisfaction with the current infrastructure (Daniels and Minot, 2025).

4.2 Research Question Two

The research question two primarily focuses on the health effects of traffic on the citizens.

For this specific segment, six healthcare professionals were approached for a two-part interview, which included a formal questionnaire being mailed to them and from which responses were received and reviewed and this was followed by a second round of interviews which was either in-person or telephonically, purpose of this interview was to gain clarity or seek additional clarifications or information as deemed necessary by the researcher.

The profile of the interviewed medical professionals was all doctor of medicine (MD), three HCPs were also doctorate of medicine (DM). The specialization of the interviewed medical doctors was as follows, four HCPs were pharmacologist, one was super-specialized in haematology-oncology and one was specialized in pulmonary medicine.

RQ2. How does traffic congestion on the specified street in Mumbai impact the health and well-being of residents and commuters? The sub questions (a, b, c, and d) for RQ2 are given as follows:

4.2.1 How does traffic impact physical health of the citizens, in the specific street?

Several concerns were raised by the healthcare providers with respect to the health impacts on physical health cascading from the traffic problem that is faced. They highlighted that traffic impacts both short-term and long-term health and has lasting sequelae. The key concerns noted by healthcare providers which were said to have profound effects are as follows.

Thematic Analysis for RQ2-SQ1: Points by the healthcare providers with respect to health impacts.

Theme	Details from HCP Interviews	Number of HCPs Mentioning
Respiratory Health Impacts	Worsened AQI due to traffic emissions; increased asthma, COPD, bronchitis, lung cancer; more clinic visits for cough and shortness of breath.	6/6
Cardiovascular Health Risks	Prolonged exposure to pollutants leads to heart disease, high BP, strokes; elevated heart rate and vascular risks due to traffic stress.	5/6
Sedentary Lifestyle Effects	Traffic reduces walking spaces, encourages prolonged sitting, increases obesity, diabetes, hypotonia, osteoporosis risk.	5/6
Sleep Disturbances	Noise and stress from traffic causing sleep disruption, fatigue, lower immunity, and productivity loss.	4/6
Musculoskeletal Disorders	Extended sitting times causing back pain, posture issues, neck stiffness.	3/6
Auditory Impairments	Noise pollution and irresponsible honking leading to hearing loss (Noise-Induced Hearing Loss - NIHL).	3/6

Theme	Details from HCP Interviews	Number of HCPs Mentioning
Road Traffic Accidents (RTAs)	Higher accident risk during congestion, causing injuries and fatalities.	2/6
Heat-Related Illnesses	Traffic congestion during hot weather exposing people to heat exhaustion and heatstroke.	2/6
Dermatological Impacts	Air pollution causing skin issues (acne, inflammation, sensitivity) and hair loss.	2/6

Table 3: Health impact of traffic as noted by healthcare professional during interviews traffic (Source: Author's own work)

Summary of Key Findings for RQ2 -SQ1:

Air Quality and Respiratory Problems: All HCPs (6/6) consistently reported that poor air quality driven by traffic emissions significantly worsens respiratory health. Increases in asthma, COPD, bronchitis, and even risks for lung cancer were emphasized. Many HCPs noted a steep rise in cases presenting with cough, shortness of breath (SOB), and allergy-related-symptoms.

Cardiovascular Risks: Five out of six HCPs highlighted that vehicle emissions, coupled with traffic-related stress, exacerbate cardiovascular issues including heart disease,

elevated blood pressure, and stroke risks. Pollutants like particulate matter (PM), nitrogen oxides, and carbon monoxide are major contributors.

Promotion of a Sedentary Lifestyle: Five out of six HCPs raised concerns that heavy traffic discourages walking or cycling, limits safe pedestrian spaces, and promotes sedentary behaviour. This leads to obesity, diabetes, muscle weakness (hypotonia), osteoporosis, and elevated cardiovascular disease risk.

Noise Pollution and Sleep Disturbances: Four out of six HCPs reported that the constant noise from honking and traffic congestion disturbs sleep patterns, causing fatigue, lowered immunity, and poorer daily functioning.

Musculoskeletal and Auditory Problems: Three HCPs discussed that long sitting times cause posture issues, back and neck pain. Noise exposure also contributes to noise-induced hearing loss (NIHL).

Road Traffic Accidents (RTAs) and Injuries: Two HCPs highlighted an increased frequency of accidents and related injuries/fatalities linked to heavy congestion.

Heat-Related and Dermatological Problems: Two HCPs each reported that individuals exposed to congestion in high temperatures suffer heat exhaustion, while air pollution affects skin and hair health (acne, inflammation, sensitivity, and hair fall).

Conclusion:

Traffic congestion on the specified street in Mumbai severely affects physical health across multiple systems — respiratory, cardiovascular, musculoskeletal, auditory, dermatological — and encourages unhealthy lifestyle behaviours. These issues lead to a cumulative decline in quality of life, an increased chronic disease burden, and heightened vulnerability to acute health events among commuters and residents.

Hence, traffic congestion can have a detrimental impact on physical health through air pollution, stress, reduced physical activity, noise pollution, and increased risk of accidents.

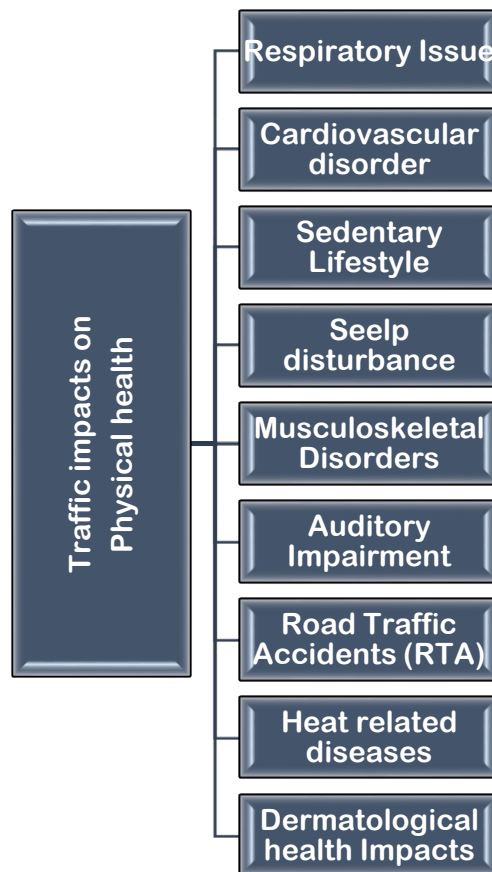


Figure-11: Impacts on physical health due to traffic (Source: Author's own work)

4.2.2 How does traffic impact the mental health and well-being, in the specific street?

Thematic Analysis for RQ2-SQ2: Mental Health Impacts of Traffic Congestion for both residents and commuters.

Theme 1: Elevated Stress and Anxiety Levels: Traffic congestion leads to significantly heightened stress among both residents and commuters.

Respondents highlighted that the unpredictability, delays, and noise exposure associated with traffic result in elevated cortisol levels, contributing to chronic stress, anxiety, feelings of helplessness, and even hypertension. The persistent frustration of being stuck in traffic becomes a daily stressor, impairing physical, mental and psychological well-being.

Theme 2: Cognitive Impairment and Mental Fatigue: Navigating through congested roads demands continuous attention, leading to mental fatigue and cognitive overload. Participants described experiences of "brain fog," decreased concentration, reduced reaction time, impaired memory, and poor decision-making. Prolonged noise pollution from traffic further exacerbates poor concentration and diminished work productivity, ultimately resulting in overall mental exhaustion.

Theme 3: Irritability, Mood Disturbances, and Road Rage: Heavy traffic was closely associated with increased irritability, agitation, and negative mood swings.

Many participants mentioned frequent experiences of frustration, anger, and despair during long commutes. The difficulty in securing transportation services due to drivers refusing to drive on congested routes also amplified emotional distress.

This persistent emotional strain was noted to sometimes escalate into road rage and aggressive behaviour, not only affecting driving but seeping into personal and social spheres.

Theme 4: Anxiety, Depression, and Emotional Burnout: Chronic exposure to daily traffic-related stress was linked to more severe mental health outcomes such as anxiety disorders, depression, and emotional burnout. Participants described feelings of helplessness and lack of control over their commuting circumstances, which over time resulted in decreased motivation, emotional exhaustion, and detachment from work and personal life.

Theme 5: Reduced Quality of Life and Social Isolation: Participants reflected those long hours spent in traffic led to missed opportunities for social engagement, family time, exercise, and hobbies. This erosion of personal time negatively impacted life satisfaction and emotional well-being, contributing to a perception of reduced overall quality of life.

Theme 6: Sleep Disturbances and Long-Term Health Risks: Traffic-induced stress and noise exposure were also found to disrupt sleep patterns, leading to insomnia, poor sleep quality, and circadian rhythm disturbances. Respondents reported that disturbed sleep adversely affected daytime functioning, academic and professional performance, and heightened risks of mental health disorders such as depression and anxiety, particularly among vulnerable groups like students and the elderly.

Summary of Key Findings for RQ2-SQ2:

Traffic congestion acts as a chronic stressor, leading to heightened stress, anxiety, and cognitive fatigue among residents and commuters.

Prolonged exposure fosters irritability, mood swings, and aggressive behaviour such as road rage. Mental health risks escalate over time, culminating in anxiety disorders, depression, emotional burnout, and reduced overall well-being.

Life satisfaction diminishes as personal time is sacrificed to long and frustrating commutes.

Sleep disturbances caused by traffic noise and stress further compound mental health issues and decrease resilience against everyday challenges.

Social relationships are strained as individuals have less time and emotional energy for family interactions and leisure activities. Over time, these accumulated psychological impacts can contribute to broader public health burdens within congested urban localities.

Feelings of helplessness and frustration are amplified when residents perceive no visible or timely solutions to traffic issues.

Overall, traffic congestion not only affects physical commuting time but deeply erodes psychological health, community well-being, and perceived quality of urban life.

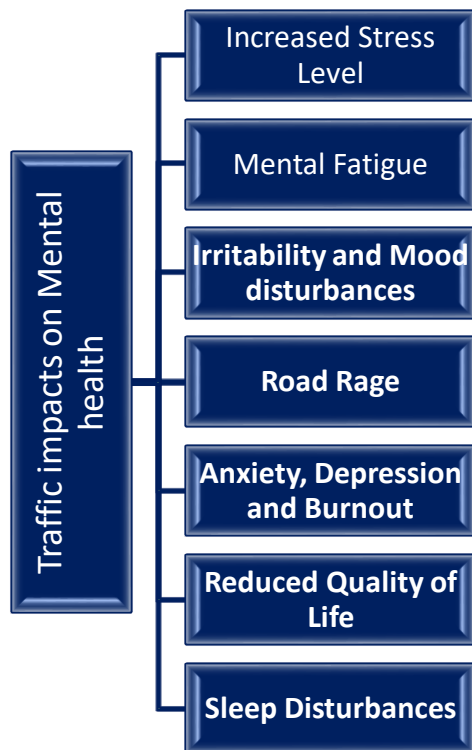


Figure-12: Impacts on mental health due to traffic (Source: Author's own work)

4.2.3 What impacts are seen on the quality of life (QOL) of the citizens, in the specific street?

Traffic congestion negatively impacts the quality of life (QOL) of citizens in multiple ways.

Thematic Analysis for RQ2-SQ3: Broader Impacts of Traffic Congestion on Health, Social Life, and Economy

Theme 1: Physical Health Deterioration: Traffic congestion results in substantial health risks due to increased exposure to air and noise pollution.

Participants noted that prolonged inhalation of vehicle emissions exacerbates respiratory conditions such as asthma and bronchitis and raises the risk of cardiovascular diseases. Sedentary behaviours enforced by long commuting hours contribute to obesity, diabetes, and other chronic conditions, thereby significantly diminishing physical health and vitality.

Theme 2: Increased Stress, Anxiety, and Mental Health Decline: The delays, frustration, and unpredictability associated with traffic congestion emerged as a strong source of chronic stress and anxiety among respondents. Constant exposure to such stressors diminishes mental resilience, reduces life satisfaction, and increases the likelihood of developing long-term mental health issues such as depression, burnout, and generalized anxiety disorders. Participants highlighted a cyclical pattern where stress led to mental exhaustion, which in turn reduced coping capacity for daily challenges.

Theme 3: Reduced Physical Activity and Lifestyle Sedentarism: A key theme was the forced sedentary lifestyle resulting from hours spent sitting in traffic. Limited opportunities for physical activity contribute to weight gain, metabolic disorders, and musculoskeletal discomfort. Respondents expressed concern about the loss of opportunities for exercise, active commuting, or recreational walking, which further entrenches an unhealthy lifestyle.

Theme 4: Sleep Disturbances and Weakened Immune Health: The mental strain and noise pollution associated with heavy traffic were noted to disrupt circadian rhythms and sleep patterns.

Participants reported sleep deprivation, insomnia, poor-quality sleep, and a cascade of associated problems such as reduced daytime alertness, decreased immune function, and heightened vulnerability to physical and mental illnesses.

Theme 5: Economic Burden and Productivity Loss: Traffic congestion was widely perceived to have tangible economic consequences. Respondents described the loss of work hours, reduced productivity, increased fuel consumption, missed appointments, and financial strain due to higher transportation costs. These economic burdens contribute to cumulative stress, reduce disposable income, and indirectly degrade overall quality of life and financial stability.

Theme 6: Social Isolation and Community Disengagement: Long hours spent in traffic were said to erode opportunities for meaningful social interactions and community participation. Respondents reported reduced time for family, friends, and social activities, fostering feelings of isolation, loneliness, and social withdrawal.

Avoidant behaviour toward commuting and community involvement emerged as an unintended consequence, further impacting mental and psychological health.

Theme 7: Environmental Degradation and Community Health: Participants were aware of the broader environmental consequences of traffic congestion. Increased vehicle emissions contribute not only to personal health deterioration but also to larger-scale environmental degradation.

Poor air quality, loss of green spaces, and a degraded urban environment diminish the liveability of communities, lowering overall life satisfaction and environmental well-being.

Theme 8: Negative Spillover Effects on Other Life Aspects: Long, exhausting commutes leave individuals with diminished time, energy, and motivation for leisure activities, personal hobbies, and family engagements. Participants frequently mentioned the feeling of "time wasted" during travel and reported rising frustration, disconnection, and emotional fatigue. The cumulative impact of these spill-overs was a diminished sense of purpose, reduced fulfilment, and growing dissatisfaction with daily life.

Summary of Key Findings for RQ2-SQ3:

Traffic congestion affects physical health through pollution exposure and enforced sedentarism. It leads to chronic stress, anxiety, and sleep disturbances, which in turn impair mental health and immune function.

Economic losses due to delayed commutes and increased transportation costs further burden individuals.

Social isolation and environmental degradation emerge as indirect but significant consequences.

Prolonged traffic exposure aggravates respiratory and cardiovascular conditions due to sustained inhalation of vehicular emissions.

Productivity losses at both individual and societal levels are exacerbated as commuting times escalate unpredictably.

Children and elderly residents are disproportionately impacted, facing greater health vulnerabilities during peak traffic conditions.

To sum up, traffic congestion critically undermines personal health, social cohesion, environmental quality, and economic stability, resulting in a profound reduction in citizens' overall-well-being.



Figure-13: Health impacts on Quality of Life (QoL) due to traffic (Source: Author's own work)

4.2.4 Impact on familial and social life of citizens, in the specific street

Traffic congestion deeply disrupts familial structures, reducing both the quantity and quality of family interactions.

Thematic Analysis for RQ2-SQ4: Effects of Traffic problems in the specific street of Mumbai on the families and society.

