ASSESSING THE IMPACT OF YELLOW LINE MASS RAPID TRANSIT (MRT) SYSTEM ON PUBLIC HEALTH AND QUALITY OF LIFE: A SUSTAINABLE URBAN MOBILITY PERSPECTIVE

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Executive Summary

Bengaluru's rapid urbanisation, growth of the IT sector, and large-scale migration have significantly intensified travel demand and private vehicle dependency, resulting in severe traffic congestion, increased commute times, elevated stress levels, and heightened exposure to air pollution and heat. The Namma Metro Yellow Line a 18.82 km corridor with 16 stations linking RV Road to Bommasandra was introduced to address the extreme traffic externalities by offering a high-capacity, sustainable, environment friendly, and time-reliable alternative compared to private vehicles.

This study presents a comprehensive baseline and post-implementation assessment of the Yellow Line MRT's impact on public health and quality of life, drawing on survey data from approximately 600 respondents comprising both regular commuters and households situated along the corridor. A follow-up phone survey of 150 respondents was conducted six months after metro operations commenced to capture perceived changes in travel behaviour and wellbeing. The study is structured around five objectives: changes in physical activity and health outcomes; exposure to heat stress, air pollution, and accident risk; mental wellbeing and accessibility; social inclusivity and work-life balance; and overall quality of life.

The key findings from the study indicates that more than 58% of baseline respondents reported no physical activity, with the highest inactivity observed among young adults aged 18–29 years. The post-implementation survey provides evidence of a meaningful modal shift from private vehicles predominantly two-wheelers and cabs to metro use. The adoption of the Yellow Line MRT has introduced incidental walking through station access and egress, contributing an estimated 10 –15 minutes of additional moderate physical activity per commute day. Regression analysis confirms that physical activity is a statistically significant predictor of wellbeing (WHO-5 score coefficient: 6.377), and that longer commute times negatively affect wellbeing, underscoring the value of time savings delivered by metro transit.

Environmental Exposure: Walking and two-wheeler users face extreme heat stress (PET above 40°C) during peak summer months of March–May, while metro commuters experience air-conditioned conditions comparable to private cars. PM2.5 inhalation dose analysis demonstrates that metro users have the lowest pollution exposure among all modes, with two-wheeler commuters and pedestrians facing the highest cumulative doses often exceeding both WHO and CPCB annual guidelines, especially during October to March.

Mental Wellbeing and Accessibility: Structural equation modelling confirms that mental wellbeing is strongly predicted by travel satisfaction ($\beta = 0.78$) and accessibility ($\beta = 0.75$), while commute stress exerts a significant negative effect ($\beta = -0.69$). Post-implementation respondents reported reduced travel time, greater predictability, lower fatigue, and improved daily comfort, all of which contributed positively to their mental health. However, inadequate last-mile connectivity, poor pedestrian infrastructure, and safety concerns at several stations continue to limit accessibility particularly for women, the elderly, and persons with disabilities.

Social Inclusivity and Productivity: The metro has created shared transit spaces that encourage social interaction and community formation. CFA results indicate that social wellbeing positively influences productivity ($\beta = 0.508$), and that reduction in commute burden including fewer late arrivals and lower travel fatigue directly improves workplace performance and work-life balance. Commuters report having more time for family, leisure, and personal activities since switching to the metro.

Barriers to Modal Shift: Despite 83% of surveyed respondents expressing willingness to shift to the Yellow Line, uptake is constrained by high fare costs (Bengaluru's fares for 10–20 km journeys are four to five times those of comparable cities such as Kolkata), inadequate last-mile connectivity, insufficient parking at stations, poor pedestrian infrastructure around several stations, and limited awareness of feeder bus services. These barriers disproportionately affect lower-income commuters and those living more than 2 km from a metro station.

Policy Recommendations

To maximise the public health and quality-of-life benefits of the Yellow Line MRT, the study recommends: (1) improving last-mile connectivity through better-integrated feeder bus services and enhanced public awareness campaigns; (2) upgrading pedestrian infrastructure around stations, particularly at Bommanahalli, Hosa Road, Signasandra, Huskur Road, and Bommasandra; (3) revisiting fare structures to improve affordability for lower-income commuters; (4) expanding parking facilities at key interchange stations; and (5) establishing a longitudinal data collection programme, including a minimum of one year of post-implementation accident data, to enable a comprehensive safety impact assessment.

Overall, the Yellow Line MRT has meaningfully improved commuting conditions and contributed to better physical, mental, and social wellbeing among its users. Realising the full public health potential of this infrastructure requires targeted investments in supporting systems and policies that make metro travel accessible, affordable, and safe for all segments of Bengaluru's population.

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1. Introduction

Rapid urbanisation, increase in population and rising private vehicle ownership have significantly changed the travel behavior of people in metropolitan cities, placing immense pressure on transport infrastructure and adversely affecting environmental quality, public health, and commuter well-being (Chatterjee et al., 2020; Conceição et al., 2023; Sogbe et al., 2025). Bengaluru, one of India's fastest-growing cities, is a prominent example of these challenges (Udachan & Patil, 2025). Over the past two decades, rapid urban expansion and increasing motorization have contributed to chronic traffic congestion, longer travel times, deteriorating air quality, and increasing physical and psychological stress among commuters. For many commuters, travelling to work now takes longer and feels more stressful (Udachan & Patil, 2025; Vijayalakshmi & Krishna Raj, 2023; Mantripragada & Prasad, 2025). If this trend continues, it will further affect the quality of life and economic productivity.

With a registered vehicle fleet exceeding 12 million units, Bengaluru has emerged as one of the world's most congested cities, where peak-hour traffic speeds on major corridors such as Hosur Road often fall below 15 km/h and average commute times frequently exceed 60 minutes for trips under 20 km (Udachan & Patil, 2025; Vijayalakshmi & Krishna Raj, 2023; TomTom Traffic Index, 2026). This rapid growth has intensified congestion, exposure to air pollution, thermal discomfort, road safety risks, and commuter stress (Conceição et al., 2023; Mantripragada & Prasad, 2025). In response to these challenges, Mass Rapid Transit (MRT) systems such as Namma Metro have emerged as sustainable mobility solutions capable of improving accessibility, reducing dependence on private vehicles, and promoting healthier and more efficient urban living (Abhijna et al., 2025).

Epidemiological research has established direct relationship between the urban mobility externalities and non-communicable disease (NCD)(Katzmarzyk et al., 2022; Nieuwenhuijsen, 2020; Sukumar et al., 2024). Sustained exposure to fine particulate matter ($PM_{2.5}$) is associated with increased cardiovascular and respiratory morbidity (R. Chen et al., 2017; Tainio et al., 2021; World Health Organization, 2020). Chronic commute stress is linked to elevated cortisol levels, sleep disturbances, and reduced immune function (Kivimäki & Steptoe, 2018; Mantripragada & Prasad, 2025). Physical inactivity endemic among private motorised vehicle users is a primary risk factor for obesity, type 2 diabetes, hypertension, and depression (Katzmarzyk et al., 2022; World Health Organization, 2020). In aggregate, these effects impose substantial and often underestimated burdens on population health and urban productivity. In this context, the Namma Metro Yellow Line has a significant potential to shift people from private motorised vehicles, and reduce commuter exposure to traffic-related air pollution, physical inactivity, and chronic commute stress.

The Namma Metro Yellow Line, extending from RV Road to Bommasandra, became operational in 2025 and spans approximately 18.82 km with 16 stations. It is one of the most important metro corridors in Bengaluru, connecting major residential areas, industrial zones, employment centers, and IT hubs such as Electronic City and Bommasandra with the other parts of the city. The corridor is expected to significantly reduce travel time and ease congestion along heavily crowded routes such as Hosur Main Road and Silk Board Junction.

Beyond improving mobility, the Yellow Line has the potential to influence several other aspects of everyday urban life and well-being. By offering faster, safer, and more reliable public transport, the corridor has the potential to reduce commuter stress, improve accessibility, encourage physical activity through walking and station access, and lower exposure to traffic-related air pollution and heat stress (Conceição et al., 2023; Peng et al., 2024). Improved connectivity may also positively affect productivity, social interaction, and work–life balance for daily commuters (Chatterjee et al., 2020; Prasad et al., 2024). Thus, the Yellow Line provides an important opportunity to understand how metro systems can contribute not only to efficient transportation but also to healthier and more sustainable urban living. Despite growing investments in metro infrastructure across Indian cities, relatively few studies have examined their broader impacts on public health and quality of life using both objective and subjective measures. In this context, this study presents a longitudinal mixed-methods pre and post-assessment of the Yellow Line's impact on commuter health and well-being, helping address an important gap in evidence-based urban transport research in rapidly growing Indian cities.

2. Project Overview

This report presents the findings of a comprehensive study examining the impact of the Namma Metro Yellow Line MRT system on public health, travel behaviour, accessibility, social well-being, productivity, and overall quality of life among commuters and households located along the corridor. The study was conducted to understand how large-scale Mass Rapid Transit (MRT) infrastructure can influence mobility patterns and everyday urban life in rapidly growing metropolitan cities.

The project set out to address one central question: "*To what extent can the Yellow Line corridor improve commuter well-being, accessibility, and quality of life while promoting more sustainable and efficient urban mobility in Bengaluru?"*

To answer this, the study combined baseline and post-implementation surveys, exposure assessment techniques, behavioural analysis, and statistical modelling to evaluate both the benefits and challenges associated with metro adoption. The research examined multiple dimensions including physical activity and health outcomes, exposure to heat stress and air pollution, mental well-being, accessibility, social inclusivity, work–life balance, and productivity. The findings are intended to support evidence-based policymaking, sustainable urban transport planning, and future metro-oriented development strategies in Bengaluru and other rapidly urbanising Indian cities.

3. Scope and Objectives

The study is structured around five objectives, followed by a final synthesis integrating the findings from each.