Theme	Description	Associated Effects
Reduced Family Time	Longer commuting times reduce the time spent with family and loved ones.	Weakened family bonds, fewer meaningful interactions, emotional distance.
Increased Stress at Home	Stress and frustration from traffic spill over into home life, affecting relationships.	Tension and conflict at home, emotional strain among family members, reduced harmony.
Limited Social Interactions	Heavy traffic deters participation in social and community activities.	Increased social isolation, feelings of loneliness, reduced social skills and engagement.

Theme	Description	Associated Effects
Impact on Children's Activities	Parents' delayed schedules impact children's schooling and extracurricular participation.	Reduced opportunities for children's socialization and development, emotional disconnect.
Decreased Quality of Life	Cumulative effects of stress, isolation, and reduced time with loved ones.	Lower life satisfaction, emotional fatigue, stagnated personal development and hobbies.
Economic Strain	Lost work hours and missed appointments due to traffic delays.	Financial losses, increased family stress, pressure on household stability.
Missed Opportunities	Tendency to avoid commitments due to traffic hassles.	Lost social, professional, and developmental opportunities; growth stagnation.

Table 4: Impact on social and familial life due to traffic (Source: Author's own work)

Summary of Key Findings for RQ2-SQ4:

Emotional well-being is compromised, with a spillover of commuting stress leading to home tensions and relationship breakdowns.

Social engagement declines as individuals avoid gatherings, events, and community activities, fostering social isolation.

Children's development is adversely impacted, with reduced parental involvement in their educational and social lives.

Overall quality of life deteriorates, as the cumulative effects of stress, disconnection, and fatigue leave little space for personal or family enrichment.

Chronic commuting burdens diminish opportunities for leisure activities, hobbies, and restorative relaxation.

Neighbourhood cohesion weakens as residents have fewer opportunities to build trust and establish mutual support networks.

Increased irritability and emotional exhaustion strain interpersonal relationships across family, work, and social settings.

Persistent dissatisfaction with commuting conditions contributes to an overall decline in mental health resilience and life satisfaction.

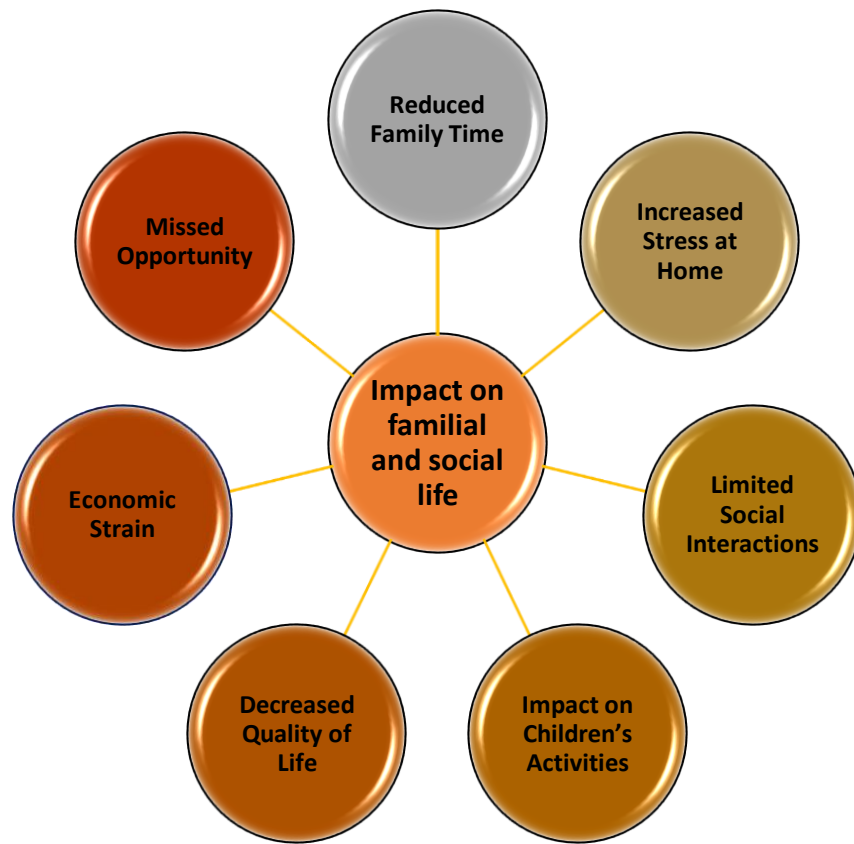


Figure-14: Impacts on Familial and social life due to traffic (Source: Author's own work)

Economic impacts from missed appointments and lost productivity place additional strains on family life, compounding the negative effects.

Avoidant behaviours develop, leading to lost opportunities in both personal and professional spheres, further alienating individuals from social structures.

4.3 Research Question Three

RQ3. What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai?

4.3.1 What measures can be taken to combat the problems pertaining to health and well-being, in the specific street?

Effects on well-being and health can be best managed by having better traffic management. Some of the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on health and well-being in Mumbai are highlighted below:

Thematic Analysis for RQ3-SQ1:

Potential Solutions to Health and Well-Being Issues from Traffic Congestion on the Specified Street in Mumbai

Theme	Description	Associated Solutions/Interventions
Reduction in Air Pollution	Air pollution from vehicle emissions worsens respiratory and cardiovascular health.	- Promote use of electric vehicles (EVs)- Introduce stricter vehicular emission standards- Enforce vehicle fitness checks- Promote carpooling and public transport use
Reduction in Noise Pollution	Noise from constant honking and traffic movement affects mental well-being.	- Designated “No Honking Zones”- Better traffic flow management to reduce idling- Implement sound barriers where feasible

Theme	Description	Associated Solutions/Interventions
Promotion of Active Transportation	Sedentary lifestyle from long hours in vehicles contributes to obesity and related health issues.	- Create safe, wide footpaths- Encourage cycling by building dedicated bike lanes- Public awareness campaigns promoting walking or cycling for short distances
Stress Reduction Interventions	Traffic stress leads to anxiety, irritability, and spillover effects at home.	- Develop green spaces and “calm zones” along the street- Implement real-time traffic updates to reduce unpredictability- Staggered work hours to reduce peak congestion
Improvement in Sleep Quality	Noise and stress from traffic disrupt sleep patterns, impacting immune function.	- Strict noise regulation enforcement especially during night hours- Traffic calming measures (speed bumps, regulated zones) at night
Enhanced Emergency Response Readiness	Traffic congestion delays emergency services, increasing health risks.	- Dedicated emergency vehicle lanes- Smart traffic light systems prioritizing ambulances and police vehicles
Health and Pollution	Lack of public awareness about health	- Regular community workshops- School programs on pollution and health impacts-

Theme	Description	Associated Solutions/Interventions
Awareness Campaigns	effects worsens the situation.	Campaigns for clean commuting alternatives

Table 5: Potential Solutions to Health and Well-Being Issues from Traffic Congestion

(Source: Author's own work)

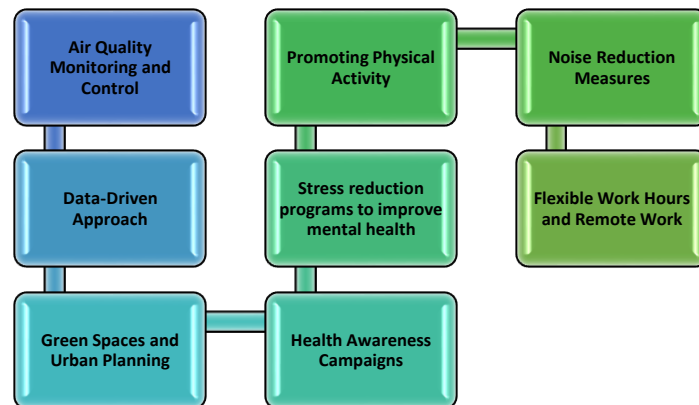


Figure-15: Suggestive measures to combat the problems pertaining to health and well-being due to traffic (Source: Author's own work)

Summary of Key Findings for RQ3 and SQ1:

Integrated transportation planning is crucial: Promoting EVs, cycling, walking, and cleaner public transport can directly improve air quality and reduce health risks.

Noise control measures must be prioritized: Establishing "silent zones" and enforcing no-honking rules can significantly lower stress and improve mental health.

Creating urban green spaces and traffic-calmed environments can directly reduce stress and promote community well-being.

Smart technology applications (real-time updates, smart lights) can reduce frustration, improve traffic flow, and lessen unpredictability that heightens anxiety.

Public education is essential: Without citizen awareness, even the best infrastructural solutions will have limited effectiveness.

Prioritizing emergency services through dedicated lanes and smart traffic management systems can save lives affected by traffic delays.

Holistic interventions are necessary: A single solution won't work; combined strategies addressing pollution, mobility, urban planning, and behaviour is critical to sustainable improvement.

4.3.2 What solutions can be implemented to mitigate the challenges and reduce the traffic, in the specific street?

Traffic congestion in Mumbai is a significant challenge with far-reaching consequences, including adverse impacts on public health and well-being.

To address this issue effectively, a multi-pronged approach is necessary, combining infrastructure improvements, technological advancements, and behavioural changes.

Context Analysis Table for RQ3 and SQ2:

This context analysis examines the various solutions and interventions proposed to alleviate traffic congestion and its associated challenges on the specified street in Mumbai. It identifies key thematic areas, including technological innovations, infrastructure development, community engagement, behavioural changes, and multi-sectoral collaboration.

By addressing these interrelated contexts, a comprehensive and dynamic approach can be formulated to effectively mitigate traffic congestion and enhance the overall urban environment.

Context/Theme	Description	Associated Effects/Impact
Traffic Management Technologies	Use of adaptive traffic signals, real-time monitoring, and smart traffic systems.	Optimized traffic flow, reduced congestion, better commuter planning.
Community Engagement	Involving citizens in solution planning and decision-making.	Greater acceptance of measures, tailored solutions, improved cooperation.
Multi-Sectoral Collaboration	Coordination between transport, urban planning, health sectors, and stakeholders.	Holistic and sustainable solutions, leveraging cross-sector expertise.

Context/Theme	Description	Associated Effects/Impact
Development of Smart Mobility Solutions	Ride-sharing programs, electric vehicle promotion, real-time traffic apps.	Reduced private vehicle usage, eco-friendly transport adoption, informed commuting choices.
Behavioural Changes	Public awareness campaigns on transport benefits and responsible driving.	Reduced unnecessary trips, better driving practices, increased public transport use.
Economic Incentives	Road pricing during peak hours, public transport subsidies, eco-friendly vehicle benefits.	Discourages peak-hour congestion, promotes environmentally friendly commuting.
Road Network Optimization	Improving signal timing, expanding roads, building flyovers, intelligent transport systems (ITS).	Smoother traffic movement, reduced bottlenecks, better infrastructure resilience.

Context/Theme	Description	Associated Effects/Impact
Parking Management	Strict parking regulations, high parking fees, creation of vertical/underground parking.	Reduced illegal parking, discouraged car usage, improved traffic flow.
Enforcement through Towing Unauthorized Vehicles	Increase fines and tow illegally parked vehicles with clear no-parking signage.	Discourages unauthorized parking, frees up road space for traffic flow.
Public Transportation Enhancement	Expanding metro lines, increasing bus services, dedicated lanes for buses, cycling infrastructure.	Greater public transport usage, less dependence on private vehicles, reduced congestion.
Infrastructure Development	Investment in new roads, lanes, intersections, flyovers, and underpasses.	Increased road capacity, improved connectivity, reduced bottlenecks.
Encouragement of Alternative Transportation	Promotion of cycling and walking via dedicated pathways.	Reduction in short-trip motor vehicle usage, improved public health and wellness.

Context/Theme	Description	Associated Effects/Impact
Carpooling and Ride-Sharing	Encouragement of shared rides among commuters.	Decrease in number of vehicles during peak hours, less congestion.
Urban Planning and Land Use Management	Mixed-use development and transit-oriented planning to minimize commuting distances.	More efficient land use, lower commuting needs, increased public transport ridership.
Multi-Faceted and Ad-Hoc Solutions	Continuous evaluation and adjustment of measures to respond to changing conditions.	Dynamic, context-specific improvements, sustained traffic relief.

Table 6: Solutions and interventions proposed to alleviate traffic congestion (Source: Author's own work)

Summary of Key Findings for RQ3-SQ2:

Technology + Infrastructure improvements (smart traffic systems, infrastructure expansion) are foundational to managing congestion.

Community engagement and public behavioural change are crucial for long-term effectiveness.

Economic incentives and enforcement measures can actively discourage excessive private car use.

Public transportation enhancement must accompany road-based solutions for sustainable results.

A multi-pronged and adaptive approach will likely yield the most significant and enduring impact on traffic reduction.



Figure 16: - Actual picture of specified street, a bike parked unauthorized is being towed away (Source: Author's own work)



Figure 17: Potential solutions to mitigate challenges and reduce the traffic (Source: Author's own work)

4.3.3 How can the use of technology, such as smart traffic management systems, improve traffic flow and reduce congestion, in the specific street?

A comparative analysis for RQ3-SQ3 for the qualitative data related to Technology-Based Solutions, Lessons from Singapore, and Mumbai's Current Steps based on the responses from profile A respondents – residents and commuters of the specific

street in Mumbai city; researcher's personal observations and secondary data from available literature on RQ3-SQ3 - how Technology Can Improve Traffic Flow and Reduce Congestion are given as follows:

Drawing from the perspectives of profile A respondents — residents and commuters of the specific street in Mumbai, as well as the researcher's personal observations, it is evident that the use of smart traffic management systems holds significant potential to transform traffic conditions. In benchmarking global best practices, Singapore emerges as a notable example of successful traffic management despite facing spatial and population density challenges similar to Mumbai.

Singapore's implementation of the Electronic Road Pricing (ERP) system demonstrates how real-time, dynamic toll pricing based on traffic density can encourage commuters to modify travel behaviour, promote public transportation usage, and reduce private vehicle dependence (Seik, 2000). Public education campaigns further strengthened community acceptance of ERP by framing it as a congestion-reduction tool rather than a revenue-generating measure (Wee Hin and Subramaniam, 2001).

Applying a similar model in Mumbai would, however, require cautious and phased adaptation. Given that Mumbai's metro infrastructure is still under extensive development, the immediate imposition of dynamic tolls may not be feasible until robust alternative public transport options are fully operational. Nevertheless, once public transportation networks are expanded and reliable, adopting a time-sensitive, congestion-based toll system could significantly contribute to managing traffic volume.

Currently, Mumbai has initiated progressive steps by deploying an AI-powered Advanced Traffic Control (ATC) system at major junctions.

This system, leveraging CCTV surveillance, adaptive signal timing, and centralized traffic monitoring, is designed to optimize vehicular flow. Early observations suggest that AI can dynamically adjust traffic light cycles based on real-time congestion levels, thus reducing waiting times and easing bottlenecks. Moreover, the system's ability to automatically recognize vehicle number plates and issue electronic challans for traffic violations promotes stricter adherence to traffic laws, curbing erratic driving behaviours that contribute to congestion.

In the specific street of Mumbai city, the local government has instituted a traffic intelligent management system that can automatically identify vehicle number plates, and even issue *e-chalans* (traffic infringement tickets) based on any kind of violations identified.

This process, which is now automated, can make sure that traffic regulations are thoroughly followed, speed restrictions are met as stipulated, and traffic flow stays uniform, thus avoiding congestion at traffic-heavy junctions.

Profile A respondents have expressed cautious optimism regarding these technological interventions. Residents noted improvements in signal management and flow during non-peak hours, while commuters acknowledged quicker clearance of traffic at select intersections. However, both groups emphasized that for lasting impact, such

technologies must be coupled with public awareness initiatives, strong enforcement of traffic rules, and continuous infrastructure upgrades.

Thus, while technology-driven traffic management strategies present a promising path forward, their success in Mumbai's context depends on the integration of smart systems with broader infrastructural, behavioural, and policy reforms, informed by lessons from global best practices.

Summary of Key Findings for RQ3-SQ3

Category	Details
Key Technology-Based Solutions	- AI-powered Adaptive Traffic Control Systems (ATC) - Real-time traffic monitoring through CCTV - Automated number plate recognition and e-challan issuance - Dynamic signal timing adjustments
Lessons from Singapore	- Electronic Road Pricing (ERP) system for dynamic congestion pricing - Public education campaigns to build acceptance - Strong integration with efficient public transportation infrastructure
Mumbai's Current Steps	- Implementation of AI-based ATC at key intersections - Use of centralized traffic control rooms - Pilot projects for e-challan systems and CCTV enforcement

Category	Details
Recommendations for Mumbai	- Expand AI-ATC systems across the city - Delay congestion pricing until metro and public transport expansions are complete - Launch public awareness campaigns on traffic regulations and new technologies - Regular monitoring and adaptive recalibration of smart systems based on traffic pattern studies

Table 7: Proposed use of technology to improve traffic flow and alleviate traffic congestion

(Source: Author's own work)

4.3.4 What role can public transportation and alternative mobility options, such as cycling and walking infrastructure, play in alleviating traffic, on the specified street?

Context Analysis and Personal Observations (from the Researcher) for RQ3-SQ4:

Public transportation and alternative mobility options, such as cycling and walking infrastructure, can play a transformative role in alleviating traffic congestion on the specified street in Mumbai. High vehicular density not only discourages physical activity due to safety concerns but also leads to an overreliance on private vehicles. From observations made by the researcher, it is evident that the lack of protected cycling lanes,

insufficient pedestrian pathways, and limited accessibility to reliable public transportation have significantly contributed to congestion and traffic bottlenecks.

Investments targeted toward developing safe and well-connected cycling and pedestrian infrastructure would address these concerns.

By creating separate, clearly demarcated lanes for cyclists and walkers, the city can promote safer and healthier modes of transport, encouraging residents to opt for walking or cycling for short distances instead of using private vehicles.

Enhancement of public transportation services is another crucial factor. Increasing the frequency and reliability of buses, adding dedicated bus lanes, and expanding metro networks can shift a significant portion of commuters from personal cars to public modes of transport.

Based on the researcher's direct observations, the current metro expansion projects underway in Mumbai are promising, but complementary investments in last-mile connectivity (such as feeder buses, safe walkways, and cycle stands) are equally critical to realizing the full benefit.

Moreover, the development of integrated mobility options—such as easily accessible park-and-ride facilities and interconnected bus-metro networks—can reduce the need for private vehicle usage, particularly during peak hours. Encouraging multi-modal transportation options through safe, reliable, and affordable means would substantially ease traffic congestion and improve overall quality of life in the area.

Public Transport Actions	Alternative Mobility Actions	Expected Impact
Increase frequency and reliability of buses and metro services.	Develop dedicated cycling lanes and pedestrian pathways.	Reduction in private vehicle use, easing road congestion.
Introduce dedicated bus lanes and priority signals for public transport.	Ensure safe crossings, protected intersections, and last-mile connectivity for cyclists and pedestrians.	Improved safety and accessibility for non-motorized commuters.
Expand metro lines and enhance integration with bus networks and feeder services.	Promote cycling and walking for short-distance travel through public awareness campaigns and infrastructure incentives.	Encouragement of active mobility, leading to less traffic density and healthier communities.

Table 8: Role of public transport and alternative mobility in improvement of traffic conditions (Source: Author's own work)

Summary of Key Findings for RQ3-SQ4:

Public transportation enhancement plays a pivotal role in reducing private vehicle dependency. Increased frequency, improved reliability, and dedicated lanes for buses and metros can make public transport a more attractive and convenient option.

Alternative mobility options, such as cycling and walking, are essential for promoting short-distance, eco-friendly travel. However, their success depends heavily on the development of safe, dedicated infrastructure like cycling lanes, pedestrian paths, and protected crossings.

Safety concerns and a lack of infrastructure are major deterrents for pedestrians and cyclists. Addressing these through focused investments can encourage higher adoption rates of non-motorized transport.

Integrated planning—where public transport networks and alternative mobility solutions complement each other—is crucial to achieving long-term, sustainable traffic decongestion on the specified street.

Behavioural change initiatives, including public awareness campaigns, will further support the shift toward public and active transportation modes by changing commuter attitudes.

4.4 Conclusion

This chapter on results/findings systematically explored the key research questions and sub-questions, drawing on the survey responses of both profile A respondents (residents and commuters) and Type B respondents (healthcare providers), alongside the researcher's personal observations. A detailed context analysis for each research sub-question provided a comprehensive understanding of the traffic challenges and potential solutions specific to the studied street in Mumbai.

The findings clearly highlight that the impact of traffic congestion on daily life is profound, affecting commuting times, stress levels, healthcare accessibility, health outcomes, and environmental conditions. Contextual analysis emphasized that both structural and behavioural factors contribute significantly to these challenges.

The insights from Type B respondents (HCPs) further reinforced the serious health implications of persistent traffic congestion. Healthcare providers reported observing higher incidences of respiratory issues, stress-related disorders, cardiovascular concerns, and delayed access to medical care among residents and commuters.

These findings underscore that traffic congestion is not merely a logistical or urban planning problem but also a critical public health concern, warranting urgent and coordinated interventions.

When examining possible solutions to mitigate traffic congestion, a multi-pronged strategy was identified as critical.

Key measures include the implementation of smart traffic management technologies, community engagement, infrastructure upgrades, better parking management, and the encouragement of behavioural changes through awareness campaigns and economic incentives. Observations suggest that while several initiatives are underway—such as the deployment of AI-based adaptive traffic control systems—consistent enforcement and public cooperation remain essential for success.

Comparative analysis with Singapore’s highly effective traffic management model demonstrated that technological interventions such as dynamic tolling (ERP systems) and public education campaigns can achieve notable improvements. However, the adaptation of such systems to Mumbai’s unique infrastructural and socio-economic realities will require phased and carefully planned implementation.

Further, the role of public transportation and alternative mobility options—such as cycling and walking—was identified as indispensable. Improved connectivity, safety-focused infrastructure investments, and expansion of metro and bus services are expected to significantly reduce reliance on private vehicles, thereby easing congestion.

Healthcare providers also emphasized the potential health benefits of encouraging walking and cycling, which could contribute to better cardiovascular and respiratory health outcomes among the local population.

The logjam occurring at inopportune times nevertheless leads to multiple systemic and mental health impacts that have lasting, dire consequences on the overall health and well-being of the residents of the specified street. By shedding light on these consequences, we can find solutions. By implementing a combination of these solutions and interventions, we can significantly reduce traffic congestion in Mumbai and mitigate its adverse effects on the health and well-being of its residents and can effectively alleviate traffic congestion.

Across all areas of inquiry, a holistic, integrated approach—balancing infrastructure, policy, technology, public health priorities, and behavioural change—was consistently shown to be the most effective pathway forward. The findings of this chapter serve as an important foundation for the subsequent discussion chapter, where these results will be critically interpreted in light of existing literature and theoretical frameworks.

CHAPTER V: DISCUSSION

5.1 Discussion of Results

The findings from the interviews conducted both from the healthcare providers' perspectives as well as from the viewpoints of the residents, residing on the specified street, support the hypothesis that traffic has everlasting consequences impacting health and well-being in many ways and additionally, also on the quality of life. The factors which caused the traffic jams were first immensely understood, both on the specified street and in general across the city of Mumbai.

Next, several variables such as the infamous monsoons, road designs, impacts on driving behaviours and miscellaneous factors were thoroughly analysed. Insights were obtained from the residents residing on this street to primarily understand the specifics and dynamics of the traffic problem on the specified street, and from healthcare professionals to mainly understand the pressing consequences on physical as well as mental health and quality of life.

The reason for calling the particular street in question 'specified street' instead of the formal name is to ensure anonymity and to protect the research participants, as they reside on the said street.

5.2 Discussion of Research Question One

RQ1 What underlying factors contribute to traffic congestion on the specified street in Mumbai?

a) **RQ1-SQ1** What are the major contributory factors of traffic in the specific street?

Upon performing a root cause analysis of all the observed factors that contribute to the traffic in the specific street in conjugation with interviewing the residence of the said street, it was noted that while several factors added to the logjam, the most eminent reasons included un-authorized parking, illegal encroachment of hawkers and food cart vendors, numerous commercial places, skewered and concentrated in this street which included hospital, utility stores, gym, and salon, furthermore unavailable parking space for visitors to these commercial places as well as residents, occupancy of pavements by stores, proximity to market place, public garden as well as schools in the vicinity and pressing impacts of quick commerce deliveries.

Additionally, a huge number of visitors park their vehicles, occupying a significant proportion of the road, to run errands in the nearby marketplace, ultimately narrowing the road available for vehicles. The street also has no pavements available for pedestrians, due to encroachments, thus the pedestrians too occupy the roadways for walking, narrowing the available road. All these factors cumulatively contribute to the traffic problem on the specific street.

In the interviews, the chief reason highlighted as a major contributor included the unauthorized parking problem, which gravely impacted the state of the traffic snarls on this street. Although the mean value of all the noted traffic contributors came to 6.8, which was suggestive that all of the mentioned factors received moderate emphasis from the residents' view.

This ultimately translates to that fact that while some factors are permanent, including presence of commercial spaces, most contributory factors can be managed by fostering a sense of community engagement and additionally involvement of appropriate stakeholders, which can in-turn help to ensure adherence to parking discipline and help in management of issues pertaining to illegal encroachments by hawkers and food cart vendors and stores that occupy the pavements. Additionally, while quick commerce is a booming industry, offering both convenience and saving time, it is irrefutably contributing to traffic jams to some degree, by placing order judiciously, and in bulk by proper household planning, will not only reduce the trips of the quick commerce and prevent traffic, it will also benefit the environment and prove to be cost effective for the delivering company, benefits of which can collaterally be passed on to the consumers, thus creating a ‘win-win situation’ for all involved parties.

b) **RQ1-SQ2** How can we qualify & quantify these factors for qualitative research purposes in the specific street?

The literature suggests several ways in which traffic causing factors can be quantified and qualified, such as measurement of average speed, travel time difference between estimated and actuals, flow rates, to name a few. However, in the specific street that is being discussed in this research, the most important factor to quantify and qualify are the timepoints at which traffic congestion are observed and the frequency of these congestion events in a day. A deeper understanding of these factors, both qualitatively and quantitatively, helps in providing a cohesive picture of the problem and aids in suggesting suitable solutions.

In the interviews that were conducted with the residents, it was mentioned that the street observes at least three traffic jams on any given day, two of these events mainly occur during the peak hours. Several factors were highlighted as the cause.

The primary reason is unauthorised parking of vehicles on this street due to its proximity to schools, marketplaces and other businesses. Upon deep diving to understand the reasons for these parking behaviours, it was noted that tardiness of the vehicle owners and parents could be the reason for rampant parking behaviours.

Enforcing laws and imposing heavy fines, and additionally towing these vehicles frequently, can remedy the situation. Likewise, keeping frequent checkpoints, especially during these traffic snarl event times, can significantly discourage illegal parking and help in the free flow of traffic.

From a community outlook, businesses and schools should at least stress these issues to parents and employees, so that it fosters a sense of civility amongst those involved.

Upon performing a statistical analysis on the received responses, there was a repetitive mention by most responders of the ‘double parking’, which significantly increased at peak hours.

This directly points at the solution that if the parking can be managed or if alternative parking means can be provided even on a pay-and-park basis in conjunction with increased frequency of monitoring by relevant stakeholders, this in turn can reduce, if not remedy, the events of traffic snarls that occur on this street.

c) **RQ1-SQ3** How do seasonal variations, such as monsoons, influence traffic congestion in the specified street?

Monsoons in Mumbai are of very high intensity and frequency, and the disruptions to traffic due to downpours observed are tremendous, which only seems to compound.

Monsoon contributes a great deal to traffic snarls in the city during the rainy season, bringing the entire city to a standstill and chiefly impacting overall productivity. In the already busy city of Mumbai, monsoons cause a slowdown of vehicles, mainly due to the intensity of the downpour. There is waterlogging and also the visibility of the driver is severely impacted, thereby reducing the average speed on the roads and thus the logjam increases.

Furthermore, in order to avoid the submerged roads, it was observed that many vehicle owners were choosing those roads that did not have water collected, thereby increasing the traffic in several locations, where it is not waterlogged.

The residents at the specified streets, also inculcated inconveniences on other factors such as passer-by's parking in an unauthorized way to enjoy monsoon delicacies which street cart vendors have to offer and additionally to parking vehicles in front of main-gates, of the residential complexes, to purchase these fried snacks, causing a nuisance.

A recent published report, support these findings and also highlighted measures BMC took in Mumbai, to discourage the illegal operations of these vending food carts, which it highlighted, jeopardized not only public-health and raised concerns but in addition significantly contributed to obstructions of pavements making it unavailable to the pedestrian and also played a role in traffic congestions, thus it aimed to curb the problem by deployment of teams to check these unauthorized carts and stalls and confiscate materials from them to discourage these carts (Kanolkar, 2024). While it is imperative to ensure the livelihoods of these food vendors are somehow compensated by providing them alternatives to continue their operations elsewhere, it is also the need of the hour to clear the unauthorised encroachments on the streets in order to combat the traffic snarls, which seemingly only intensify during downpours.

During the interviews, numerous concerns were highlighted, and on the basis of which solutions may include as noted below.

Water logging due to poor drainage causes reduced traffic flow, which leads to traffic diversion to dry streets, concentrating congestion on those streets. The reason for the drainage clogging is that waste is being thrown out on the streets, making its way into the drainage systems and clogging them further. A potential solution to this problem could be clearing up the drainages ahead of the monsoons and monitoring them so that this problem can be avoided at the grassroots level itself.

Another issue highlighted was that low visibility during heavy rains leads to slower driving speeds, an increased risk of accidents and bottlenecks. While these events and incidents are purely acts of God, and an advisory issued ahead of time would chiefly help the citizens to plan their journeys in such a way that, only in the event of emergencies, do they drive their vehicles.

By staying up-to-date on the weather, alerts and advisories that are received, traffic snarls can be avoided to a great degree. Furthermore, staying vigilant and informed about road closures and waterlogged junctions can further prevent traffic congestion. If the job roles allow, on very heavy rainy days, work-from-home can be opted to prevent road traffic accidents and mishaps and also aid in retention of productivity.

Vehicle maintenance is another crucial solution that needs to be implemented during rains; these include routine maintenance such as checking wipers, cleaning vehicle window panes, and ensuring that tires are in good shape with adequate pressure to ensure no breakdowns occur.

An alternative would be to have a treatment of water repellent done to the windshield to aid raindrops to roll off, thus enhancing clarity and visibility. The best way will be to avoid flooded roads whenever one can to prevent vehicular breakdown instances mid-journey, which further intensify logjams events.

As for the formation of potholes, that are responsible for disruption of smooth traffic movement, these can be fixed ahead of monsoons. Moreover, more durable roads can be constructed to prevent and reduce the need for annual repairs.

Lastly, prevention of hawkers and food cart vendors, on junctions and busy streets, especially during monsoons, by adequate monitoring and administrative actions to ban parking of these carts, by imposing fines and confiscation of items may prevent further illegal encroachments and also bring down the number of stationed vehicles of the customers thus preventing break journeys and eventually improving vehicular flow and reducing unnecessary bottlenecks.

- d) **RQ1-SQ4** What role do urban infrastructure and road design play in exacerbating or alleviating traffic congestion in this area of the specific street in Mumbai city, used for this research purpose?