Problem Statement: To address the lack of understanding of how Mass Rapid Transit (MRT) systems (here, the Yellow line - RV Road to Bommasandra) impact public health, mental well-being, and quality of life, aiming to evaluate these outcomes to position sustainable mobility as a key public health measure.

Aim of the Project: To evaluate the short-term impacts of the Yellow Line Mass Rapid Transit (MRT) system on public health and overall quality of life in Bengaluru by assessing changes in physical activity, mental well-being, social inclusion, and urban productivity, thereby promoting sustainable and healthier urban communities.

Objectives:

1. ***Changes in Physical Activity Levels and Health Outcomes:*** To evaluate changes in physical activity levels resulting from the shift to the Yellow Line MRT and assess their contribution to health outcomes.
2. ***Exposure to Heat, Pollution, and Accident Risks:*** To assess the impact of the Yellow Line MRT on reducing commuters' exposure to heat stress, air pollution (NOx, PM2.5), and the risk of road accidents, contributing to safer and healthier urban mobility.
3. ***Mental Wellbeing and Accessibility:*** To investigate potential improvements in mental

wellbeing through enhanced travel satisfaction, with a focus on accessibility as a primary factor expected to influence ease of movement, job opportunities, reduce stress, and enhance travel experiences post-implementation.

4. ***Social Inclusivity, Work-Life Balance:*** To analyze the role of the Yellow Line MRT in fostering social inclusivity, community interaction, and to measure improvements in urban productivity through time savings, reduced travel congestion and fatigue, and enhanced work-life balance.

5. ***Overall Quality of Life:*** To integrate objective and subjective assessments to evaluate the role of the Yellow Line MRT in improving health outcomes and enhancing the overall quality of life

4. The Need for This Study

Rapid urbanisation, population growth, and increasing dependence on private vehicles have placed enormous pressure on Bengaluru's urban transport system, resulting in severe traffic congestion, longer commute times, rising air pollution, road safety concerns, and increasing levels of physical and mental stress among commuters. These transport-related challenges not only affect mobility and accessibility but also have wider implications for public health, productivity, environmental sustainability, and overall quality of life.

The operation of Namma Metro Yellow Line presents a major opportunity to shift commuters from private vehicles to a more sustainable and efficient mode of transport. While metro systems are generally recognized for reducing congestion and improving connectivity, limited studies in the Indian context have comprehensively examined their broader impacts on public health, mental well-being, social inclusivity, accessibility, productivity, and quality of life.

Therefore, there is a strong need to scientifically evaluate how the Yellow Line influences travel behavior and everyday urban living using both objective and subjective measures. The findings from this study are expected to support evidence-based policymaking, improve metro-oriented planning strategies, and help develop healthier, more sustainable, and people-centered urban transport systems in Bengaluru. The ouput from this study can also be applied to other rapidly urbanising Indian cities.

5. The Yellow Line MRT Corridor: Description of Study Area

The Namma Metro Yellow Line is an 18.82-km corridor with 16 stations (Figure 1) connecting RV Road to Bommasandra. The Yellow line plays a critical role in connecting South Bengaluru to the East West and central Bengaluru. The Yellow line would connect the major industrial area (Bommasandra) and the major IT hub Electronic city and would provide easy mobility to the people working there. The line is also believed to shift people from private vehicles to public transport, thereby reducing the traffic on the Hosur Main Road and Silk Board Junction. This line is also expected to reduce travel times and congestion, improve air quality, increase accessibility and thereby improving the physical and mental wellbeing and quality of life.

The significance of the yellow line corridor lies in its alignment with one of India's most highly congested urban arterials roads and junction. Hosur Main Road and NH44 serves as the primary surface connectivity for over 300,000 daily vehicle trips, with peak hour speed falling below 8 km/h at Silk Board Junction, that has been consistently ranked among the top ten most congested intersections globally in annual urban mobility studies (TomTom Traffic Index, 2026).

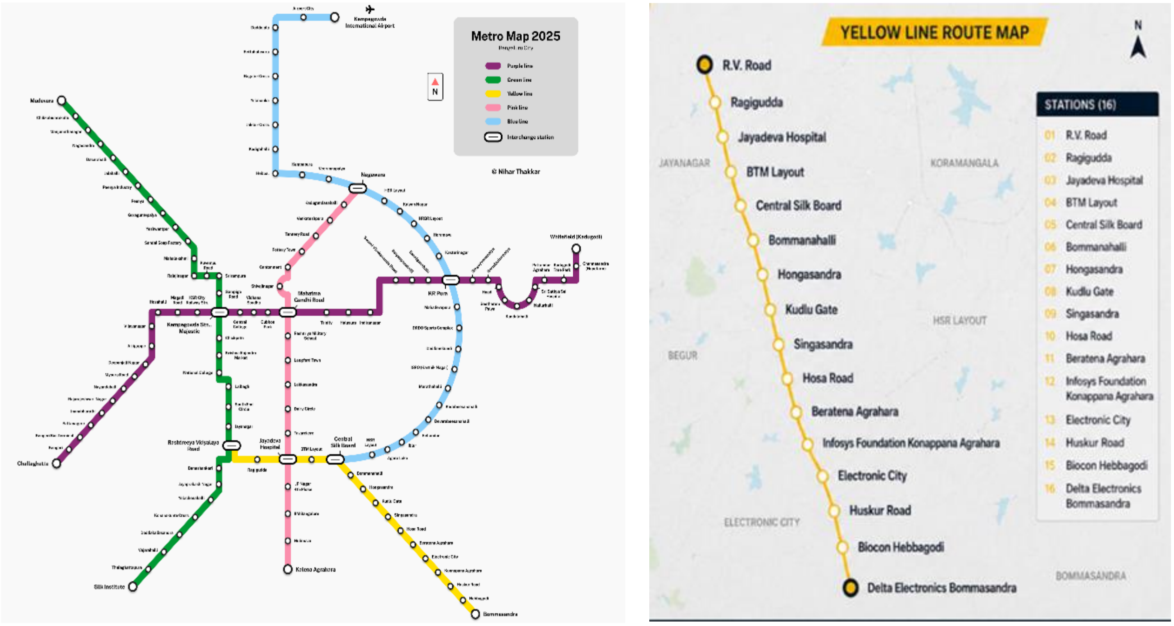


Figure 1: The Metro rail network of Bengaluru and the Yellow Line Metro and its stations

6. Analysis and Results

6.1 Design of Questionnaire:

A paper-pencil based survey questionnaire was designed to collect the responses from the household as well as the commuters along the Yellow Line metro. The questionnaire had nine sections to collect perceptions on socioeconomic, trip characteristics, physical activity (using IPAQ-short form guidelines), overall wellbeing (WHO-5 Wellbeing Index scores), social wellbeing, and quality of life. After designing the questionnaire, a pilot survey was conducted among a small group of commuters along the yellow line to check the adequacy and acceptability of the questionnaire. Based on the observations from the pilot survey, the questionnaire was refined and finalized for the main survey. A copy of the questionnaire is given at the end of the report.

6.2 Data Collection and Database Development for the Baseline Survey

Surveykshan, was employed for collecting the baseline data for the present study. The questionnaire was digitised into mobile and tablet compatible (Figure 2), and the data collection was carried out by a number of trained enumerators employed by Surveykshan (Figure 3).

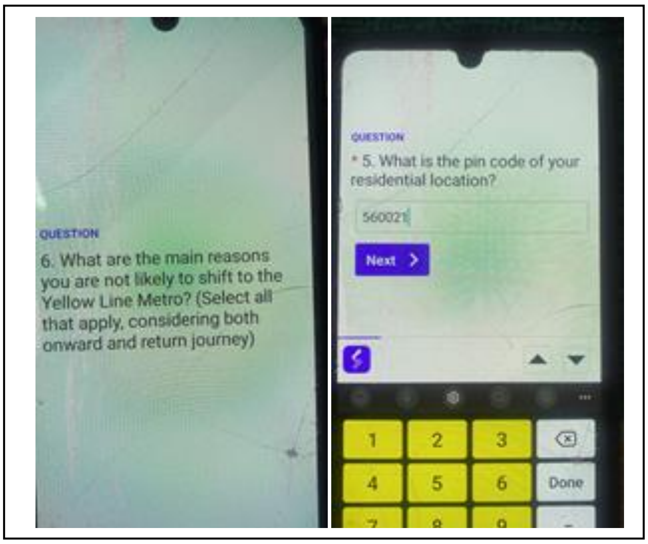


Figure 2: Digitisation of the questionnaire

The enumerators were trained over multiple online sessions for the purpose of data collection. The data collection was carried out using a stratified random sampling technique.