Infrastructure and road designs are both critical elements when it comes to traffic management. In the interviews conducted with the residents of the specified street, several inefficiencies and shortcomings were highlighted by the responders, with respect to design, infrastructure and the absence of pavements. Most respondents voiced their opinion's that 'lots of improvements' can be made pertaining to infrastructure and road quality. The observation was that the space on roads was limited due to pre-occupied foot-paths owing to encroachments and even two-wheelers parking on these pavements, obstructing the pathways and thereby pedestrians were forced to use the road, meant for vehicles, to walk, ultimately reducing road space availability by narrowing the roads and increasing the density and contributing to traffic. Given that this arterial street was never a part of the original plan of development and moreover, given its proximity to multiple schools, marketplaces and other prominent shops and establishments, the volumes of traffic it witnesses have peaked over time.

Additionally, this road adjoins to several main roads thereby the vehicular flow has significantly increased as passers-by opt for this street to reach the main roads. The street often has slow-moving traffic due to aforementioned reasons. A study conducted in Netherlands, to understand the impact of infrastructure on road-speed, by reducing smooth surfaces on the roads on an experimental basis, concluded that infrastructural changes, can bring about reduction in driving speed by increasing mental-load (Waard, 1996), the findings in this study, aligns with the findings that infrastructure plays a crucial role in speed in general and thus can impact management of traffic.

5.3 Discussion of Research Question Two

RQ2 How does traffic congestion on the specified street in Mumbai impact the health and well-being of residents and commuters?

Traffic congestion on the specified street in Mumbai extensively impacts the health and well-being of both residents and commuters in several ways. The excessive volume of vehicles results in prolonged exposure to harmful pollutants, dust, elevated noise levels, and percolates to increased stress levels, all of which have far-reaching consequences on the lives of the citizens.

The daily struggle with traffic not just impacts the physical health but in addition it takes a toll on mental well-being. Moreover, the continuous delays and unpredictability of travel time contribute to a decline in the overall quality of life. These challenges extend beyond individual experiences, influencing familial and social dynamics, reducing the amount of time available for meaningful interactions and activities.

The compounding effects of traffic congestion ultimately create a challenging environment for residents and commuters, underscoring the need for effective solutions to mitigate these impacts.

- a) **RQ2-SQ1** How does traffic impact the physical health of the citizens, in the specific street?

The influences of traffic on the physical health of the citizens are concerning, as noted by medical doctors as well as the residents of the specified street. The impact of traffic congestion on physical health is primarily due to the pollution that comes along with it, such as air pollution and noise pollution, as well as its direct impacts, like back pain and other musculoskeletal disorders that arise as a result of prolonged sitting in stationary vehicles in logjams.

Persistent traffic snarls are interrelated to an alarming increase in hypertension, chronic fatigue syndrome, and overall decline, with the passage of time, in both physical and mental health (Subair et al., 2024). In terms of health impacts due to air pollution, prolonged exposure to automobile emissions leads to respiratory issues like bronchitis, asthma and chronic obstructive pulmonary disease (COPD). This is because fine particulate matter (PM_{2.5}) and nitrogen dioxide (NO₂) levels tend to be higher in traffic congested areas, also intensifying the risk of cardiovascular diseases and pulmonary cancer. Substantial exposure to traffic-associated air pollution surges the risk of premature death (Engström and Forsberg, 2019).

Noise pollution also has links to adverse cardiovascular effects, as highlighted by the World Health Organization (WHO).

Continuous exposure to high noise levels from honking, engines, and general traffic can lead to hearing loss, hypertension, and increased stress levels. In the current study, the residents have hinted at the commotion that is caused during traffic jams in the specified street. All the hullabaloo and the air pollution from the congestion trigger allergies in those residents residing on the specified street, especially those who are staying on the lower floors, impacting their families and even their pets. A resident had also pointed out that they and their family have suffered from multiple episodes of chronic coughs and suspect that the traffic jams nearby may have been the cause. Also, during traffic jams, time spent in traffic by drivers and passengers increases, their time of exposure to pollutants and additionally alongside also increases in roadway pollutant concentrations, that subsequently increase personal cumulative exposures and doses (Levy 2010).

During the interviews with the HCP's multiple concerns were raised all profoundly impacting the health of citizens. Each of the concerns discussed is summarized below.

Respiratory issues: 'The air quality index (AQI) of the city is already very concerning, and traffic is exceedingly contributing to the poor air quality'. Traffic jams intensify vehicle emissions, thereby worsening air quality and the AQI levels. This further aggravates respiratory conditions like asthma, chronic obstructive pulmonary disease (COPD), and bronchitis, and even compounds the risk of lung cancer. 'Worsening AQI levels were evident this winter in Mumbai, even the visibility was greatly affected due to pollution levels being extremely high' Higher AQI levels put citizens at greater risk for heart disease, strokes, asthma, COPD and cancers.

As pointed out by one of the HCPs, there was a steep rise in in-clinic patient visits, mainly due to complaints of cough and shortness of breath (SOB) caused by allergies, particularly triggered by dust and smog.

Cardiovascular Health: Vehicles release harmful pollutants like nitrogen oxides, particulate matter, and carbon monoxide. Traffic jams increase exposure to these pollutants, leading to respiratory disorders, heart disease, and other health issues. Prolonged exposure to traffic-related pollution and stress can heighten the risk of heart disease, increase heart rate, high blood pressure, and stroke.

Sedentary Lifestyle: Traffic jams often result in extended periods of idle sitting in vehicles, reducing physical activity and additionally increasing the risk of obesity and related health concerns. Furthermore, it can discourage physical activity, such as walking or cycling, due to safety concerns and a lack of infrastructure. People may choose to drive instead of walking or biking, leading to a more sedentary lifestyle and associated health risks like obesity and heart disease. Heavy traffic on the roads usually results in reduced open spaces and walking areas, which results in reduced physical mobility. A major portion of the roads and pavements are preoccupied leaving no room for pedestrians to walk. A sedentary lifestyle due to reduced mobility eventually contributes to obesity, diabetes, cardiovascular disease, and certain types of cancer. It can also cascade into muscle weakness (hypotonia) and osteoporosis.

Sleep Disturbance: The noise and stress from traffic congestion can disrupt sleep patterns, thereby causing fatigue, decreased productivity, and weakened immune systems.

Other Parameters

Musculoskeletal Disorders:

Extended intervals of sitting in a vehicle can lead to poor posture and musculoskeletal issues, including back and neck pain.

Auditory Impairment:

Heavy traffic inevitably causes higher noise pollution (partly due to irresponsible honking). Prolonged exposure to traffic noise may lead to hearing disturbances or noise-induced hearing loss (NIHL).

Road Traffic Accidents (RTA):

Traffic congestion increases the risk of accidents, that may result in injuries and fatalities.

Heat related diseases:

Traffic during hot weather can cause heat-related illnesses, like heat exhaustion and additionally heatstroke.

Dermatological health Impacts:

Excessive pollution arising from traffic, which is often precipitated in the air, can cause severe impacts to skin such as acne, inflammation, sensitivity to state a few and can also cause hair fall. The specific health impacts can vary based on an individual's baseline health status, the severity of the congestion, and the frequency and duration of exposure.

In the interviews, conducted with HCP's from different domains, all participating healthcare providers raised special concerns on the deleterious impacts on respiratory health and also voiced their worries with regards to cardiovascular health impacts, stemming from both, exposure to pollutants and also as a repercussion of sedentary lifestyle, both being a direct progression of traffic in the city. Overall, traffic congestion poses a significant threat to the physical health of citizens, contributing to a range of chronic health conditions. This eventually leads to reduced quality of life.

In summary, traffic congestion can have a detrimental impact on physical health through air pollution, stress, reduced physical activity, noise pollution, and an increased risk of accidents, which eventually burdens society as a whole and increases healthcare costs exponentially.

b) **RQ2-SQ2** How does traffic impact the mental health and well-being, in the specific street?

Traffic congestion in conjunction with its associated stressors can cause a deep impact on mental health. Longer travelling times have led to increased stress, anxiety, and frustration amongst commuters, causing a decline in general well-being (Subair et al., 2024). The unpredictability and delays, along with time-pressure caused by heavy traffic, can lead to heightened tension and anxiety among these commuters. The constant need to navigate through congested streets can be mentally taxing. It can amplify frustration and irritation and also contribute to mental fatigue, feelings of despair and a lack of control.

A finding in the literature highlighted that the adverse effects related to commuting negatively had residual impacts noted in the home and job (Liu et al., 2022). Traffic impacts can cascade into chronic stress and related mental disorders, and hence remain concerning.

Upon discussing this further in the interviews, the emergent and prominent themes included elevated stress and anxiety levels, cognitive impairment and mental fatigue, mood disturbances, irritability, road rage, emotional burnout, depression, social isolation and reduced quality of life as aftermath caused due traffic impacts. Additional consequences that follow included disturbed sleep and long term impacts on health and mental wellness.

To subdue these effects, it is vital that citizens accept responsibility and in whatever capacity possible, to act as a society and take some proactive steps to mitigate these unfavourable effects. This could be in the form of engaging in activities as a community, having dialogues on mental well-being, checking in on one another at regular intervals, starting support groups involving the community and inviting folks to participate from vicinities, preferably over weekends, to encourage community involvement.

c) **RQ2-SQ3** What impacts are seen on the quality of life (QOL) of the citizens, in the specific street?

The impact on QOL of traffic, as noted by healthcare professionals as well as residents alike, is profound, as its impacts spill through and affect all facets of life, such as health, both physical and mental, economic, familial, social and overall leads to decreased satisfaction level.

To look at the modern developments of recent times, we have now surpassed the mere basics such as food, clothing and shelter, and currently every development and advancement mankind works towards, across all sectors, are focused on enhancing the quality of life, however why is it then, traffic should continue to erode the quality of life?

To name a few ways traffic congestion can affect QOL, and the one that tops the list would be the health and well-being of the citizens, which then has a pressing cost on finances. The citizens also have a loss of productivity as increased commute times can lead to lost hours, which would have otherwise been spent on productive activities, thereby impacting work-life balance and economic output.

As highlighted earlier, the health costs are also significant due to traffic, and the physical and mental health issues associated with traffic congestion contribute to higher healthcare costs for individuals and cumulatively for the community.

Furthermore, traffic-congested streets also contribute to greater levels of air and noise pollution, degrading the urban environment and diminishing the quality of life. A study, comprising 382 participants, conducted to gauge the effects on the quality of life due to traffic, concluded that traffic congestion had a poor quality of community life and it also affected daily routines (Ghazali and Tahar, 2024).

Another study, conducted to understand the relationship between living near traffic congestion and its impacts on health-related quality of life (HRQOL), comprising 6197 participants, who were divided into 3 cohorts, mainly based on the geographic positioning of their bedrooms and their proximity to the road.

The three groups were, bedrooms which were either located close by to an arterial road (AR), or to other roads (OR), and the third cohort comprised of, that was not located to any road (NR), the findings concluded that HRQOL scores of the arterial road (AR) as well as other roads (OR) cohort were inferior to the NR group across all domains (Yamazaki et al., 2005).

The results of the current study align with the previous findings in the literature, where the residents highlighted that they were quite disturbed by all the honking and commotion caused by traffic congestion.

From the interviews, it was evident that traffic has been a catalyst in greatly reducing the quality of life of citizens, some of the conspicuous themes included physical health deterioration, increased stress, mental health decline, reduced physical activity, sedentarism, deprived sleeps percolating to disrupted circadian rhythm and over dependence on stimulants such as teas and coffee. It also extends to other areas of life such as economic burden, productivity loss, social isolation and disengagement of community, eventually directly or indirectly encumbering every facet of life.

d) **RQ2-SQ4** Impact on the familial and social life of citizens, in the specific street

The impacts of traffic on both familial and social life are intense. Several residents of the specified street reported a sense of disconnect during weekdays from their family members, as they were reportedly ‘too tired to interact beyond the usual pleasantries’. A respondent stated that while she loved to cook dinner upon returning from work for herself and her family, she was unable to do so, as congestion robbed her of the time and opportunity, and she now had to depend on help for this.

The general working hours have already increased significantly, and prolonged commute time, to-and-fro work, further shrinks the quality time one gets to spend with their loved ones.

Consequently, this can strain relationships and reduce the time available for shared activities and familial bonding. Additionally, the remnant frustration and irritability from the traffic congestion often translates into familial quarrels. It can also impact child development, as the reduced availability of parents due to extended commuting hours can impact the development and well-being of children, as they may receive less attention and support in all aspects of life, including their overall development and even their education.

A responder in the interview, mentioned that although she was highly qualified herself, yet she did not find the time to sit through study sessions of her children, due to her packed work-schedules and subsequent long commuting hours, on weekdays, attributing the wasted time to traffic congestion, and thus she had to hire a tutor for her primary level children. Impacts on social life is also highlighted, where longer commute time leads to social isolation. People often avoid social interactions and events due to the mounting stress and inconvenience of travelling through congested areas, which can perpetuate social isolation and diminished community engagement.

In literature, a study that examined the links between increased divorce rates explored the contributing factors that lead to these marital problems, and its findings pointed to traffic congestion as one of the major contributing factors of increased divorce rates.

It voiced that a couple already has to withstand enormous pressures at their professional settings to prove competency in their respective jobs and over and above this they have to also withstand the challenges of spending endless hours in traffic gridlock on a daily basis, which subsequently hinders bonding among the couples (Sarker and Pareek, 2024).

Traffic congestion thus has grave consequences on the social and familial life and arguably while one can opt for virtual social interactions to keep the social bonds intact, however a better approach to find a work-around traffic congestion problem in the context of familial life would be to opt for hybrid working models to strike a work-life balance or to opt for faster modes of transports, such as local trains or metro, when available, which would not only benefit the reduction of overall traffic burden on the roads, but also increase the time available for family and social life.

5.4 Discussion of Research Question Three

RQ3 What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai?

- a) **RQ3-SQ1**-What measures can be taken to combat the problems pertaining to health and well-being, in the specific street?

The opinions received from healthcare professionals suggest adherence to air quality monitoring and use of masks, when outdoors, especially for those who have pre-existing medical conditions, residing on the specified street. If the AQI is reportedly high, then

staying indoors while traffic congestion events occur, specifically around peak time and having air purifiers installed will be beneficial to improve health outcomes.

Healthcare providers also opined that health awareness campaigns, green spaces, stress reduction programs and promotion of physical activity as means and ways to promote physical health and mental well-being.

Furthermore, measures must be put in place, such as emission control and monitoring of vehicles by implementing strict emission standards for vehicles and conducting regular emission checks, which can help reduce air pollution to improve citizens' health. Incentivising and encouraging the use and adoption of electric vehicles (EVs) can further significantly minimise harmful emissions. Other suggestive measures were noise barriers and sound-proofing installation to mitigate challenges of noise pollution and promoting the use of quieter vehicles, and encouraging drivers to minimize honking, that can also help to reduce noise levels.

Additionally, encouraging employers to espouse telecommuting and flexible work hours will reduce the number of commuters during peak hours, thereby easing traffic congestion. These approaches can also be beneficial from the perspective of work-life balance and will also reduce the stress of the employees. A brief summary is provided below to encompass all the suggestions.

Measures to Combat Health and Well-Being Issues

Air Quality Monitoring and Control:

Installing air quality monitoring stations and implementing measures to control vehicle emissions can help improve and enhance air quality. Encouraging the use of electric and hybrid vehicles can also reduce pollution.

Implementing stricter emission standards for vehicles can help. Furthermore, road-facing huge workplaces can have centrally controlled air purifiers installed by constantly monitoring the quality of indoor air, given that a huge portion of most employees' time is spent indoors, it is imperative to have good quality of air.

Additionally, citizens and especially patients with predisposing factors and comorbidities, should always use an air-purifier when indoors and at least while sleeping confined in a room; this can give them a cumulative benefit over time. When outdoors, the use of a mask, around traffic-heavy areas, can help tremendously. Overall, by implementing emission-reducing technologies, increasing the use of electric or hybrid vehicles, and enhancing public transportation, air quality can be improved, and this can eventually help improve the health of citizens.

Data-Driven Approach:

Collect data on traffic patterns, pollution levels, and health outcomes to inform decision-making and evaluate the effectiveness of interventions.

Green Spaces and Urban Planning:

Incorporate green spaces, parks, and gardens into urban planning to mitigate the negative impacts of traffic on physical health. Increasing green spaces and vegetation will eventually improve air quality and keep a balance. A good way to achieve this would be to

promote the use of green roofs and vertical gardens, which can be incorporated into buildings and also help absorb pollutants and reduce noise.

Creating and maintaining green spaces along congested streets can not only enhance air quality but also provide residents with areas for relaxation and recreation.

Health Awareness Campaigns:

Conducting public health campaigns to raise awareness regarding the health hazards associated with traffic congestion and promoting healthy lifestyle choices can help mitigate some of the adverse effects. Counselling for patients likely to have adversely impacted mental health due to traffic congestion or other reasons. Educating the public and promoting healthy behaviours, such as using masks to filter pollutants, can help citizens protect themselves.

Stress reduction programs to improve mental health:

Offering stress management programs along with mental health support services may help individuals cope with the stress and anxiety caused by traffic congestion.

Stress-Reducing Interventions may include implementation of interventions, like mindfulness programs, meditation sessions, or yoga classes to combat stress. Reduce stress levels associated with traffic congestion by providing alternative transportation options and promoting a less car-dependent lifestyle. Create more pedestrian-friendly spaces to encourage physical activity and social interaction.

Promoting Physical Activity:

Encouraging physical activity through community programs and providing facilities such as parks and recreational areas can help counteract the sedentary lifestyle associated with long hours in traffic.

Promoting physical activity among citizens by ensuring open spaces, creating pedestrian-friendly and bike-friendly infrastructure for citizens and children in any neighbourhood.

Noise Reduction Measures:

Implementing noise reduction measures, such as sound barriers, noise-reducing asphalt and promoting the use of quieter vehicles and increased green spaces, can help reduce the impact of traffic noise on sleep and overall well-being. Penalising excessive honking to reduce noise pollution.

Flexible Work Hours and Remote Work:

Encouraging businesses and employers to adopt flexible work hours, telecommuting work arrangements and remote work options can reduce peak-hour traffic congestion and improve work-life balance for employees.

By fully leveraging the technological advancements, companies can now promote telework and flexible work arrangements, which is mutually beneficial to the employees and employers alike. Adoption of hybrid work models and more work from home facilities so to reduce the commute time will tremendously increase productivity and improve work-life balance.

b) **RQ3-SQ2** What solutions can be implemented to mitigate the challenges and reduce the traffic, in the specific street?

To address traffic congestion and mitigate its adverse effects on the specified street in Mumbai, a multifaceted approach is required. Potential solutions and interventions can be categorised into infrastructure improvements, enhancement of public transport, policy measures, surge charges levied for peak hours, technological advancements, community engagement and behavioural changes. Focusing on enhanced public transportation would mean improving the efficiency, reliability and coverage, of public transportation that can reduce the reliance on private vehicles, thereby significantly decreasing traffic congestion. Initiatives such as expanding bus and metro services and introducing dedicated lanes for public transport can make commuting more appealing and convenient.

When it comes to leveraging the usage of technology, the use of traffic management technology and smart mobility solutions is paramount. However, application of these solutions on the specified street will only be beneficial when traffic entering from the main adjoining roads is well managed and implements these solutions.

From the standpoint of using modern technology on an individual level, for those that reside on the specified street, use of private bus services such as ‘City-flow’ and ‘Shuttle’ that are comprising of options to book through apps, which have enabled commuters to track status live and pre-book a seat, remain an important options in curbing the traffic. The advantage of these bus services is that they have common stops, which optimises the time it takes to reach their pre-decided destinations, that are workplaces located in close proximity to one another and have flexible schedules and timeslots, are air-

conditioned and very comfortable. By opting for these options instead of a private car, the volumes of vehicles on the roads can be impressively reduced.

As most residents of this street travel to work, travel similar routes, car-pooling becomes another appealing and attractive option to opt for. A few community groups comprising of different routes, can be created on apps such as 'WhatsApp' that can be used and a roster can be prepared, which will enable folks traveling on similar routes to car-pool and take turns on usage of their automobiles, thus not only saving on fuel but also aid in reducing traffic. This could be highly beneficial and immensely workable if practised throughout the city, particularly in huge housing complexes, which can substantially curb the number of vehicles on the roads. It will also bring about community engagement, trigger ideas and conversations.

A notable problem that is faced by almost all the residents is the unauthorized parking, and the most optimum solution to handle this challenge will be to increase the frequency of visits of the towing vehicles, which can easily tow multiple two-wheelers in a single visit moreover imposition of fines for cars, when the parking is not done in congruence. While these initiatives are already being followed, what is really lacking in the specified street is the frequency and timeslots in which it is being done. A predictable timing of the towing van directly inspires law and order in its given arrival schedule; however, this is not the case when the towing vehicle is not expected. Thus by increasing the frequencies of the towing vehicles at various time intervals can help curtail the problem. It is noteworthy that the specified street also has an even-odd dates parking system on both

sides of the road; however, that is not followed diligently, and this is an area where improvement can be made to increase efficiencies.

These small but significant changes and updates, when diligently implemented and followed, will work like a domino effect to bring about a paradigm shift in the overall traffic management throughout the city. That will ipso facto positively impact the specified street that is currently being studied in the research.

Traffic Management Technologies:

Implementing smart traffic management systems, such as adaptive traffic signals and real-time traffic monitoring, can optimize traffic flow and reduce congestion.

Community Engagement:

Involvement of the community in the planning along with implementation of solutions to ensure that their needs and concerns are addressed.

Multi-Sectoral Collaboration:

Foster collaboration between transportation agencies, health departments, urban planners, and other stakeholders to develop and implement comprehensive solutions. Improve overall public transportation options and quality to reduce reliance on private vehicles.

Develop Smart Mobility Solutions:

Implement ride-sharing and carpooling programs, which are now both secure and possible, given the digitalisation and excessive use of smartphone apps. Another

initiative would be to promote the use of electric vehicles and other eco-friendly transportation options for the citizens.

Where in the ownership and use of electric vehicles should be promoted by allowing slashed tax on insurance of such vehicles, even on the purchase cost and waivers offered to citizens on tolls.

A very recent development which the researcher encountered was an EV auto-rikshaw (*figure 18*), which is a welcome change within the city. Although a new initiative, if this can proliferate quickly, can immutably prove to be very beneficial from health aspect as well as cost-effective.

Additionally, developing and implementing real-time traffic information systems can aid commuters in planning travel and taking alternative routes.

Behavioural Changes:

Public Awareness Campaigns can educate the public about the benefits of public transportation and alternative modes of transport. This can go a long way when the awareness is brought as a region-wise initiative. Another way to help management of overall traffic would be to promote responsible driving habits and discourage unnecessary car trips.

Economic Incentives:

Introducing congestion surge charges or road pricing to discourage individual car use during peak hours may help curtail the logjam at peak hours. Providing subsidies for public transportation and eco-friendly vehicles is another way to help manage traffic problems.

Road Network Optimization:

Improve traffic signal timing and synchronization. Implement intelligent transportation systems (ITS) to manage traffic flow dynamically. Better planning of new constructions so that an increase in the number of cars on the road is matched by better infrastructure. Construct flyovers, underpasses, and widen roads to increase capacity.

Parking Management:

Implement open road parking restrictions and introduce parking fees to discourage car use. Encourage the development of park-and-ride facilities. Create public parking lot buildings, which allow pay and park by using underground and vertical space, to optimize the parking situations and facilities. Lastly, limiting vehicle entry in high-congestion areas by having high parking fees and time slots (to reduce late-night traffic).

Towing unauthorized, illegally parked vehicles:

In order to discourage unauthorized parking, no parking sign boards in such areas need to be clearly placed, where they these sign boards are not hidden in any way. Further to

discourage unauthorized parking and allow traffic to flow through freely, towing of vehicles must be done and the release fines for such vehicles must be increased, in order to ensure that parking in authorized places only is followed strictly.

Public Transportation Enhancement:

Improving the efficiency, coverage, and reliability of public transportation can reduce the number of private vehicles on the road. This includes expanding metro lines, increasing bus frequency, and introducing dedicated bus lanes and enhancing pedestrian and cycling infrastructure.

Increase the frequency and capacity of buses, trains, and other public transport options. Increased investments and funds towards development in infrastructure to improve connectivity and reduce travel times.

Infrastructure Development:

Investing in infrastructure such as widening roads, adding lanes, and renovating intersections can help improve traffic flow. Additionally, constructing flyovers and underpasses can reduce bottlenecks and promote traffic free-flow.

Encouragement of Alternative Transportation:

Promoting the use of bicycles and walking through the development of dedicated bike lanes and pedestrian pathways can reduce the reliance on motor vehicles and promote physical and mental wellness.

Carpooling and Ride-Sharing:

Encouraging carpooling and the use of ride-sharing services can decrease the number of vehicles on the road, thereby reducing congestion.

Urban Planning and Land Use Management:

Implementing better urban planning strategies, such as mixed-use development and transit-oriented development, can reduce the need for long commutes and promote the use of public transportation. By deploying a multifaceted approach and improvising these solutions on an ad hoc basis, traffic challenges can perhaps be mitigated.

Improved zoning regulations can help decongest central areas and encourage growth in underutilized zones. Prioritizing pedestrian-friendly infrastructure and integrating green spaces can enhance urban mobility and quality of life. Coordinated planning between transport authorities and city planners is essential for long-term traffic resilience. Incorporating smart city technologies and data-driven traffic modelling can further optimize land use and travel flows. Community participation in planning processes ensures the solutions are inclusive and context-sensitive.

Moreover, effective land use management must account for the diverse needs of residential, commercial, and industrial zones to create a balanced urban ecosystem. Incentivizing the development of satellite townships and decentralizing essential services can help redistribute traffic loads away from congested cores. Introducing parking regulations, congestion pricing, and dedicated cycling lanes can also shift travel behaviour

toward more sustainable modes. In rapidly growing urban centres like Mumbai, integrating land use planning with environmental sustainability goals is critical to ensuring liveability and long-term resilience. A holistic and adaptive framework is key to managing growth without overwhelming existing infrastructure.



Figure 18: Actual image of an eco-friendly EV autorickshaw [green number plate]

(Source: Author's own work)

- c) **RQ3-SQ3** How can the use of technology, such as smart traffic management systems, improve traffic flow and reduce congestion, in the specific street?

By leveraging technological advancements in traffic management, given that every individual now has access to smartphones, traffic updates can be sent centrally to the citizens via the use of apps, which will enhance management. Borrowing from the idea of Singapore, adopting a toll collection system, like the electronic road pricing system (ERP), that charges a toll based on traffic, can be implemented once all the metro lines are completed in the city, to discourage car use during peak hours and promote the use of public transport, this in turn will significantly bring down traffic throughout the city.

The other initiative, of use of artificial intelligence advance traffic control (ATC) system that uses modern technology and algorithms to analyse flow rates of traffic with its access to a centralized traffic control room and real time data, used only in major junctions, can broaden its scope and also provide coverage to arterial road networks such as the specified street that is studied in this research. This would then provide a holistic approach and aid better traffic management and to locate hotspot junctions of congestion, in these road networks, factor-in the increased time, so that it can suggest alternate routes to commuters, to counterbalance the traffic and also automatically raise traffic infringement

tickets to offenders without human intervention, thereby ensuring the adherence to regulations.

In order to bring about a paradigm shift, it is vital that all technological advancements can be integrated into a single platform and operate seamlessly, which will not only benefit the policymakers in ease of management but even to the community as a whole, by allowing them to make informed choices when commuting, without adding frivolously to digital clutter by multiple apps.

- d) **RQ3-SQ4** What role can public transportation and alternative mobility options, such as cycling and walking infrastructure, play in alleviating traffic, on the specified street?

Active transportation infrastructure, which encompasses the development of infrastructure for walking and cycling, such as pedestrian pathways and dedicated cycling lanes, can encourage citizens to choose these healthier modes of transportation. This would not only reduce traffic logjams by reducing the number of vehicles on the road, but also promote physical activity and well-being.

By investing in road-grid constructions of dedicated cycle lanes, it can not only aid in establishing safer and more efficient tracks for cyclists, but additionally encourage more citizens to leave their cars behind and opt for cycling and in the aftermath, help with traffic reduction. In today's competitive time, a working professional spends around 9 to 10 hours of their day on sedentary desktop jobs, where their mobility is limited.

This position in itself is very uncomfortable and furthermore, the commute to and from work is also via private vehicles and cars. Thus, for commuting to nearby distances,

both options of cycling and walking can provide practical alternatives to driving, plummeting the number of vehicles on the roads.

By opting for walking and cycling options to run nearby errands, one can afford the opportunity to improve their health and prevent an unhealthy lifestyle. Investment in building infrastructure too can help traffic congestion.

A noteworthy problem of unauthorized parking was highlighted by many respondents in the interview residing on specified street, due to its proximity to nearby places, such as marketplaces etc, therefore by constructing a multistorey parking building nearby at a feasible location or alternatively underground parking spaces, can aid the smooth flow and uninterrupted passing of traffic on the specified street.

As this street also lacks usable pavements due to illegal encroachments by shops, establishments and hawkers alike, poor maintenance and uneven and narrow roads, making it unusable and impractical for walking, this leads to usage of street roads by pedestrians on the specified street, which is a road-safety concern and it further narrows lanes for vehicles to pass-by, thereby increasing traffic.

A reliable way to mitigate this problem is by enforcing regulations of clear pavements by policymakers, and by investing in the maintenance of footpaths, walking can become an available option for the residents. Currently, public transport systems, such as local trains and bus services, have out-passed their capacities and, consequently, to avoid the overcrowding, people opt for using their private cars and driving for hours instead of choosing public transport, especially during rush hours, thereby, a surge in traffic is seen.

If more reliable and convenient transportation options can be developed, by increasing the capacity and efficiency, it will automatically discourage private car usage, and citizens will themselves opt for public transport alternatives, which would be faster, cheaper and more convenient. Another add-on to public transportation can be to facilitate and accommodate different types of comfort options, catering to a wide array of commuters.

CHAPTER VI: SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

Traffic is a crucial problem that is becoming a major cause of health concerns across several big cities around the world. Mumbai is already facing tremendous impacts of traffic from the standpoint of health, well-being, quality of life and economic impacts. Development of infrastructure such as roadways and metro lines is underway and thus, its construction occupied space is presently adding to the traffic issues. Other major factors, such as illegal encroachments and parking behaviours, are further contributing to the traffic woes.

The city that witnesses a regular influx of people, due to lucrative career opportunities, is also withstanding the problem of increased car ownership, and correspondingly, these citizens in their pursuit of better accommodations, are opting for redevelopment projects, which in turn also implies more vehicles.

With the economy becoming fairly stronger, with India now being the fourth largest economy in the world, and Mumbai being the most expensive city in Asia, the ownership of private vehicles has boomed exponentially due to a rise in purchasing power, which translates into increasing traffic. Seasonal variations, especially monsoons, are another factor that slows down traffic, by increased travel time, as road visibility, owing to heavy downpours, is greatly impaired and there is waterlogging in several places.

Law violations, poor driving practices, signal jumping, road rages, hostility, car crashes are all other behavioural factors that tremendously contribute to the traffic problem.

While these impacts seldom stay as a standalone problem, it infact percolates to health and well-being of the citizens, contributing directly or indirectly to a vast array of health issues. The health impacts include respiratory health, cardiovascular health, mental health, emotional disturbance and have a bearing on the overall well-being of its citizens.