Figure 3: Enumerators employed by Surveykshan are collecting data on the field

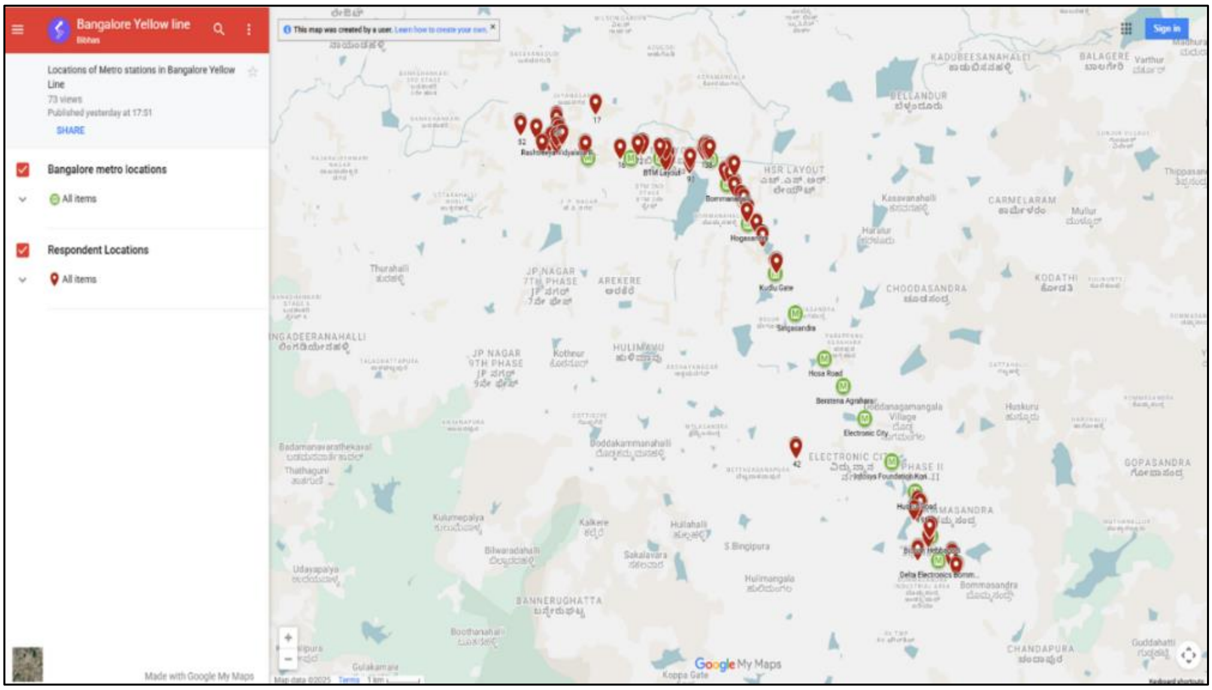


Figure 4: Location of commuters and household surveys done by the team

During the survey, sufficient time was spent to explain clearly each of the statements using Kannada and English, photographs, and the context-specific meaning. Although the participation in the survey was completely voluntary, a large number of respondents finally participated in the survey and recorded their responses for all the sections considered in the present work. Altogether, around 700 commuters + household people were approached, and

650 people responded positively and gave their inputs. The collected data were coded digitally and processed further after removing the incomplete responses, and finally, 600 responses were retained for analysis. The acceptability of the databases was judged in terms of the required minimum sample size and was found to be satisfactory (Bartlett II et al.,2001). In order to encourage response from females, the team of enumerators included female members.

Out of the 600 cleaned data obtained from the survey, 54% were commuters and other 45% respondents were from households along the Yellow line metro. It was very interesting to note that 83% of the people were willing to shift to the Yellow line metro once it becomes operational. However, the remaining 17% of the respondents were doubtful about shifting to the Yellow line for their travel. On further enquiring regarding the reason for not shifting to the metro, high metro fare is one of the main causes, followed by accessibility issues and lack of parking facilities. Figure 5 highlights the various reasons respondents are not shifting to the metro.

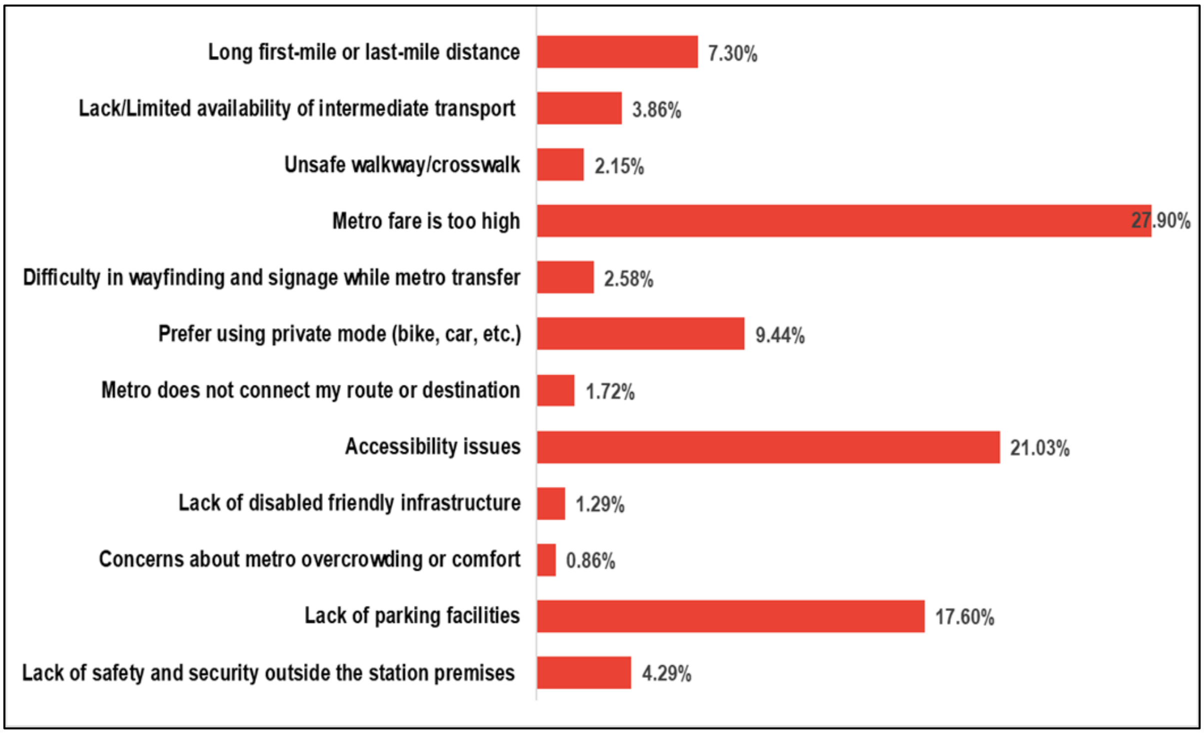


Figure 5: Reasons for not shifting to the Yellow line

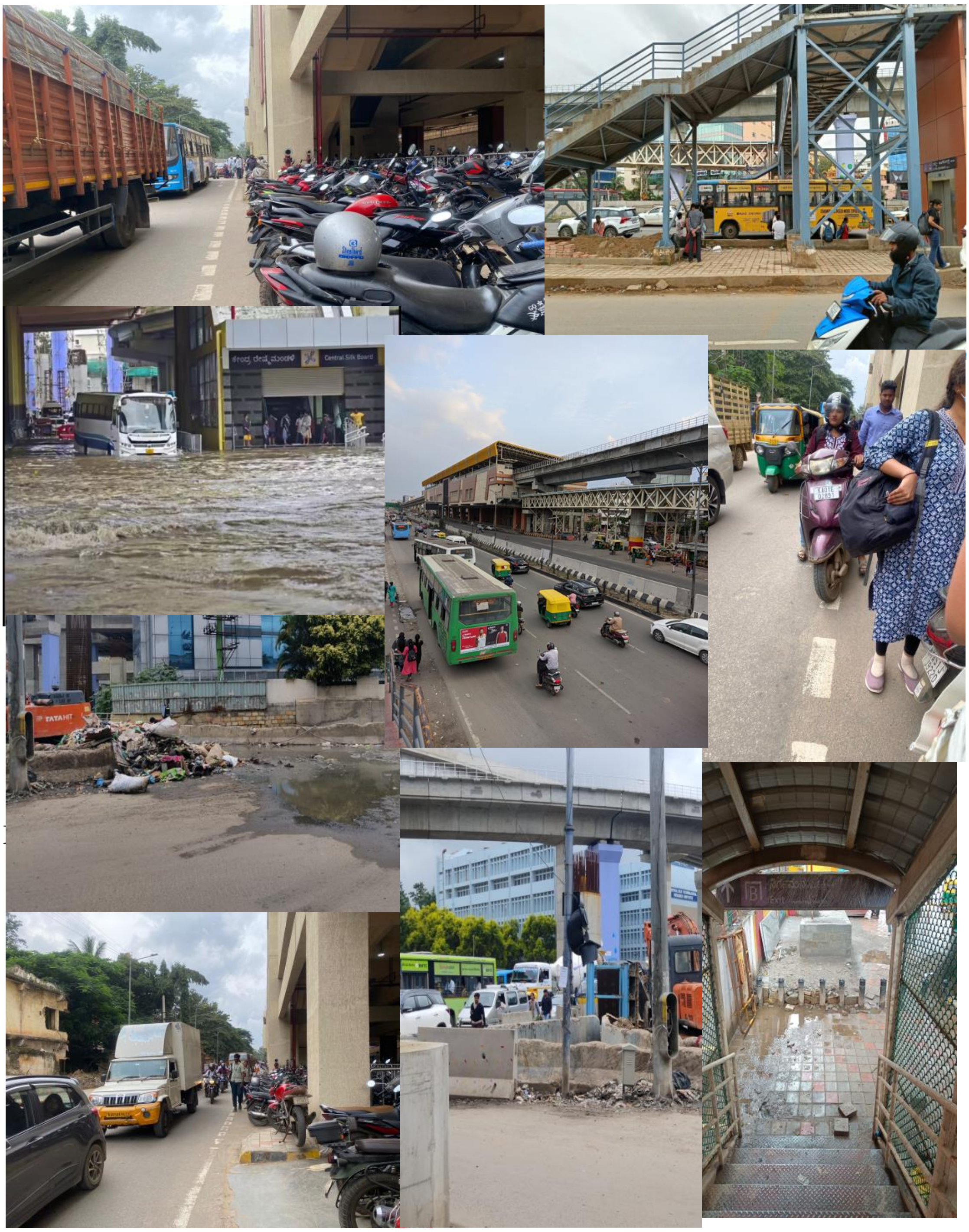


Figure 6: Some issues at the Yellow line Metro stations

Based on the respondent's response, the Metro fare being too high has been quoted as the primary reason for users not willing to shift to the Metro. A comparative analysis reveals that for distances of 10 to 20 km, Bengaluru Metro fares (₹60–₹70) are 4 to 5 times higher than Kolkata Metro (₹15) for equivalent distances. This cost differential represents a significant barrier to modal shift, particularly for lower-income commuters (monthly family income below ₹30,000) who constitute 27% of the study sample.