It also erodes familial, social life, and likewise majorly impacts individual quality of life and negatively affects both the environment and the economy of the city and additionally skyrockets healthcare costs. Given all the above stated problems, a large research gap motivated this research to find some tailormade solutions for Mumbai, thus this research used a single street as a case example, wherein the residents residing on the street were interviewed to understand explicitly reasons of the traffic causes on the specific street, the inconveniences they face as a result of this traffic and its impacts. The study was also undertaken to understand how seasonal variations played a part in the traffic snarls, especially those that the city suffers through during the peak of the monsoons. Another set of interviews with domain experts, healthcare professionals, in various medical specialities were completed to fully understand the health impacts of the traffic, involving on physical, mental health and overall quality of life, which they witness while treating patients as a part of their daily medical practice and suggestive measures which they recommend, to help deal with the problem. The research also focused on finding solutions by understanding how road designs and other infrastructure parameters hampered or aided in traffic flow.

The research additionally concentrated on leveraging technological advancements and enhancement of other means of transport, such as public transport, transport alternatives, for instance, walking and cycling infrastructure, to help with the traffic burden distributions.

By taking into account the theoretical framework of contingency theory, this study was based on, which involved finding tailored solutions by primarily understanding how various interdependencies such as infrastructure, population density and other factors interplay in the traffic predicament and how they can be better managed by the involvement of numerous stakeholders.

For instance, the rise in purchase power in the city translates to increased vehicular ownership, however it is noteworthy, that this is a vicious cycle, as those that are benefiting from the use of private cars are also the same folks that eventually suffer the consequences of traffic and the cascading health problems, that are described in this piece of research.

Deployment of effective management strategies can not only enhance the quality of life, health and well-being, but also their benefits are directly proportional to increased productivity and economic growth. These strategies may include investing in infrastructure upgrades, enhancing the already present alternative modes of public transport and also hint at behavioural modifications by fostering better practices and regulations. Community inputs and interventions can further remedy the situation.

A total of fifteen highly educated residents, residing on the street that was being case studied in this research, were interviewed to collect information pertaining to specific contributing factors to traffic, on the specified street, several variables cumulatively involved and their impacts on their health and well-being. In addition, six healthcare experts, from different domains, were interviewed to specifically understand health concerns pertaining to traffic in the city.

These interviews with healthcare professionals were conducted in two parts, where in questionnaires were mailed and responses were received via email, followed by telephonic interviews. The questions that focused chiefly on healthcare concerns involving impacts on physical, mental and general well-being of the residents, all emerging as an aftermath of traffic. These interviews gave an in-depth understanding of the several means by which traffic repercussion eventually disrupts health, uproots daily well-being and its impacts in turn, spill over to all facets of life. They additionally provided altruistic propositions, measures, and suggestions to improve the health and well-being of the urban citizens.

In the resident's interviews segment of the study, that was chiefly focused on understanding the various factors that come into play and contribute to traffic congestion from the lens of the residents, it was understood that the vast majority of traffic contribution came primarily from the behavioural aspect of passerby's and visitors like unauthorized parking, double parking, halting of vehicles to procure food from street vendors and hawkers who have additionally acquired space on the pavements.

This space, which was primarily dedicated to pedestrians, which then leaves them without any option other than to use the road's width, that is originally designated for vehicular movements, thereby eventually leading to narrowing down the lane and slowing down the free flow of this traffic.

Thus, the problem of traffic on this street has multiple interdependent factors that are contributing to the traffic and are leading to further intensification of the problem. Another important factor noted was illegal encroachments of roads by shops on the roads and pavements.

It is a well-established fact that real estate prices in Mumbai have skyrocketed, and thus, shop owners are now occupying spaces outside their shops to display and entice customers. Quick commerce too is seeing a rapid growth across the city, and while convenient, its impacts on traffic are hard to ignore, while it is quite handy in times of need and urgency, heavy reliance on these services will undeniably increase the traffic, as to make timely deliveries to acquire customers, these services often disregard the laws and often violates traffic rules like signal jumping, using wrong lanes, fast driving, to highlight a few.

A very specific problem that this street faces is its proximity to various busy areas, such as marketplaces, schools and a public garden. This means that parents who use private vehicles to drop off their children at school often park on this street. School buses additionally create a jam on this street while passing through.

This street also has many commercial shops and establishments skewered in the area, such as the gym, a hospital, shops and a saloon, which automatically is a crowd-puller. Peak hour congestion has remained an all-time problem, which slows down the free flow of traffic twice a day.

With regards to seasonal variation, Mumbai witnesses some of the most harsh monsoons, often drenching the city and sometimes even bringing it to a complete standstill. The city often experiences intense showers, which lead to waterlogging and a slowdown of traffic. While the waterlogging may be attributed to poor infrastructure, at certain places, its impacts on the productivity, economy and citizens' commute are quite noteworthy, during this season, perpetuating to increase travel time, road closures, slow driving due to waterlogging, potholes and effects on drivers' visibility. As many of the public transport systems become non-operational during bad weather, there is heavy reliance on private vehicles and cab services, eventually increasing the car volumes on the roads. While it has become quite customary for city dwellers to enjoy hot fried local snacks whilst enjoying the rains, they habitually park their vehicles adjacent to these carts to procure their snacks, not necessarily in a uniform manner and most likely in unauthorised ways, leading frequently to bottleneck situations and traffic jams.

The street cart vendors serving local street food and tea, other hawkers are present throughout the year, preoccupying a substantial part of portion of the road and pavements by illegal encroachment, which is a chief concern in terms of law infringement and a deficit when it comes to pavement accessibility of pedestrians.

The inadequacy of infrastructure in terms of quality, for the remainder of the footpaths, also leads to avoidance of its usage and the citizens are then forced to opt for the roads to walk. Most residents highlighted the shortcomings by mentioning the need for ‘a lot of improvements’ that can be made to the infrastructure.

The second segment of the interviews conducted with healthcare professionals was vastly focused on understanding the health effects of the traffic on the citizens, mainly its impacts on physical and mental health, its cascading impacts on other aspects such as quality of life, social and familial life, etc.

The primary discussion revolved around the impacts of traffic on physical health, experienced both in the short and long run. Main concerns that were emphasised were on the respiratory health, which was specified by all the participating HCPs, cardiovascular risks and sedentary lifestyle, both came as close second, raised as a concern by five of the six participating HCPs. The main impacts on the respiratory health noted were due to the ever-declining air quality index (AQI) in the city, mainly caused by vehicular traffic emissions, resulting in asthma, shortness of breath, COPD, bronchitis and lung cancers due to the toxic emissions.

From the perspective of cardiovascular health, continuous exposure to pollutants can lead to elevated blood pressure and heart rate, heart diseases and even strokes. The traffic stress also entails vascular risks. Traffic and car congestion on the roads are growing by leaps and bounds, and in turn, reducing the space available for pedestrians, which is percolating into obesity and diabetes. Even those who are driving are seated for prolonged periods of time, due to traffic snarls, further raising health concerns for citizens.

The impacts of prolonged sitting also furthered to musculoskeletal disorders, like chronic neck and back pain and postural issues. Sleep disturbances and disruptions stemming from noise and traffic stress additionally result in lowered immunity and lethargy. Some HCPs also touched upon the auditory impairment, heat-related illnesses and dermatological effects on skin, all caused by traffic, in the present study.

While deliberating upon the impacts on mental health and overall well-being, it was highlighted precisely on how traffic effectuates the citizens' mental health by causing elevated stress and anxiety levels, cognitive impairment, mental fatigue, heightened irritability, mood disturbance, depression and emotional burnout.

Furthermore, it leads to deplorable living conditions, encompassing severe decline in quality of life, social isolation and even road rage. An overall steep decline of quality of life, largely involving health, social life and economy, was regarded due to traffic and the themes that primarily emerged from these discussions involved noteworthy, deterioration to physical health, mental health decline, reduced physical activity, sleep disturbance, weakened immune health, productivity loss causing economic burdens, social isolation and disengagement from the community, which all cumulatively eroded the quality of life and impacts were also prominent on environmental degradation and community health, negative spillovers of which can be felt through all other facets of life.

On the part of social and familial dynamics impacted by traffic, it was highlighted how traffic congestion alters familial structures and robs citizens of quality family time. Longer commute time leaves no room for the much-needed family time, which correspondingly weakens familial bonds and creates emotional distance.

Additionally, it also brings about increased stress at home, developmental impacts on children, limited social interactions, missed opportunities, financial losses, and an overall compromised quality of life.

Measures recommended by esteemed health professionals to tackle health impacts included suggestions to reduce air pollution by implementing remedies such as enforcement of routine vehicle fitness checks, use of electric vehicles, walking to short distances instead of using a private vehicle, and using public transport. Similarly, the insights suggested a reduction in noise pollution by declaring no-honking zones and sound barriers, as per feasibility. Encouraging active transport usage, such as cycling and walking, by investing in wider footpaths, can combat the issue of a sedentary lifestyle and reduce obesity. They also highlighted the importance of stress reduction by developing green spaces, calm zones and staggering work hours to reduce the burden on peak time congestions. For improvement on sleep quality, they additionally stressed upon noise regulations, especially in the night hours. Awareness campaigns for the promotion of health and prevention of pollution as community workshops, were recommended to bring cognizance about health.

Solutions that can be implemented to assuage traffic related challenges included an amalgamation of numerous factors including technological innovations, addressing infrastructure shortcomings and additional developments and upgrades to public transport, enhanced connectivity, engagement of community, collaboration of relevant stakeholders, smart mobility solutions, enforcement of laws, and more so behavioural changes amongst citizens.

These would necessitate encouraging the citizens to opt for alternative transportation, car-pooling and urban planning and enhanced land use management and ad-hoc solutions which aimed at context-specific improvements deployed on a need basis.

Leveraging technology to improve and enhance present traffic conditions is a prudent initiative. This will not just aid in streamlining the way the traffic is managed, but the deployment of these methods will transform traffic conditions. The only hold-back of immediate implementation of these technological initiatives would be the current 'under-development' phase of public transport, for instance, the ongoing metro projects that are underway, once this stage is surpassed into completion, implementation of technological advancement such as congestion based time-sensitive tolls, public education camps, integration of several transport systems to form effective inter-connected public transport networks, expansion of AI-ATC, will most certainly optimize traffic by targeting efficiently the root problem.

Suggestive alternatives to private vehicles, such as public transportation, cycling and walking infrastructures and their role in alleviating traffic is paramount. These additional alternatives offer citizens the chance to not only avoid traffic, but some of these alternatives even add to the citizens' health benefits. Conversely, mounting traffic is hampering the health of these citizens by promoting a sedentary lifestyle. The allotment of a proportion of the road, which is primarily dedicated to alternative mobility, for example, designated cycling lanes, walking pathways, can bring about a paradigm shift in the way citizens commute.

Augmenting the currently present options of public transport by enhancing comfort and reliability will encourage more citizens to opt for public conveyance alternatives. By addressing the concerns of safety, rectifying deficiencies with infrastructures and raising awareness of how alternative active modes of transport can be feasible alternatives for commuting and would also have positive health and environmental impacts, can drive quicker acceptance and adoption and promote utilization of these alternative mobility, over private cars.

6.2 Implications

The crucial role of the community's intervention to improve the overall traffic conditions necessitates their involvement. Furthermore, to bring about a substantial change in the traffic conditions, a comprehensive approach would reap fruitful results. These would be from addressing specific challenges faced by certain pockets of the city, such as double parking, infrastructure improvements and investments in alternative mobility, which can be extrapolated to other parts of the city and overall help in intercity traffic management.

6.3 Recommendations for Future Research

The current study only explored a single street in the bustling city of Mumbai; thus, the study has further scope to expand its research across many streets in Mumbai and further many more regions in many major metropolitan cities around the world.

A mix approach comprising of viewpoints from multiple stakeholders such as healthcare professionals from various super-specializations, residents and additionally

from the researchers own perspective and observation, enables to gauge the problem from multiple angles, for instance health and well-being, impacts on daily life of the citizens and also find tailormade solutions which can bring about significant changes to the situation. Also, this study's findings have explored drivers' behavioural aspects and their role in contributing to traffic, which can be further explored in greater detail.

6.4 Conclusion

While the findings of this research may have been specific to the specified street being studied, these findings can be extrapolated and generalized throughout most parts of the city of Mumbai, facing similar challenges. The study in addition to adding to a body of knowledge for research, it correspondingly identifies the contributing factors of the problem, how it affects the health of citizens and offers practical insights and means of improvements that can be made, which can enhance and optimize the overall operation and streamline the management of city's traffic. The associated health impacts too can consequently be avoided and its adverse effects can be significantly be reduced.

APPENDIX A
SURVEY COVER LETTER

Dear doctor,

Greetings!

Thank-you for your agreement in participating in my research study.

To provide a brief background and context of my work, this is a doctoral academic thesis with the Swiss school of business and management (SSBM) Genève, Switzerland, on the problem of traffic in the city of Mumbai, its impact on health and lastly the suggestive ways to manage the problem. For this research, I am primarily looking at a specific street in Mumbai, where traffic has been at its peak.

I am delighted to have you participate in my thesis and given your expertise in healthcare, I am sure your valuable inputs in the research will benefit tremendously to critically understand the various aspects.

The questions attached herewith, are based on the health impacts on the citizens of Mumbai city, that is observed by you both in general and in your day-to-day practice. My request for you is to please respond to these questions, please note there are no word limits so please feel free to elaborate and provide your valuable insights.

Once again, I thank you for your participation, valuable time and inputs.

We will discuss further over an interview (in-person or telephonically) to gain additional clarity, at time suitable to you.

Thank-you,

Kind regards,

Neha

(Source: Swiss school of business & management, Geneva, Switzerland)

APPENDIX B
INFORMED CONSENT [SET-A]

Dear,

Greetings!

Thank-you for your taking out time from your extremely busy schedules and for your agreement in participating in my research study.

To provide a brief background and context of my work, this is a doctoral academic thesis with the Swiss school of business and management (SSBM) Genève, Switzerland, on the problem of traffic in the city of Mumbai, its impact on health and lastly the suggestive ways to manage the problem. For this research, I am primarily looking at a specific street in Mumbai, where traffic has been at its peak.

I am delighted to have you participate in my thesis and I am sure that your valuable inputs will help benefit this research.

The questions below are based from the perspective of traffic observed in Mumbai city pertaining to the specific street this research takes into account, and its impact on your day to day life. My request for you is to please respond to these questions, please note there are no word limits so please feel free to elaborate.

All your data and contact information will be kept confidential, anonymous and pseudonymised and will only be used for the purpose of the above stated research.

Once again, I thank you for your participation, valuable time and insights. We will discuss further over an interview (in-person or telephonically) to gain additional clarity, at time suitable to you.

Kind regards,

Neha

(Source: Swiss school of business & management, Geneva, Switzerland)

APPENDIX C
INFORMED CONSENT [SET-B]

I,agree to be interviewed for the research which will be conducted by.....a doctorate student, at the Swiss school of business and management, Geneva, Switzerland.

I certify that I have been fully informed of the confidentiality of the information acquired for this research and the anonymity of my participation, that I have been given adequate opportunities to ask questions and to seek clarifications, and have also received reasonable answers to my queries pertaining to all research procedures and other related topics. I have also been counselled that my participation is optional and autonomous and I am free to withdraw my consent and to discontinue participation in the research or activity at any time without specifying any reason.

I agree to participate in interview or interviews for the purpose of the research and I permit the researcher to record these interviews as required. I fully understand that such interviews and related records will be kept completely confidential, anonymous and pseudonymised and that the results of this study might be published in any form without revealing any participant's identity.

Signature of Interviewee: Date:

(Source: Swiss school of business & management, Geneva, Switzerland)

APPENDIX D
INTERVIEW GUIDE-RESEARCH QUESTIONNAIRE [SET-A]

Interview Questionnaire

Thank-you for your participation in this research. This research is being carried out to understand the causes of traffic, its impacts on the lives, health and well-being of its citizens and additionally to understand any measures that can be implemented to alleviate these impacts.