Table 1: Comparison of fare chart

Distance	Lowest fare for 0-2 km	Highest fare
Metro fare Delhi (DMRC)	₹11/	More than 32 km ₹64
Metro fare Kolkata	₹ 5/	More than 20 km- ₹25
Metro fare Mumbai	₹ 10	Line 1/2A/7: ₹40 (>21 km) Line 3 (Aqua): ₹80 (>33.5 km)
Metro fare Pune	₹10	More than 16 km- ₹35
Metro fare Bengaluru	**₹10**	**More than 32 km ₹90**

Similarly, the second most popular reason is an accessibility issue. From Figure 6, it is clear that most stations have barriers such as garbage, broken concrete blocks, and waterlogged areas, making it difficult for people to access the metro station. Qualitative observation at station vicinities observed during the survey documented barriers like lack of parking facilities (17.6% of respondents cited this as a concern), lack of safety and security outside station premises (4.29%), inadequate last-mile connectivity, poor pedestrian infrastructure, including waterlogged footpaths and lack of covered walkways. Several stations like the Bommanahalli, Hosa Road, Signasandra, Huskur Road, and Bommasandra lack proper accessibility, along with safety and security issues. The foot overbridge is not easily accessible in some locations and proper disability wheelchair ramp is not available forcing pedestrians to take long detours, walk along roads having no proper pedestrian infrastructure, navigate steep staircases, and face poor weather protection. This is particularly a matter of concern for the elderly, young children, pregnant women, and persons with disabilities. The absence of safe and convenient crossing infrastructure forces many commuters to cross the road in high traffic, significantly increasing the likelihood of accidents. Inadequate lighting, especially at the points where footbridges terminate onto service roads and side streets, poses a serious safety risk for women commuters travelling after 9 PM, making certain stretches effectively inaccessible to them after dark. Therefore, for more people to start using the metro, it becomes very important to address these gaps in infrastructure planning, inaccessible design, unsafe road crossings, and insufficient lighting, along with inefficient last-mile connectivity, to ensure the Yellow Line serves all segments of society.

Out of the total survey, 83% of people who were willing to shift to the yellow line, further study of the project would be carried out based on their perception to understand the present quality of life, and further compare the change in quality of life after they start using the Yellow Line regularly. It was seen out of the 83% people surveyed, 71% males compared to 29% females. For the mode of travel, 30% of respondents were found to use two wheelers, followed by cab, 25%, and private car contributed to 21% of mode share. Public transport contributed to 13% of the mode.

Following the completion of the baseline study, the same group of respondents were contacted to assess behavioural shifts and perceived changes in quality-of-life post shifting to the Yellow Line metro. An interval of six months was maintained between the baseline data collection and the post-implementation survey. This gap was considered necessary and sufficient to allow respondents to meaningfully integrate the Yellow Line into their daily mobility routines, develop habituated travel patterns, and form substantive perceptions regarding changes in commute experience, physical accessibility, time savings, stress levels, and broader quality of life dimensions. The six-month acclimatisation period aligns with findings in the literature suggesting that a minimum period of regular use is required before stable experiential assessments (De Oña and De Oña, 2015).

Respondents who had confirmed their shift to the Yellow Line metro were first prioritised for the follow-up round. The re-contact was initially attempted for a face-to-face survey; however, due to the respondents' reluctance to participate in face-to-face interactions attributed to time constraints, the post-implementation survey was done entirely over the phone for a structured 10–12-minute interview. It was interesting to note that some respondents who were not willing to shift to the metro during the baseline survey have responded positively and have shifted to the metro and are using it regularly for their travel.

A total of 150 respondents agreed to be a part of the post-metro implementation survey. Each respondent was contacted over the phone and surveyed for 10-12 minutes to get their responses. A detailed, objective-wise analysis of the impact of the metro on the quality of life is presented below

6.3 Objective 1: Changes in Physical Activity Levels and Health Outcomes

To evaluate changes in physical activity levels resulting from the shift to the Yellow Line MRT and assess their contribution to health outcomes.

To address this objective, a baseline survey was done to commuters residing and working along the Yellow Line corridor, capturing self-reported physical activity and health data along with the detailed travel behaviour and mode use information. The baseline survey revealed a deeply concerning pattern of physical inactivity among Bengaluru's 18years and above urban population. When enquired further about their daily physical activity and self-reported health issues, more than 58% of survey respondents reported no physical activity (0 MET-min/week) in the baseline survey data. This is particularly concerning as the International Physical Activity Questionnaire (IPAQ) establishes 600 MET-min/week as the minimum threshold for adults to maintain health benefits (Ipaq Research Committee, 2005). 63% of respondents aged over 65 reported some physical activity, only 29% of the 18–29 age group had some physical activity, indicating the highest physical inactivity among young adults. These people with no physical activity were found to mostly use only a single mode of transport.

Cross-tabulation of physical activity levels against self-reported health conditions, clearly reveals that respondents with no physical activity (inactive lifestyle) show substantially higher rates of hypertension (15%), diabetes (18%), and breathing problems (4.6%). Among those with rigorous exercise habits, hypertension prevalence drops to 0.6% and diabetes to 0.6%, underscoring the protective role of regular physical activity. These findings provide strong evidence that higher levels of physical activity along the corridor are associated with a lower burden of non-communicable diseases (NCDs). This has also been supported by previous studies, which showed that regular physical activity helps reduce the risk of chronic diseases and improves overall health. (Biswas et al., 2015; Katzmarzyk et al., 2022).

It becomes essential to assess whether additional factors influenced the WHO-5 well-being score. Accordingly, a linear regression model was developed to examine the association between WHO-5 well-being scores and age group, physical activity, and health condition. The following equation is is obtained from the linear regression analysis.

$$\textbf{WHO-5} = \textbf{65.643} + \boldsymbol{\beta_1}\textbf{(Age}_\textbf{i}\textbf{)} + \textbf{6.377(Physical Activity)} - \textbf{10.878(Health condition)} + \textbf{1.463(Public transport)} + \textbf{8.711(two wheeler)} + \textbf{7.204(Car)} - \textbf{0.129(travel time)}$$

People of age 54-65 years and 65 years above show negative associations with wellbeing. This may be because people >54 years of age show various age-related challenges such as declining physical health, reduced mobility, and increased social isolation or increased dependence, which adversely affect the mental well-being this have also been discussed in some literatures (Hajek & König, 2016; Morrish et al., 2025; Noguchi et al., 2021). Overall, well-being appears to improve from early to late middle age, with a modest decline observed among elderly adults.

The regression analysis revealed a statistically significant positive association between physical activity levels and WHO-5 well-being scores, indicating that respondents reporting higher MET-min/week values demonstrated correspondingly higher subjective well-being. The positive regression coefficient confirms that lower levels of physical activity are associated with diminished psychological well-being among the study population, underscoring the critical role that regular physical activity plays in sustaining mental health outcomes. These findings are consistent with the broader previous epidemiological studies in literature that established physical activity as a determinant of well-being (Buecker et al., 2021; Mahindru et al., 2023).

Respondents reporting health conditions had substantially lower WHO-5 scores, underscoring the strong negative impact of poor health on well-being. Longer travel time with a negative coefficient also signifies a negative impact on well-being. It highlights the importance of reducing commute duration for better well-being outcomes (Mantripragada & Prasad, 2025) , these findings demonstrate that chronic ill-health and prolonged commuting are independent and compounding determinants of poor well-being and shifting to Yellow line Metro would reduce travel time thereby improving commuter well-being (Abhijna et al., 2025; Chatterjee et al., 2020).

Post Metro Implementation Survey

Prior studies have established a consistent relation between public transport use and physical activity. Studies have established that use of public transport leads to an additional 8–33 minutes of daily physical activity, primarily through access and egress walking and within-station movement. As a result, regular transit users are more likely to achieve the World Health Organisation (WHO) guideline of ≥150 minutes per week of moderate physical activity (Lachapelle & Frank, 2009; Rissel et al., 2012).

The baseline study reported 38% of respondents relied on two-wheelers and 46% share on private cars and cabs, highlighting a predominance of low-activity, door-to-door travel modes. The post-implementation survey provides empirical evidence of a meaningful modal shift, with most respondents transitioning from private motorised modes particularly two-wheelers and cabs to metro use. This shift represents a change in travel behaviour with direct implications for physical activity. Based on previous estimates in literature, an additional 10–15 minutes of walking per commute day corresponds to approximately 50–75 minutes of moderate physical activity per week. This is particularly beneficial in the present study context, where over 58% of respondents reported no physical activity. Overall, the findings suggest that adoption of the Yellow Line MRT has led to a measurable and modest, increase in physical activity among former private vehicle users, with potential for further gains as last-mile connectivity improves.

6.4 Objective 2: Exposure to Heat, Pollution, and Accident Risks

To assess the impact of the Yellow Line MRT on reducing commuters' exposure to heat stress, air pollution (NOx, PM2.5), and the risk of road accidents, contributing to safer and healthier urban mobility.

Heat stress:

The Physiological Equivalent Temperature (PET) method, computed using Rayman software (Hoppe, 1999; Matzarakis, 2012), was considered for the calculation of heat stress. PET is a human-centric index that integrates air temperature, humidity, wind speed, and radiation load, capturing urban microclimate variations and directly linking thermal comfort to mobility behaviour. Originally developed for European countries, PET has been adapted in several studies to suit the Indian context. Accordingly, for the present study, Indian-specific PET thresholds were applied (Banerjee & Chattopadhyay, 2020; Kotharkar et al., 2024; S & Rajasekar, 2022). The neutral comfort zone for Indian populations extends to 23–30°C, and the extreme heat threshold shifts from 41°C (European standard) to 46°C. For the present study, the monthly average data of air temperature, relative humidity, and wind speed from January to December 2025 were considered. Height (1.75 m), weight (75), age (35), gender (Female), metabolic rate (80 W/m2) is assumed constant, which is inbuilt in the software. The assumed clothing insulation in the present study is 0.5 (ASHRAE, 2020; ISO, 2005).

Monthly meteorological data for the study corridor were extracted from the ERA5-Land reanalysis data at 0.1° spatial resolution (Hersbach et al., 2020; Open-Meteo, 2026). Air temperature, relative humidity, wind speed, and solar radiation were extracted at the Silk Board location (12.9177°N, 77.6238°E) for the year 2025. To evaluate thermal stress experienced by commuters across different travel modes, PET was calculated separately for four scenarios: walking, two-wheeler, bus, and air-conditioned car. Each mode was characterised by distinct metabolic rate, effective wind exposure, and solar radiation shielding, following established conventions from the Compendium of Physical Activities and outdoor thermal comfort literature (Ainsworth et al., 2011; Höppe, 1999). PET was calculated across exposure durations of 15, 30, 45, and 60 minutes to reflect the range of typical urban commute lengths along the Yellow Line corridor.

Results confirm that walking and two-wheeler commuters face extreme heat stress during March and April. Non-AC bus commuters face moderate heat stress during peak summer months. AC car commuters experience no thermal stress year-round. These findings underscore a critical thermal inequity at baseline, wherein climate-controlled transport remains a privilege of private vehicle users. This gap further compounded by the absence of any regulatory provision for outdoor commuter thermal protection under India's National Building Code 2016 or existing urban Heat Action Plans. Thus, commuters travelling in Metro with AC, do not experience any heat stress and benefit from conditions comparable to a car.

Post Metro Implementation Survey

The post-implementation survey sought to capture users' perception of heat exposure and thermal discomfort; the responses were largely inconclusive. A majority of respondents characterised Bengaluru's climate as pleasant or temperate, and did not associate their daily commute with any significant experience of heat stress. This perception gap is not uncommon in tropical cities where populations have developed a high degree of thermal adaptation over generations, effectively normalising chronic low-to-moderate heat exposure (Banerjee et al., 2020; Gajjar et al., 2024). As a result, respondents neither reported discomfort attributable to their previous modes nor articulated any perceptible improvement in thermal comfort since switching to the metro.

Air Quality and Pollution Exposure

Bengaluru's AQI trends from the year 2020–2026, as obtained from AQI.in (Figure 7), reveal a consistent seasonal pattern. The AQI exceeds 50 from October to April, with the highest readings obtained in January to March, whereas AQI falls below 40 during May to September.

Hourly $PM_{2.5}$ and PM_{10} data for the years 2024 and 2025 were obtained from Karnataka Pollution Control Board(KSPCB) monitoring stations at Silk Board, located along the Yellow Line. The month-wise comparison of $PM_{2.5}$ and PM_{10} for the years 2024 and 2025 is given in Figure 8. AN denotes the Annual PM limits set by the Central Pollution Control Board to protect health. Considering the approximately 14 km distance between Silk Board and Bommasandra, data from the Silk Board station were used as a proxy for the study corridor. This approach is supported by existing literature suggesting that pollution levels at a busy urban monitoring site can reasonably represent conditions along adjacent road corridors within a range of up to 20 km (Rafiepourgatabi et al., 2021).

Figure 7: AQI trend for Bengaluru 2020-2026

The permissible limit for each parameter is calculated as per the WHO and CPCB limits. The World Health Organisation (WHO) recommends strict limits for PM2.5 and PM10: for PM2.5, it's 5 µg/m³ (annual mean) and 15 µg/m³ (24-hour mean); for PM10, it's 15 µg/m³ (annual mean) and 45 µg/m³ (24-hour mean). As per India's National Ambient Air Quality Standards (NAAQS) set limits for PM2.5 at 40 µg/m³ (annual) and PM10 at 60 µg/m³ (annual) and 100 µg/m³ (24-hour mean).

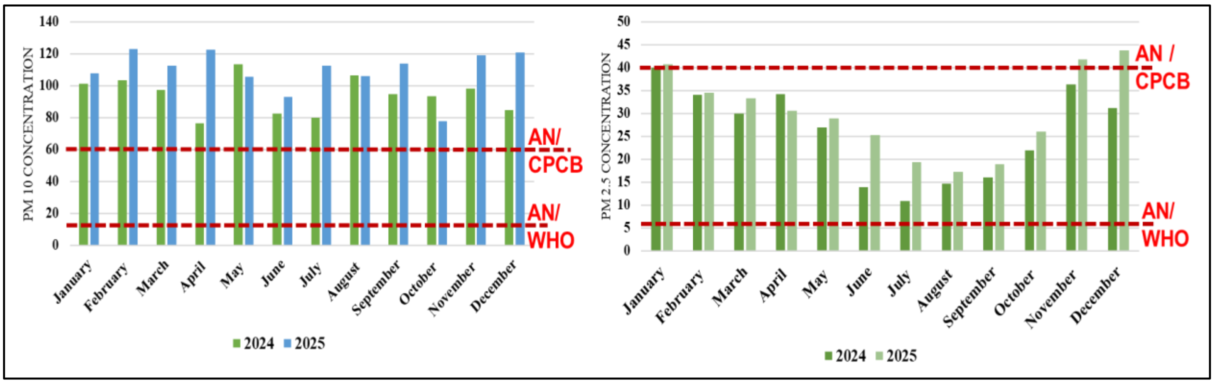
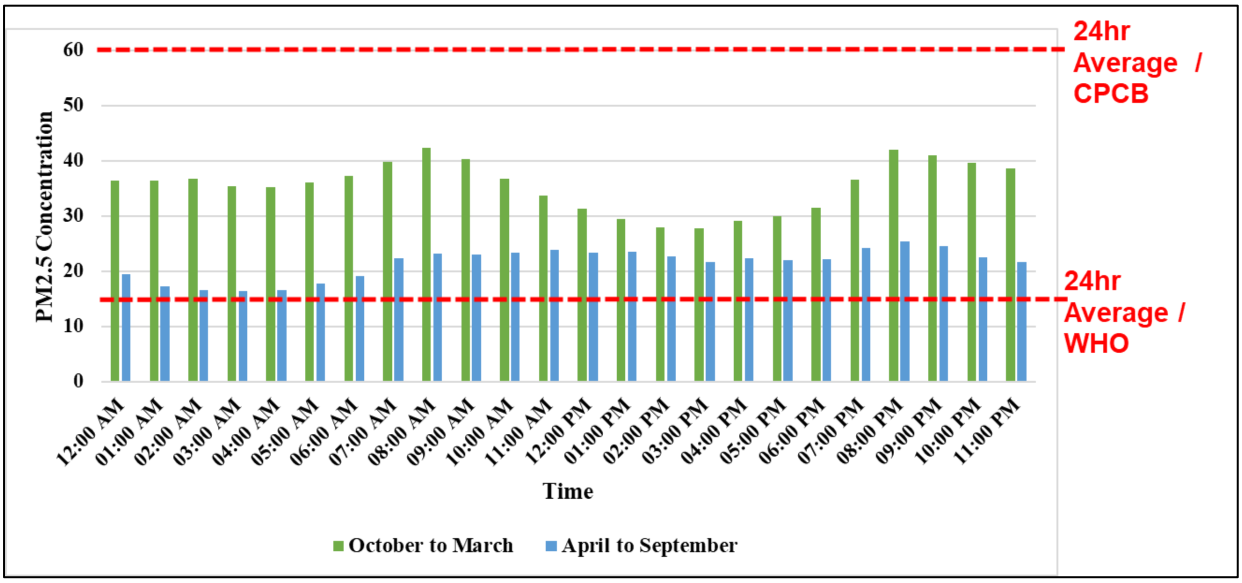


Figure 8: Month-wise comparison of PM2.5 and PM 10 for 2024 and 2025



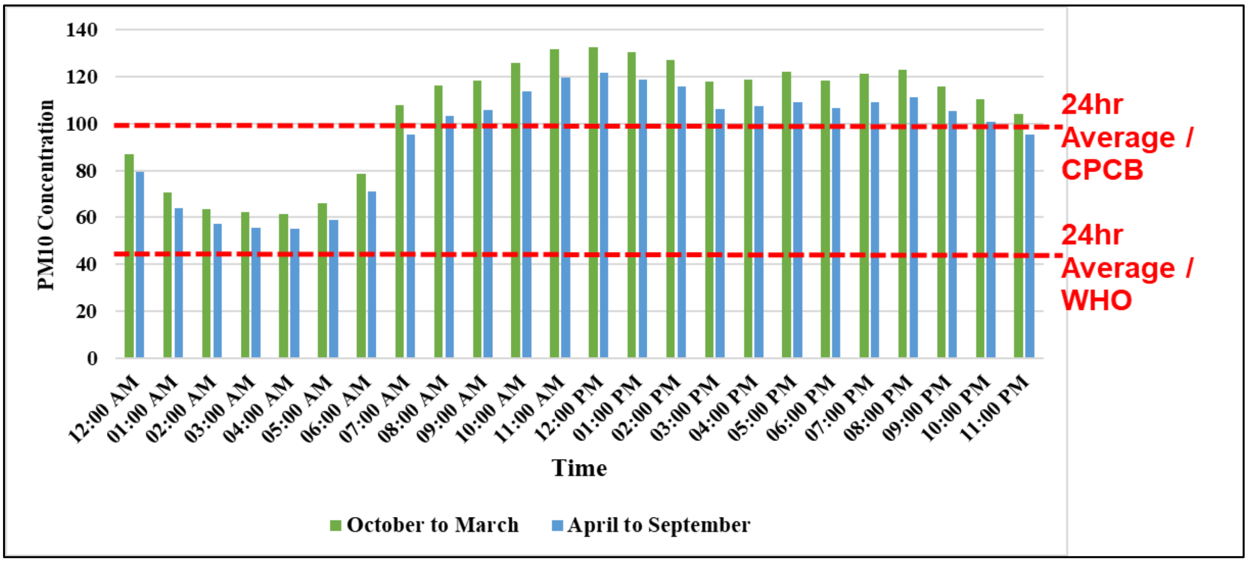


Figure 9: Monthly variation of PM2.5 and PM 10 along 24hours in a day for 2025

Given the observed seasonal variability in air quality (Figure 8) and also the 24hr variation of particulate matter (Figure 9), it is important to examine how these conditions translate into real-world commuter exposure. An exposure dose analysis was therefore undertaken across different transport modes and travel durations to quantify these differences. Prolonged exposure to elevated levels of particulate matter, particularly $PM_{2.5}$ and PM_{10}, is associated with adverse health outcomes, including respiratory and cardiovascular diseases. Consequently, understanding variations in exposure across commuting modes is critical for assessing potential health risks and informing mitigation strategies. In addition, a comparative analysis of different transport modes was carried out to understand how a shift from the present mode to the metro would lead to lower exposure and subsequently better health.