General instructions to fill out the questions

- *Please fill out all questions that are relevant to your domain.*
- *Should a question not apply to you, request you to please write not applicable (NA) to that said question.*
- *There are no word limits to any questions.*

RQ2. How does traffic congestion on the specified street in Mumbai impact the health and well-being of residents and commuters? The sub questions (a, b, c, and d) for RQ2 are given as follows:

- a) How does traffic impact physical health of the citizens, in the specific street?
- b) How does traffic impact the mental health and well-being, in the specific street?
- c) What impacts are seen on the quality of life (QOL) of the citizens, in the specific street?
- d) Impact on familial and social life of citizens, in the specific street.

RQ3. What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai? The sub questions (a, b, c, and d) for RQ3 are given as follows:

- What measures can be taken to combat the problems pertaining to health and well-being, in the specific street? (*from healthcare perspective*)

APPENDIX E

INTERVIEW GUIDE-RESEARCH QUESTIONNAIRE [SET-B]

Interview Questionnaire

Thank-you for your participation in this research. This research is being carried out to understand the causes of traffic, its impacts on the lives, health and well-being of its citizens and additionally to understand any measures that can be implemented to alleviate these impacts.

General instructions to fill out the questions

- *Please fill out all questions that are relevant to your domain.*
- *Should a question not apply to you, request you to please write not applicable (NA) to that said question.*
- *There are no word limits to any questions.*

RQ1. What underlying factors contribute to traffic congestion on the specified street in Mumbai? The sub questions (a, b, c, and d) for RQ1 are given as follows:

- 1 What are the major contributory factors of traffic in the specific street?
- 2 How do seasonal variations, such as monsoons, influence traffic congestion in the specified street?

RQ3. What are the potential solutions and interventions to alleviate traffic congestion and mitigate its adverse effects on the specified street in Mumbai? The sub questions (a, b, c, and d) for RQ3 are given as follows:

- 1 What measures can be taken to combat the problems pertaining to health and well-being, in the specific street? (*from layman perspective*)
- 2 What solutions can be implemented to mitigate the challenges and reduce the traffic, in the specific street?
- 3 How can the use of technology, such as smart traffic management systems, improve traffic flow and reduce congestion, in the specific street?
- 4 What role can public transportation and alternative mobility options, such as cycling and walking infrastructure, play in alleviating traffic, on the specified street?

REFERENCES

- Abdoli, N., Farnia, V., Delavar, A., Esmaeili, A., Dortaj, F., Farrokhi, N., Karami, M., Shakeri, J., Holsboer-Trachsler, E., Brand, S., 2015. Poor mental health status and aggression are associated with poor driving behavior among male traffic offenders. *Neuropsychiatr Dis Treat* 2071–2078.
- Aftabuzzaman, M., Currie, G., Sarvi, M., 2011. Exploring the underlying dimensions of elements affecting traffic congestion relief impact of transit. *Cities* 28, 36–44.
- Agarwal, I., Singh, A., Agarwal, A., Mishra, S., Satapathy, S.K., Prusty, M.K., Mohanty, S.N., 2024. Enhancing Road Safety and Cybersecurity in Traffic Management Systems: Leveraging the Potential of Reinforcement Learning. *IEEE Access*.9963-9975
- Ahmad, P., Ram, N., Shekhar Bellamkonda, R., Kumar, A., 2025. Consumer Satisfaction and Reuse Intention of Food Delivery Apps: Integration of Service Quality Model and Expectation Confirmation Theory. *Journal of Quality Assurance in Hospitality & Tourism* 1–29.
- Alhusinan, A., 2024. The relationship between traffic congestion and quality of life. *Journal of Police and Legal Sciences* 15, 4.
- Ali, R., Aslam, J., Moeed, K., Gupta, N., 2008. Vehicular emissions-their impact on environment and human health.(no pagation)
- Amarnath, M., Baloch, M., Gupta, M., Chaudhari, S., Landge, I., 2024. Traffic Flow Optimization for Metropolitan Cities. *Traffic* 4.214-219
- Anand, N., 2006. Disconnecting experience: Making world-class roads in Mumbai. *Econ Polit Wkly* 3422–3429.
- Anciaes, P.R., Metcalfe, P.J., Heywood, C., 2017. Social impacts of road traffic: Perceptions and priorities of local residents. *Impact assessment and project appraisal* 35, 172–183.
- Araral, E., 2020. Why do cities adopt smart technologies? Contingency theory and evidence from the United States. *Cities* 106, 102873.

- Babisch, W., Ising, H., Gallacher, J.E.J., Sweetnam, P.M., Elwood, P.C., 1999. Traffic noise and cardiovascular risk: the Caerphilly and Speedwell studies, third phase-10-year follow up. *Archives of Environmental Health: An International Journal* 54, 210–216.
- Badami, M.G., Haider, M., 2007. An analysis of public bus transit performance in Indian cities. *Transp Res Part A Policy Pract* 41, 961–981.
- Bansal, N., Patel, S., Panchal, S., 2010. Traffic congestion and fuel wastage due to idling vehicles at crossroads. *National Journal of Community Medicine* 1, 41–43.
- Benz, S.L., Kuhlmann, J., Schreckenber, D., Wothge, J., 2021. Contributors to neighbour noise annoyance. *Int J Environ Res Public Health* 18, 8098.
- Berg, C.D., Schiller, J.H., Boffetta, P., Cai, J., Connolly, C., Kerpel-Fronius, A., Kitts, A.B., Lam, D.C.L., Mohan, A., Myers, R., 2023. Air pollution and lung cancer: a review by international association for the study of lung cancer early detection and screening committee. *Journal of Thoracic Oncology* 18, 1277–1289.
- Bhide, A., 2021. Reformation & Transformation of Mobility in India's Economic Capital.
- Bloom, 2020. Ranked: The World's 20 Most Stressed-Out Cities (The Worst In The US Will Surprise You). *Forbes*. URL <https://www.forbes.com/sites/laurabegleybloom/2020/01/30/ranked-worlds-20-most-stressed-out-cities/> (accessed 5.25.25).
- Boelen, P.A., Eisma, M.C., de Keijser, J., Lenferink, L.I.M., 2024. Treatment gap in mental health care for victims of road traffic accidents. *Clin Psychol Psychother* 31, e2970.
- Borgalli, R., 2020. Smart pothole detection and mapping system. *Journal of Ubiquitous Computing and Communication Technologies* 2, 136–144.
- Cao, Z., Zhou, J., Li, M., Huang, J., Dou, D., 2023. Urbanites' mental health undermined by air pollution. *Nat Sustain* 6, 470–478.
- Castleberry, A., Nolen, A., 2018. Thematic analysis of qualitative research data: Is it as easy as it sounds? *Curr Pharm Teach Learn* 10, 807–815. <https://doi.org/https://doi.org/10.1016/j.cptl.2018.03.019>
- Cheng, Y., Watkins, S.J., Anciaes, P., 2024. What interventions are effective in reducing congestion? in: *Advances in Transport Policy and Planning*. Elsevier, pp. 201–229.

- Chor, C.H., Habibur, R.M., 2011. An impact evaluation of traffic congestion on ecology. cit. on 20.
- Clark, B., Chatterjee, K., Martin, A., Davis, A., 2020. How commuting affects subjective wellbeing. *Transportation (Amst)* 47, 2777–2805.
- Collingridge, D.S., Gantt, E.E., 2008. The quality of qualitative research. *American journal of medical quality* 23, 389–395.
- Costa, L.G., Cole, T.B., Coburn, J., Chang, Y.-C., Dao, K., Roqué, P.J., 2017. Neurotoxicity of traffic-related air pollution. *Neurotoxicology* 59, 133–139.
- Curry, K., 2016. An exploration of the effects of roads and traffic on mental health in Auckland, New Zealand. 11-113
- Dabholkar, A.S., Khatib, S., Dabholkar, T., 2015. Psychological problems faced by Navi Mumbai bus conductors. *Int J Community Med Public Health* 2, 184.
- Dahman, L., Gauthier, V., Camier, A., Bigna, J.J., Glowacki, F., Amouyel, P., Dauchet, L., Hamroun, A., 2024. Air pollution and kidney cancer risk: A systematic review and meta-analysis. *J Nephrol* 37, 1779–1790.
- Daniels, L., Minot, N., 2025. An introduction to statistics and data analysis using Stata®: From research design to final report. Sage Publications.
- Das, R.D., Purves, R.S., 2019. Exploring the potential of Twitter to understand traffic events and their locations in Greater Mumbai, India. *IEEE Transactions on Intelligent Transportation Systems* 21, 5213–5222.
- De Nazelle, A., Nieuwenhuijsen, M.J., Antó, J.M., Brauer, M., Briggs, D., Braun-Fahrlander, C., Cavill, N., Cooper, A.R., Desqueyroux, H., Fruin, S., 2011. Improving health through policies that promote active travel: a review of evidence to support integrated health impact assessment. *Environ Int* 37, 766–777.
- Dimri, S.C., Indu, R., Bajaj, M., Rathore, R.S., Blazek, V., Dutta, A.K., Alsubai, S., 2024. Modelling of traffic at a road crossing and optimization of waiting time of the vehicles. *Alexandria Engineering Journal* 98, 114–129.
- Dostál, J., 2015. Theory of problem solving. *Procedia-Social and Behavioral Sciences* 174, 2798–2805.

- Dubey, P.P., Borkar, P., 2015. Review on techniques for traffic jam detection and congestion avoidance, in: 2015 2nd International Conference on Electronics and Communication Systems (ICECS). pp. 434–440. <https://doi.org/10.1109/ECS.2015.7124941>
- Edwards Jr, D.B., 2019. Shifting the perspective on community-based management of education: From systems theory to social capital and community empowerment. *Int J Educ Dev* 64, 17–26.
- Emo, A.K., Matthews, G., Funke, G.J., 2016. The slow and the furious: Anger, stress and risky passing in simulated traffic congestion. *Transp Res Part F Traffic Psychol Behav* 42, 1–14.
- Engström, E., Forsberg, B., 2019. Health impacts of active commuters' exposure to traffic-related air pollution in Stockholm, Sweden. *J Transp Health* 14, 100601. <https://doi.org/https://doi.org/10.1016/j.jth.2019.100601>
- Foraster, M., Eze, I.C., Vienneau, D., Schaffner, E., Jeong, A., Héritier, H., Rudzik, F., Thiesse, L., Pieren, R., Brink, M., 2018. Long-term exposure to transportation noise and its association with adiposity markers and development of obesity. *Environ Int* 121, 879–889.
- Ghazali, M., Tahar, A. Ben, 2024. A Queuing Theory Approach to Task Scheduling in Cloud Computing with Generalized Processor Sharing Queue Model and Heavy Traffic Approximation. *IAENG Int J Comput Sci* 51.
- Gill, 2018. Auto-rickshaws cause traffic mess, commuters see red. *The Tribune*. URL <https://www.tribuneindia.com/news/archive/amritsar/auto-rickshaws-cause-traffic-mess-commuters-see-red-647332/> (accessed 5.27.25).
- Gowda, G., Thenambigai, R., 2020. A study on respiratory morbidities and pulmonary functions among traffic policemen in Bengaluru city. *Indian Journal of Community Medicine* 45, 23–26.
- Gupta, K., 2007. Urban flood resilience planning and management and lessons for the future: a case study of Mumbai, India. *Urban Water J* 4, 183–194.
- Haider, M., Kerr, K., Badami, M., 2013. Does commuting cause stress? The public health implications of traffic congestion. *The Public Health Implications of Traffic Congestion* (August 2, 2013).

- Hale, J.L., Householder, B.J., Greene, K.L., 2002. The theory of reasoned action. The persuasion handbook: Developments in theory and practice 14, 259–286.
- Hamra, G.B., Guha, N., Cohen, A., Laden, F., Raaschou-Nielsen, O., Samet, J.M., Vineis, P., Forastiere, F., Saldiva, P., Yorifuji, T., 2014. Outdoor particulate matter exposure and lung cancer: a systematic review and meta-analysis. *Environ Health Perspect.* 2014 Sep;122(9):906-11. doi: 10.1289/ehp/1408092.
- Hang, P., Lv, C., Xing, Y., Huang, C., Hu, Z., 2020. Human-like decision making for autonomous driving: A noncooperative game theoretic approach. *IEEE Transactions on Intelligent Transportation Systems* 22, 2076–2087.
- Harriet, T., Poku, K., Emmanuel, A.K., 2013. An assessment of traffic congestion and its effect on productivity in urban Ghana. *International Journal of Business and Social Science* 4,225-234
- Hatoyama, K., Nishioka, M., Kitajima, M., Nakahira, K., Sano, K., 2019. Perception of time in traffic congestion and drivers' stress, in: *International Conference on Transportation and Development 2019*. American Society of Civil Engineers Reston, VA, pp. 165–174.
- Hays, T., Olds, P., Spence, J., 2016. Happiness and Traffic: An Analysis of Long Term Effects.1-13
- Hegewald, J., Schubert, M., Freiberg, A., Romero Starke, K., Augustin, F., Riedel-Heller, S.G., Zeeb, H., Seidler, A., 2020. Traffic noise and mental health: a systematic review and meta-analysis. *Int J Environ Res Public Health* 17, 6175.
- Hennessy, D., 2011. Social, personality, and affective constructs in driving, in: *Handbook of Traffic Psychology*. Elsevier, pp. 149–163.
- Hu, S., Lin, H., Xie, K., Dai, J., Qui, J., 2018. Impacts of rain and waterlogging on traffic speed and volume on urban roads, in: *2018 21st International Conference on Intelligent Transportation Systems (ITSC)*. IEEE, pp. 2943–2948.
- Jadallah, C.C., 2025. Positionality, relationality, place, and land: Considerations for ethical research with communities. *Qualitative Research* 25, 227–242.

- Jadhav, M.C., Ansari, N., 2024. Automating Traffic Law Enforcement: Leveraging AI for Real-Time Number Plate Recognition and Owner Identification. *International Research Journal on Advanced Engineering Hub (IRJAEH)* 2, 836–844.
- Jain, S.P.K.S., 2021. Application of operations research for traffic management in mumbai. *International Research Journal of Modernization in Engineering Technology and Science* 03, 198–208.
- Jalihal, S.A., Ravinder, K., Reddy, T.S., 2005. Traffic characteristics of India, in: *Proceedings of the Eastern Asia Society for Transportation Studies*. pp. 1009–1024.
- Jensen, H.A.R., Rasmussen, B., Ekholm, O., 2018. Neighbour and traffic noise annoyance: a nationwide study of associated mental health and perceived stress. *Eur J Public Health* 28, 1050–1055.
- Kale, U., Sawant, P., 2017. Correlation between traffic congestion on seasonal variation of vehicles and RSPM levels at the traffic junctions of Mumbai. *TTEM* 25.264-267
- Kale, U.S., Sawant, P.H., 2015. Evaluation Of Exposure Analysis On People Exposed To Traffic Congestions.
- Kanolkar, 2024. Mumbai: BMC Cracks Down On Illegal Food Stalls In City & Suburbs Amid Rising Health Concerns. *The Free Press Journal*.URL.
<https://www.freepressjournal.in/mumbai/mumbai-bmc-cracks-down-on-illegal-food-stalls-in-city-suburbs-amid-rising-health-concerns> (accessed 6.25.25).
- Karim, H.K., Sharif, B.M., 2023. Road Rage and Anger-Provoking Situations in Sulaimani City-Iraq. *Sulaimania Journal for Engineering Sciences* 10.78-87
- Kheder, M.Q., Mohammed, A.A., 2024. Real-time traffic monitoring system using IoT-aided robotics and deep learning techniques. *Kuwait Journal of Science* 51, 100153.
- Khreis, H., 2020. Traffic, air pollution, and health, in: *Advances in Transportation and Health*. Elsevier, pp. 59–104.
- Kim, D., Jin, J., 2023. Commuting time and happiness: Empirical evidence from Korean Youth Panel data. *J Transp Health* 33, 101690.