Silk Board, being one of the busiest junctions, exposes a large number of commuters to polluted air daily, particularly during the winter and pre-monsoon seasons. While the monsoon brings some relief due to rainfall, pollution levels often remain higher than recommended limits. As a result, people who regularly pass through or live near Silk Board are likely to experience continuous exposure to particulate pollution, which can gradually impact their respiratory health and overall well-being. The trip diary of respondents from the baseline survey indicates that most travelled to work between 7:00 AM and 12:00 PM and returned from work after 4:00 PM, with average travel durations ranging from 15 minutes to >60 minutes. Considering walking, two-wheelers, private cars/ cabs, and buses as the predominant modes of transport, and comparing Figure 13 with the travel diary, the level of pollution exposure is calculated across the different modes at peak time of the day, 8 am, 9 am, 12 pm, 5 pm, 8 pm and 11 pm. Following Allirani and Verma (2025), exposure to fine particles (PM2.5) is measured as the inhaled dose.

PM inhaled dose for X modes = $\sum\_(X = 1)\hat{}X = \;〚EC\ X\ \ IR\ X〛\;\; ET$

The “X” modes considered in this study for exposure estimation are car, two-wheeler, and bus. EC is the exposure concentration, which is the total PM2.5 emitted from vehicles, and ET is the duration of exposure, i.e., the total hours travelled by each mode. IR is the inhalation rate of air while doing different activities. The IR for different modes, as given by the United States Environmental Protection Agency, (Allirani & Verma, 2025) and Goel et al. (2015), is used as follows: car (0.010 m3/min), two-wheeler (0.020 m3/min), bus (0.0124 m3/min), walking (0.024).

Walking and two-wheeler users likely experience the highest direct exposure due to open travel conditions, followed by bus commuters, while car and cab users may have comparatively lower exposure depending on vehicle ventilation and time spent in traffic. Figures 15–16 show that PM_{10} levels are higher than both the WHO and CPCB limits, indicating very poor air quality. In comparison, $PM_{2.5}$ levels are much higher than WHO guidelines but remain close to the CPCB limit. This creates a situation where air may seem acceptable under national standards, but still be harmful when compared to international health-based guidelines. The analysis also shows clear differences in exposure depending on travel mode. Walking leads to the highest $PM_{2.5}$ inhalation, followed by two-wheelers, while metro users have the lowest exposure. This means that although walking and other active modes are good for health and the environment, they can increase exposure to air pollution. The estimated inhalation levels for both $PM_{2.5}$ and PM_{10} are much higher than the WHO safe limits, yet they are still considered "acceptable" under Indian standards. However, research shows that even low to moderate exposure to particulate matter can increase the risk of heart disease, lung problems, diabetes, cognitive decline, and early death (H. Chen et al., 2017; Mei et al., 2023; World Health Organization, 2023). In India, these impacts are especially serious, with a large share of global pollution-related deaths occurring in the country, even at pollution levels below current national standards (de Bont et al., 2024; Jaganathan et al., 2024)

India's CPCB air quality limits for PM2.5 and PM 10 are much higher than the WHO guideline and are implemented keeping in mind on what is achievable in practice rather than what is safest for health. Studies show that even at levels within Indian standards, people still face serious health risks. In contrast, WHO guidelines are based purely on medical evidence and aim to protect human health, making them a better benchmark for assessing pollution impacts (Adhikary et al., 2024; Gani et al., 2020). Therefore, in the present study considering the WHO limit, travel at any time of the day during any time of the year exposes the commuters to a high level of pollution dose.

Post Metro Implementation Survey

The post-implementation survey revealed a partially aware but insufficiently informed respondent base on the question of air pollution. Unlike heat stress, where respondents largely dismissed the concern, a portion of commuters did acknowledge that air quality in Bengaluru had worsened in recent years, and several reported experiencing respiratory symptoms, notably a persistent cough and throat irritation, particularly during the October–March period. This indicates that the respondents were practically aware of the pollution's effects on health; most respondents were ignorant of the pollution effects or could not clearly link it to their travel mode to quantify its impact.

Therefore, the exposure dose calculations presented in this study would provide a more valid evidence base to make people aware of the pollution exposure using their current mode of transport. For example, a person shifting from two-wheeler use to metro travel, there is a significant reduction in PM2.5 inhalation, which indirectly contributes to better health. A 30–45-minute two-wheeler commute or walking during October–March exposes the rider to cumulative PM2.5 levels well exceeding the WHO and CPCB annual average guideline, whereas the equivalent metro journey involves near-zero direct outdoor pollution exposure.

Accident Risk Analysis

Road traffic accidents are a major concern in fast-growing cities like Bengaluru, especially along busy roads such as Hosur Road. This study tries to understand how the introduction of the metro might influence accident numbers. While metros are usually seen as a good solution to reduce traffic and dependence on private vehicles, they also attract more people to station areas. This increases pedestrian movement and interactions with vehicles, which can affect road safety.

To analyse this, accident data along the study area i.e the Yellow line metro with 2.5km buffer were studied from 2015 and 2017. The number of accidents mostly pedestrian fatalities were considered in the present study. Assuming business as usual scenario, the data has been projected to the year 2025 and compared with the accident data available in the traffic police website of Bangalore.

YEAR	**Whole Bengaluru**		**Only along the Yellow line**	
	Total Accidents	**FATAL**	**Accidents**	**Fatality**
2015	4828	714	528	81
2016	5333	754	666	99

2017	5064	609	489	62
2018	4611	663	509	76
2019	4688	744	517	84
2020	3236	622	357	71
2021	3213	621	354	72
2022	3822	752	422	85
2023	4974	882	549	100
2024	4769	869	526	99
2025	4893	843	540	97

Using a Negative Binomial regression model, for the three-year data to identify the prominent attribute contributing to the accidents, the analysis found that locations near bus stops tend to experience higher accident frequencies (IRR = 1.512, $p = 0.023$). Increased activity around transit hubs, where more pedestrians, vehicles, and crossings generally occur, leading to a higher likelihood of conflicts. However, the same perception was obtained during the post-metro survey; the users were not able to exactly quantify the accident risk, but clearly mentioned the issues they faced even after the metro implementation, and the non-availability of pedestrian infrastructure forced them to walk on the road. Along with that, the single footbridge connecting one side of the road to the metro station makes it very difficult for them to access the metro. The people living between two metro stations need to walk on the road, and there is always a chance of being hit by a two-wheeler. Thus, it can be concluded that without proper pedestrian infrastructure outside metro stations, there would be a high chance of an increase in accidents.

However, the precise impact of metro introduction on accident risks could not be quantified due to insufficient data availability. A minimum observation period of one year is required to reliably assess the effects on accident risk along the corridor.

6.5 Objective 3: Mental Wellbeing and Accessibility

To investigate potential improvements in mental well-being through enhanced travel satisfaction, with a focus on accessibility as a primary factor expected to influence ease of movement, reduce stress, and enhance travel experiences post-implementation.

Mental well-being is recognized as a critical dimension of urban quality of life life and a primary outcome of interest in transport health impact assessment. The relationship between commuting conditions and psychological health has been extensively studied. (Stutzer & Frey,

2021) identified commuting as one of the daily activities most negatively associated with subjective wellbeing, with a consistent disutility found across European studies. In the Indian context, where commute durations regularly exceed 60 minutes each way for urban professionals, this disutility is particularly acute. Commuting conditions like travel time, reliability, crowding, and perceived safety have been found to have associations with stress, anxiety, emotional fatigue, and overall psychological health. In the present study, we try to examine which attribute is associated with mental well-being. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) have been used to study the relationship between attributes and mental well-being. Figure 10 shows the proposed CFA model.

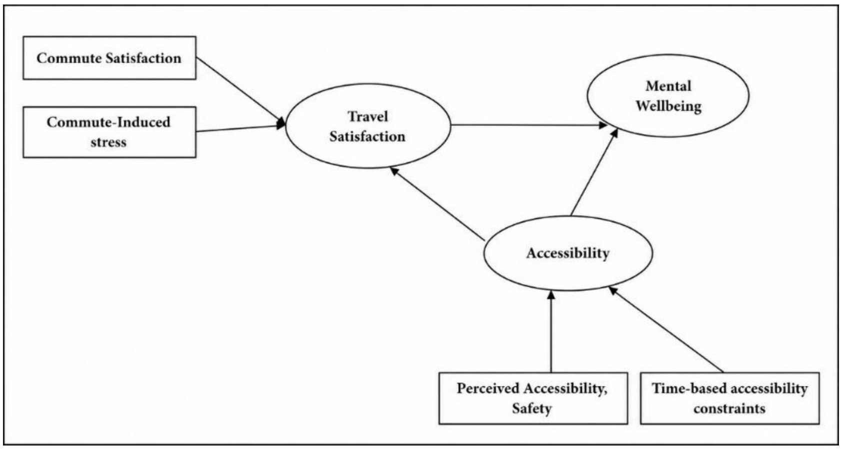


Figure 10: Proposed model to understand the relationship of Mental Wellbeing and Accessibility.

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The findings from the analysis indicate that mental wellbeing has a strong and statistically significant positive influence on travel satisfaction ($\beta = 0.78$), followed by accessibility (0.75). However, commute stress is found to have a significant negative effect ($\beta = -0.69$) indicating that higher stress levels during commuting lowers the perceived quality and satisfaction of the overall travel experience These results are in agreement with earlier studies which highlight that improved travel conditions and reduced travel-related stress contribute significantly to enhanced subjective wellbeing and satisfaction (De Vos et al., 2019).

Post Metro Implementation Survey

Before the metro implementation, users along the yellow line were mostly dependent on two-wheelers, cars, and cabs, for their daily travel, resulting in heavy traffic, congestion, increased travel time contributing to increased levels of stress. With the introduction of the Yellow Line metro, connectivity in the area has improved significantly and travel has become quicker and more reliable, making daily journeys far more predictable and less tiring thereby lowering commute stress and enhancing travel satisfaction. During the post metro survey also, the respondents were very happy and satisfied with the metro usage. The respondents have told that metro usage have significantly reduced their travel time from 2hours to 30min, improved connectivity. Now they feel less tired, have more time for themselves and also can reach any part of the city comfortably. These improvements in daily travel have not only enhanced convenience but have also contributed positively to their mental wellbeing, as reduced travel stress allows individuals to feel more relaxed, less anxious, and more in control of their daily routines. In turn, this has led to an overall improvement in quality of life, as commuters are able to better balance work, personal time, and leisure activities. Similar findings have been reported in literature, where the use of high-quality public transport systems has been associated with improved travel satisfaction and reduced psychological stress (Ettema et al., 2011; Olsson et al., 2013). However, some of the respondents were dissatisfied with the time gap between two trains and also fare.

Despite the benefits associated with metro usage, several challenges continue to hinder the users shifting from private vehicles to metro. During the post metro survey, some respondents living more than 2km distance from metro stations clearly mentioned the issues faced by them in using the Yellow Line Metro service. Though the commuters were willing to shift to metro for their regular travel they find it difficult and extremely stressful therefore avoid using metro rather use their private vehicles. The most prominent issues mentioned by the users are inadequate last-mile connectivity, limited availability and poor awareness of metro feeder bus services. As per the respondents though BMTC has introduced feeder buses to metro lines but most of the commuters are not fully informed about the route, timing of the feeder buses thereby reducing the accessibility. In addition, if the users use their private vehicles to reach the metro station, insufficient parking facilities at metro stations discourage them. The respondents were concerned about the safety of their vehicles leaving on the road for the whole day. Therefore, the respondents even though they are aware of the benefits of metro travel tend to continue using private modes. Addressing these issues through improved feeder integration, better information dissemination, would increase shift to metro thereby improving the mental health and wellbeing.

6.6 Objective 4: Social Inclusivity, Work-Life Balance

To analyse the role of the Yellow Line MRT in fostering social inclusivity, community interaction, and to measure improvements in urban productivity through time savings, reduced travel congestion and fatigue, and enhanced work-life balance.

Travelling in a metro reduces congestion, improves access, and fosters social inclusivity and interaction (Lucas, 2012; Pereira et al., 2017). Travelling in the Yellow Line MRT would reduce travel time and thereby enhance productivity, reduce travel fatigue, and support work-life balance (Litman, 2021; Currie & Delbosc, 2011). This study examines the social and economic benefits of travelling in the metro. A EFA followed by confirmatory factor analysis (CFA) was conducted to study the effect of five latent constructs as given in the proposed model in Figure 11.

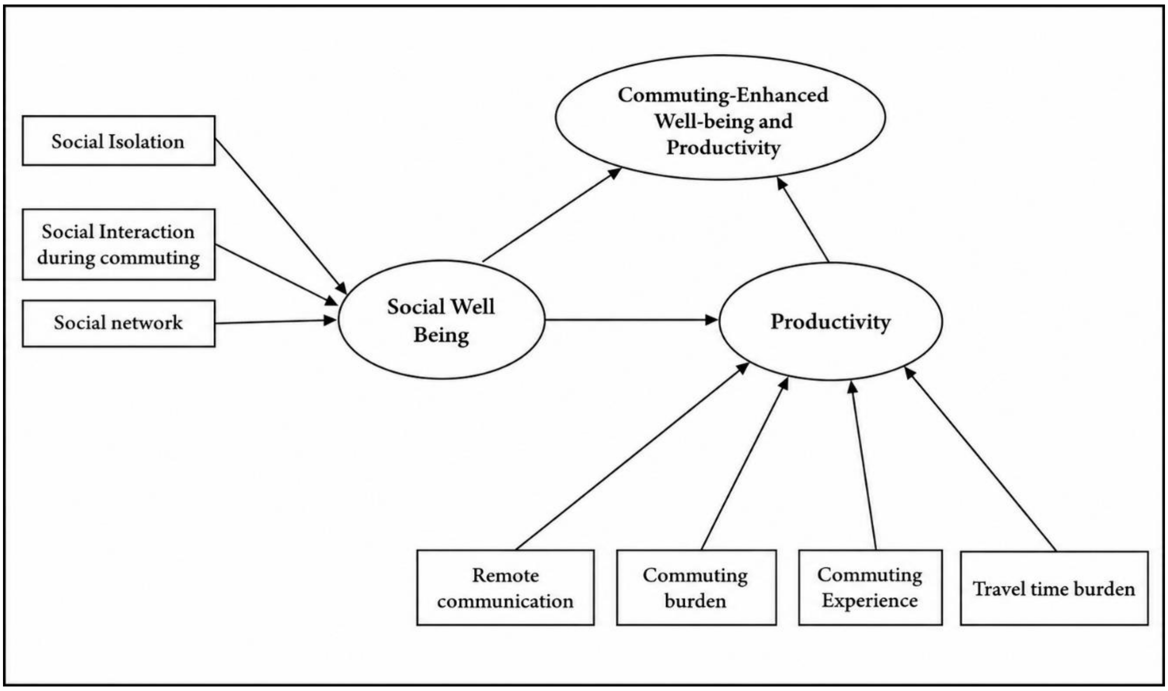

Figure 11:Proposed model to understand the relationship of Social Wellbeing and Productivity.

The findings from the model indicate that social wellbeing has the strongest positive influence on social isolation (β = 0.702), followed by social interaction (β = 0.648), while its effect on social network is moderate (β = 0.405). Among productivity, commute burden is the strongest contributors to productivity loss, indicating that commuting adversely affects both professional and personal life. The commute experience construct is predominantly loaded by commuting burden (0.696), Commute experience (0.672), and travel time burden (0.650), confirming that the emotional quality of commuting significantly shapes social and productive outcomes. The significant positive correlation between social wellbeing and Productivity ($\beta = 0.508$) further underscores that social connectedness and occupational performance are deeply intertwined, consistent with findings that commuting conditions shape both social capital and work performance (Chatterjee et al., 2020; De Vos et al., 2019).

Post Metro Implementation Survey

Prior to metro introduction, most of the people were dependent on private vehicle for their travel resulting in heavy traffic, congestion, increased travel time thus limited social interaction opportunities. With the metro, a shared, predictable, and less stressful travel environment there is a chance that the commuter can have social connectedness among commuters. Also, with less time spent in travel the users have more time to connect with friends, families and relatives. Along with that comfortable, stress free and reliable travel in metro would significantly reduce the travel burden resulting in commuters reporting to office on time with increased energy and lower fatigue. These gains translate into measurable improvements in workplace productivity and overall quality of life, Similar findings in literature confirm that reliable, high-quality public transport reduces commute-related stress and enhances occupational performance (Chatterjee et al., 2020; Künn-Nelen, 2016).

6.7 Objective 5: Overall Quality of Life

To integrate objective and subjective assessments to evaluate the role of the Yellow Line MRT in improving health outcomes and enhancing the overall quality of life

The objectives 1-4 established that commuters along the Yellow Line corridor exhibit high physical inactivity and NCD burden (Objective 1), face elevated thermal stress and air pollution exposure particularly among two-wheeler and walking commuters (Objective 2), and experience measurable deficits in mental wellbeing linked to poor travel satisfaction and limited accessibility (Objective 3), while productivity and work–life balance are substantially constrained by commute-related fatigue and time loss (Objective 4). Thus a combined analysis of all the above factors into a single, Quality of Life (QoL) score would quantifying the well-being at the baseline scenario.

A confirmatory factor analysis (CFA) was conducted to study the effect of five latent constructs, General Wellbeing, Travel Wellbeing, Accessibility, Social wellbeing, Physical

Activity, and Productivity and work life balance on the Quality of Life. Figure 12 gives the proposed model to be analyzed using CFA. The model was found to satisfy all the tests of reliability and validity. From the analysis General Wellbeing was found to be the strongest predictor of Quality of Life, followed by Travel Wellbeing. This finding aligns with the findings of Diener & Seligman (2004) on the hedonic basis of life satisfaction, and confirms that transport conditions effect the physical and psychological state, and to the overall life quality of life of the commuter.