- Kimata, H., 2004. Exposure to road traffic enhances allergic skin wheal responses and increases plasma neuropeptides and neurotrophins in patients with atopic eczema/dermatitis syndrome. *Int J Hyg Environ Health* 207, 45–49.
- Koshy, 2019. Fifteen of the 20 most polluted cities in the world are in India. *The Hindu* .URL <https://www.thehindu.com/sci-tech/energy-and-environment/fifteen-of-the-20-most-polluted-cities-in-the-world-are-in-india/article26440603.ece> (accessed 5.21.25).
- Koźlak, A., Wach, D., 2018. Causes of traffic congestion in urban areas. Case of Poland, in: *SHS Web of Conferences*. EDP Sciences, p. 01019.
- Kreis, C., Héritier, H., Scheinemann, K., Hengartner, H., de Hoogh, K., Rössli, M., Spycher, B.D., 2022. Childhood cancer and traffic-related air pollution in Switzerland: a nationwide census-based cohort study. *Environ Int* 166, 107380.
- Kumar, N., Kumar, S., Pandey, S.P., 2023. Traffic-Related Air Pollution and Associated Human Health Risk, in: *Macromolecular Symposia*. Wiley Online Library, p. 2100486.
- Kuttler, T., 2024. Urban mobilities in Mumbai: Towards worker-centric platformisation beyond ‘urban solutionism.’ *Urban Studies* 00420980241264645.
- Kutzbach, M., 2010. Megacities and megatraffic. *ACCESS Magazine* 1, 31–35.
- Leijssen, J.B., Snijder, M.B., Timmermans, E.J., Generaal, E., Stronks, K., Kunst, A.E., 2019. The association between road traffic noise and depressed mood among different ethnic and socioeconomic groups. The HELIUS study. *Int J Hyg Environ Health* 222, 221–229.
- Lesteven, G., 2016. Behavioral Responses to Traffic Congestion—Findings from Paris, São Paulo and Mumbai. *Traffic Management* 3, 121–138.
- Levy, J.I., Buonocore, J.J., Von Stackelberg, K., 2010. Evaluation of the public health impacts of traffic congestion: A health risk assessment. *Environ Health* 9. <https://doi.org/10.1186/1476-069X-9-65>
- Li, G., Lai, W., Sui, X., Li, X., Qu, X., Zhang, T., Li, Y., 2020. Influence of traffic congestion on driver behavior in post-congestion driving. *Accid Anal Prev* 141, 105508.
- Liu, J., Ettema, D., Helbich, M., 2022. Systematic review of the association between commuting, subjective wellbeing and mental health. *Travel Behav Soc* 28, 59–74. <https://doi.org/https://doi.org/10.1016/j.tbs.2022.02.006>

- Liya, M.C., Rajan, S.K., Kenath, A., 2024. Psychological experiences and travel Adversities: A Mixed-Method study of the regular commuters in traffic congestion. *Transp Res Part F Traffic Psychol Behav* 101, 130–141.
- Mahajan, R., Mahajan, D., 2022. To Study the Factors Causing Traffic Problems in India with Specific Reference to Pune City: A Conceptual Framework. *Civ. Eng. Arch* 10, 1071–1080.
- Maheshwari, A., Ranka, M., Rao, C.D., 2024. Impact of Vehicle Loans, Consumer Behavior and Income Level on the Passenger Segment of the Automobile Industry since year 2011. *Motherhood International Journal of Research & Innovation* 1, 8–17.
- Maitra, B., Sikdar, P.K., Dhingra, S.L., 2004. Modeling of congestion: a tool for urban traffic management in developing countries. *European Transport*.27.45-56.
- Majid, M.A.A., Othman, M., Mohamad, S.F., Lim, S.A.H., Yusof, A., 2017. Piloting for interviews in qualitative research: Operationalization and lessons learnt. *International Journal of Academic Research in Business and Social Sciences* 7, 1073–1080.
- Mala, A., 2023. The Biggest Traffic Jams In History WorldAtlas [WWW Document].
- Marve, S.R., Bhorkar, M., Baitule, P., 2016. A survey on environmental impacts due to traffic congestion in peak hours. *IJSTE* 2.
- Mascarenhas, B., Suri, A., 2018. A study on intersection typology and road safety: Case of Mumbai, in: *Intergovernmental Eleventh Regional Environmentally Sustainable Transport (Est) Forum in Asia*. (no pagination).
- May, A.D., 1994. Traffic management from theory to practice: past, present, future. *Transp Res Rec* 1457, 5.
- Mohammed, A.A., Ambak, K., Mosa, A.M., Syamsunur, D., 2019. A review of traffic accidents and related practices worldwide. *The Open Transportation Journal* 13.65-83
- Moreno, F., 2023. Traffic Congestion and Management in Zamboanga City, Philippines: The Public Transport Commuters’ Point of View. *Philippines: The Public Transport Commuters’ Point of View* (July 14, 2023),1-30
- Morris, E.A., Hirsch, J.A., 2016. Does rush hour see a rush of emotions? Driver mood in conditions likely to exhibit congestion. *Travel Behav Soc* 5, 5–13.

- Münzel, T., Schmidt, F.P., Steven, S., Herzog, J., Daiber, A., Sørensen, M., 2018. Environmental noise and the cardiovascular system. *J Am Coll Cardiol* 71, 688–697.
- Mushtaq, R., Hashmi, O., 2022. Traffic congestion and prevalence of mental and physical health issues in Karachi. *Pak J Psychol* 53, 15.
- Nadrian, H., Taghdisi, M.H., Pouyesh, K., Khazae-Pool, M., Babazadeh, T., 2019. “I am sick and tired of this congestion”: Perceptions of Sanandaj inhabitants on the family mental health impacts of urban traffic jam. *J Transp Health* 14, 100587.
- Næss, P., 2020. Validating explanatory qualitative research: Enhancing the interpretation of interviews in urban planning and transportation research. *Applied Mobilities*, 186-205
- Nallathiga, R., 2006. Envisioning a comprehensive transport strategy for Mumbai. *Indian Journal of Transport Management* 30, 153–177.
- National Cancer Institute, n.d. Traffic-Related Outdoor Air Pollution [WWW Document]. National Cancer Institute (NIH) Division of Cancer Epidemiology & Genetics. URL <https://dceg.cancer.gov/research/what-we-study/traffic-related-outdoor-air-pollution> (accessed 5.25.25).
- Natu and Sen, 2024. Auto, taxi queues outside Andheri East station to decongest traffic-choked area. *The Times of India*. URL <https://timesofindia.indiatimes.com/city/mumbai/auto-taxi-queues-outside-andheri-east-station-to-decongest-traffic-choked-area/articleshow/108248526.cms> (accessed 4.23.25).
- Novaco, R.W., Gonzalez, O.I., 2009. Commuting and well-being. *Technology and well-being* 3, 174.
- Observer Research Foundation, 2023. Addressing Mumbai’s traffic woes. ORF. URL <https://www.orfonline.org/expert-speak/addressing-mumbais-traffic-woes> (accessed 4.23.25).
- Ouis, D., 2001. Annoyance from road traffic noise: a review. *J Environ Psychol* 21, 101–120.
- Parida, P., Gangopadhyay, S., 2008. Estimation of fuel loss during idling of vehicles at signalized intersections in Delhi, in: *Journal of Indian Roads Congress*. pp. 61–70.
- Patil, G.R., Sharma, G., 2022. Urban Quality of Life: An assessment and ranking for Indian cities. *Transp Policy (Oxf)* 124, 183–191.

- Pawar, G.B., 2022. An analysis of new normal consumer behaviour for buying cars in Indian automotive industries in Mumbai. *Journal of Positive School Psychology* 6, 6258–6270.
- Pham Xuan, R., 2025. Mapping trends and demographics in research on intersectional education and pedagogy: a scoping review (2020–2024). *Intercultural Education* 1–19.
- Quartieri, J., Mastorakis, N.E., Guarnaccia, C., Troisi, A., D'Ambrosio, S., Iannone, G., 2010. Traffic noise impact in road intersections. *International Journal of Energy and Environment* 1, 1–8.
- Rahma, A., Wantini, W., 2024. Human Behavior in Social Context. *Jurnal Impresi Indonesia* 3, 411–417.
- Rahman, M.M., Najaf, P., Fields, M.G., Thill, J.-C., 2022. Traffic congestion and its urban scale factors: Empirical evidence from American urban areas. *Int J Sustain Transp* 16, 406–421.
- Raoniar, R., Perumal, V., 2025. Factors affecting driver speeding behavior in Mumbai school zones. *Transp Res Part F Traffic Psychol Behav* 109, 652–671.
<https://doi.org/https://doi.org/10.1016/j.trf.2024.12.029>
- Sarker, S.C., Pareek, G., 2024. Eroding Social Capital and Increasing Divorce in Dhaka City. *Social Science Review* 41, 161–178.
- Seidler, A., Schubert, M., Romero-Starke, K., Freiberg, A., Zeeb, H., Riedel-Heller, S., Hegewald, J., 2019. Traffic noise and mental illness—a systematic review. *Environmental Epidemiology* 3, 360.
- Seik, F.T., 2000. An advanced demand management instrument in urban transport: electronic road pricing in Singapore. *Cities* 17, 33–45.
- Sen, N.C.J., 2023. Mumbai traffic chaos: Highest private car density of 650 per km leads to gridlock. *The Times of India*. URL <https://timesofindia.indiatimes.com/highest-private-car-density-of-650-per-km-leads-to-city-gridlock/articleshow/104980948.cms> (accessed 5.25.25)
- Shaban, A., Sattar, S., 2023. Mobility and transport infrastructure in Mumbai Metropolitan Region: growth, exclusion and modal choices. *Urban Plan Transp Res* 11.
<https://doi.org/10.1080/21650020.2023.2212745>

- Sharma, A., Madan, V., Bhargav, V., Gulati, N., 2024. Smart City Traffic Control System: A Literature Review, in: 2024 14th International Conference on Cloud Computing, Data Science & Engineering (Confluence). IEEE, pp. 36–40.
- Shivatare, C., Dalvi, S., Patil, P., Shete, R., 2017. Pune Traffic Problems & Control Measures. in chief Dr. GR Kulkarni: <http://www.ejournal.aessangli.in/ASEEJournals/CIVIL86.pdf>.
- Shkera, A., Vaishali, P., 2024. Cycling, walking, and public transport versus private cars: an empirical investigation of travel mode choices for shopping trips in Mumbai metropolitan region. *Transactions on transport sciences* 15, 4–16.
- Silveira, C., Ferreira, J., Miranda, A.I., 2024. Health impact pathways related to air quality changes: testing two health risk methodologies over a local traffic case study. *Air Qual Atmos Health* 17, 1077–1089.
- Singh, 2015. Traffic jams due to auto-rickshaw menace common sight. *Hindustan Times*.
- Singh, E., Singh, D.P., 2021. Decongesting Urban Roads: An Investigation into Causes and Challenges, in: *Lecture Notes in Civil Engineering*. https://doi.org/10.1007/978-981-16-1303-6_8
- Singh, R., Khan, S., 2023. Impact of traffic congestion on health (Physical and psychological)- A study of Udaipur city, Rajasthan. 78-85.
- Singh, V., Unadkat, V., Kanani, P., 2019. Intelligent traffic management system. *International Journal of Recent Technology and Engineering (IJRTE)* 8, 7592–7597.
- Siva Raju, S., Ahire, K., 2018. Climate change and air pollution in Mumbai. *Climate Change and Air Pollution: The Impact on Human Health in Developed and Developing Countries* 289–308.
- Solomon, H., 2021. Death traps: Holes in urban India. *Environ Plan D* 39, 423–440.
- Soni, A.R., Chandel, M.K., 2020. Impact of rainfall on travel time and fuel usage for Greater Mumbai city. *Transportation Research Procedia* 48, 2096–2107.
- Sony, M., Naik, S., 2020. Industry 4.0 integration with socio-technical systems theory: a systematic review and proposed theoretical model. *Technol Soc* 61, 101248.
- Srinivas, T., 2014. Transportation and its health implications in India. *Int. J. Eng. Res. Dev* 10, 67–73.

- Srivastava, A., Maity, R., 2023. Assessing the potential of AI–ML in urban climate change adaptation and sustainable development. *Sustainability* 15, 16461.
- Stokols, D., Novaco, R.W., 1981. Transportation and well-being: An ecological perspective, in: *Transportation and Behavior*. Springer, pp. 85–130.
- Subair, S.O., Ibitoye, B.A., Kuranga, A.T., 2024. Effect of Traffic Delay, Physical and Mental Health on Commuters: A Review. *Adeleke University Journal of Engineering and Technology* 7, 9–13.
- Sun, W., Bao, P., Zhao, X., Tang, J., Wang, L., 2021. Road traffic and urban form factors correlated with the incidence of lung cancer in high-density areas: an ecological study in downtown Shanghai, China. *Journal of Urban Health* 98, 328–343.
- Tchounwou, P.B., Han, O., 2013. International Journal of Environmental Research and Public Health Best Paper Award 2013. *Int J Environ Res Public Health*. 443-445
- Thacher, J.D., Snigireva, A., Dauter, U.M., Oudin, A., Mattisson, K., Sørensen, M., Borgquist, S., Albin, M., Broberg, K., 2024. Road traffic noise and breast cancer: DNA methylation in four core circadian genes.168
- Thangavel, P., Park, D., Lee, Y.-C., 2022. Recent insights into particulate matter (PM_{2.5})-mediated toxicity in humans: an overview. *Int J Environ Res Public Health* 19, 7511.
- Troup, J.D.G., 1978. Driver's back pain and its prevention: A review of the postural, vibratory and muscular factors, together with the problem of transmitted road-shock. *Appl Ergon* 9, 207–214.
- van Westen, C., Naz, I., Atun, F., Hassinger, L., van den Bout, B., Flacke, J., Manzella, I., Marr, P., Agmon, G., Ottow, B., 2023. The web-based simulation and information service for multi-hazard impact chains. Design document.1-143
- Veber, T., Pyko, A., Carlsen, H.K., Holm, M., Gislason, T., Janson, C., Johannessen, A., Sommar, J.N., Modig, L., Lindberg, E., 2023. Traffic noise in the bedroom in association with markers of obesity: a cross-sectional study and mediation analysis of the respiratory health in Northern Europe cohort. *BMC Public Health* 23, 1246.

- Vijayalakshmi, S., Raj, K., 2020. Economic estimation of health and productivity impacts of traffic congestion: A case of bengaluru city. Institute for Social and Economic Change.1-26
- Waard, 1996. The measurement of drivers' mental workload. University of Groningen.53-96
- Wang, 2010. The relationship between traffic congestion and road accidents: an econometric approach using GIS.1-238.
- Weber, J., Kwan, M.-P., 2002. Bringing time back in: A study on the influence of travel time variations and facility opening hours on individual accessibility. The professional geographer 54, 226–240.
- Wee Hin, L.T., Subramaniam, R., 2001. Smart-card traffic system keeps Singapore in the fast lane. Nature 411, 737.
- Wimpenny, P., Gass, J., 2000. Interviewing in phenomenology and grounded theory: is there a difference? J Adv Nurs 31, 1485–1492.
- Yamazaki, S., Sokejima, S., Nitta, H., Nakayama, T., Fukuhara, S., 2005. Living close to automobile traffic and quality of life in Japan: a population-based survey. Int J Environ Health Res 15, 1–9.
- Zhang, K., Batterman, S., 2013. Air pollution and health risks due to vehicle traffic. Science of the total Environment 450, 307–316.