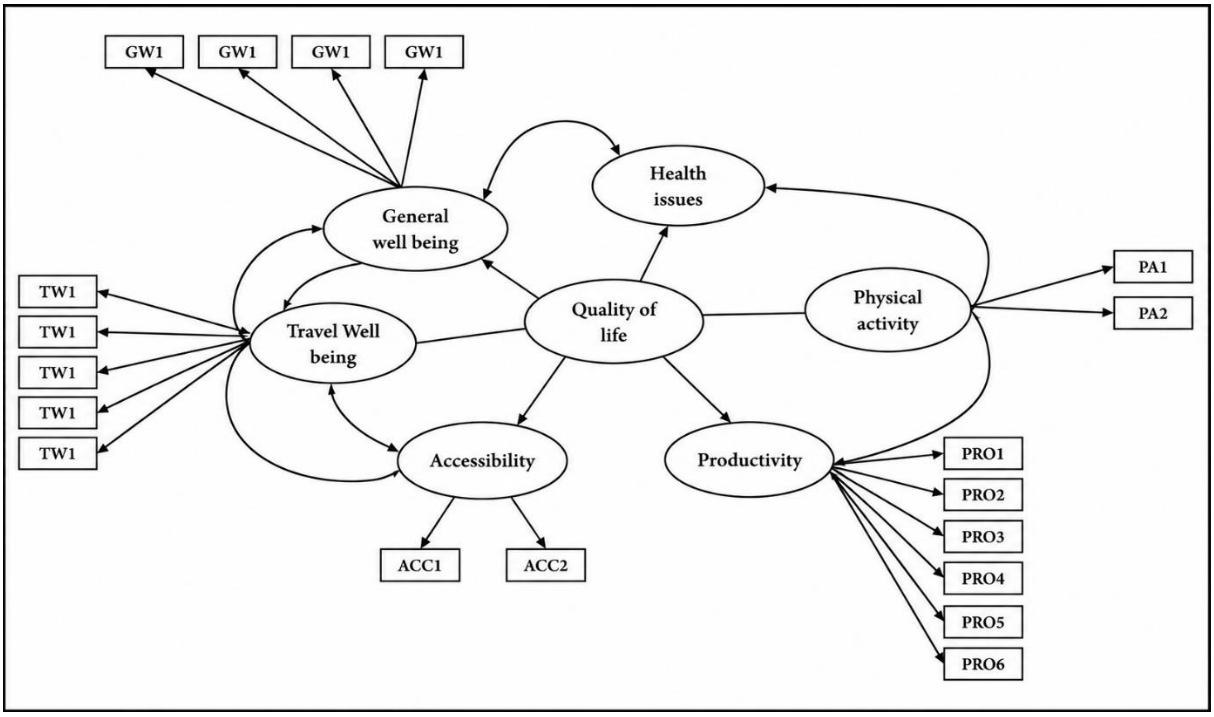

Figure 12: Proposed Model to study the effect of attributes on Quality of life

However, these results cannot be considered conclusive due to the unavailability of post-metro implementation accident data, which represents a critical gap in the current assessment framework. The lack of accident risk data prevents a holistic evaluation of the metro's impact on overall quality of life and safety outcomes. Consequently, for a comprehensive and quantifiable impact assessment study, an extended data collection period is essential. This would necessitate gathering accident statistics, incident reports, and safety data for a minimum duration of one-year post-implementation to enable meaningful comparative analysis and derive statistically significant conclusions.

As the metro becomes operational and ridership increases, longitudinal monitoring of these indicators will be essential to quantify the true magnitude of this improvement. Ultimately, the evidence positions metro rail investment not just as an infrastructure decision, but as a public health and human development intervention with measurable returns across physical, psychological, and social dimensions of commuter well-being.

7. Discussion

This study presents a comprehensive assessment of the Yellow Line MRT's impact on public health and quality of life in Bengaluru. The findings across the four analytical objectives collectively indicate that a modal shift from private motorised vehicles to metro transit has substantial potential to improve population-level health outcomes. However, these benefits can only be attained with improved last-mile connectivity, better pedestrian infrastructure, and proper integration of all the facilities.

The physical activity results are particularly important in regards to India's increasing count of non-communicable diseases. With more than 58% of the sample physically inactive from the survey, and the highest inactivity observed among young urban professionals (18–29 years), the regression results suggest that even modest increases in daily walking such as those associated with metro access and egress can lead to meaningful improvements in physical wellbeing. The observed regression coefficient of 6.377 for physical activity indicates a notable increase in WHO-5 wellbeing scores among active individuals, highlighting the potential of metro-induced behavioural change to contribute positively to both physical and mental health outcomes.

A significant proportion of commuters, particularly two-wheeler users, are exposed to high thermal stress conditions during summer.two wheelers and walkrs are also the most exposed category of commuters exposed to air pollution. Therefore, the shift to metro not only reduces exposure but also contributes to better health

The structural equation modelling results demonstrate that both travel satisfaction and accessibility are critical determinants of mental wellbeing, with comparable path coefficients, indicating that improvements in service quality must be complemented by ease of access to maximise benefits. In addition, the social wellbeing analysis suggests that metro systems can facilitate social interaction and a sense of community among commuters. The emergence of a strong social connectedness construct indicates that shared transit spaces can act as informal social environments, contributing to enhanced social wellbeing and, in turn, overall quality of life.

However, the post-metro survey findings reveal a gap between perceived benefits and actual travel behaviour. While a large proportion of respondents expressed willingness to shift to metro due to its advantages in terms of reduced travel time, improved comfort, and better connectivity, several practical barriers continue to hinder this transition. The absence of adequate last-mile connectivity, limited availability and awareness of feeder bus services, and insufficient parking facilities at metro stations were identified as major constraints. As a result, even commuters who recognise the benefits of metro usage tend to continue relying on private vehicles due to convenience and flexibility. This behavioural resistance highlights the importance of addressing not only the core transit service but also the supporting infrastructure and policy environment to make the transit successful. Furthermore, concerns regarding the continuous increase in metro fares have also been identified as one of the deterrents in people shifting to metro.

Overall, the findings suggest that while the Yellow Line MRT has significantly improved commuting conditions and have started to enhance mental, physical, and social wellbeing, its effectiveness is currently constrained by gaps in supporting infrastructure. Addressing issues related to last-mile connectivity, feeder services, parking provision, and fare policies is essential to encourage people to shift to sustainable transport mode. These improvements would not only enhance metro usability but also contribute to the public health and quality-of-life benefits of metro adoption in rapidly urbanising contexts.

8. Conclusions

This study establishes a comprehensive baseline and analytical framework for evaluating the public health impact of the Yellow Line MRT in Bengaluru. The evidence indicates that modal shift to metro transit is associated with potential improvements across all four assessed dimensions: physical activity gains through incidental walking, reduced environmental exposure to heat and air pollution, enhanced mental wellbeing through improved travel satisfaction and accessibility, and increased social connectivity and urban productivity.

However, the full benefit of improved quality of life would only be achieved on overcoming the infrastructure and policy barriers, most critically last-mile connectivity, fare affordability, and pedestrian safety that is currently limiting metro adoption among lower-income and physically vulnerable population segments. The study provides actionable, evidence-based recommendations for planners, policymakers, BMRCL, BBMP, and the Government of Karnataka with an actionable, evidence-based roadmap to maximize the health benefits of Bengaluru's metro network.

Implementing these recommendations will help the Yellow Line achieve its full potential as a public health intervention. It can contribute to reducing the burden of non-communicable diseases (NCDs), improving mental wellbeing, promoting social inclusion, and enhancing the overall quality of life for the thousands of people who use the metro every day.

9. Recommendations

The evidence generated by this study informs a comprehensive, multi-tiered policy framework designed to maximise the public health co-benefits of the Yellow Line MRT. This framework is organised around six strategic policy domains, each grounded in the empirical findings and supported by international best practice evidence.

1. Last-Mile Connectivity and Feeder Integration

The study identifies inadequate last-mile connectivity as one of the barrier to shifting to metro. A substantial proportion of commuters willing to shift to metro travel are effectively excluded by the absence of reliable, affordable, and safe first- and last-mile options. International evidence from Singapore (LTA, 2019), Hong Kong (MTR Corporation, 2020), and Curitiba (URBS, 2018) demonstrates that integration of feeder bus networks, para-transit services, and non-motorised transport infrastructure within 800 metres of metro stations is the most effective and cost-efficient strategy for maximising ridership and equity of access. Therefore, an integrated BMTC feeder bus network with proper information of the schedule in Kannada and English available online and offline, subsidised e-rickshaw feeder services and designated auto rickshw zone outside each metro station would help more commuters to shift to metro.

2. Pedestrian Infrastructure

The absence of continuous, covered, well-lit, and accessible pedestrian walkway, foot over bridges, signalisd crossing facility have been clearly documented in the baseline survey study. In absence of the pedestrian infrastructure the risk of accident, safety and security issues increases which in turn demotivates people from using metro. Therefore, construction of continuous pedestrian walkways with guard rail, better crossing facilities, escalators and elevators at foot over bridges, high-quality LED lighting would improve the condition.

3. Fare Rationalisation

The study documents a stark fare disparity: Bengaluru Metro fares for journeys of 10–20 km (₹60–₹70) are four to five times higher than comparable Kolkata Metro fares (₹15), and substantially higher than metros in Delhi, Mumbai, and Chennai on a per-kilometre basis. This pricing structure effectively excludes lower-income and middle income commuters who constitute 57% of the sample. A student and senior citizen concession pass and employer-subsidised commuter pass for IT/ITES companies will help more commuters to shift to metro.

4. **Station Area Parking and Intermodal Integration**

Parking deficiency at metro stations was cited by 17.6% of respondents as a reason for not shifting to metro, a significant deterrent among commuters who use private two-wheelers and four wheelers for station access. Developing a dedicated four-wheeler parking station would also more people shifting to metro.

10. Limitations and Future Research

The study's primary limitations include the telephonic format of the post-implementation survey, which could not collect all the data. The absence of 12-month post-implementation accident data prevents in understanding the change in accident risk and pedestrian safety. The reliance on a single ambient air quality monitoring station (Silk Board) as a corridor proxy introduces spatial uncertainty in pollution exposure estimates. Future research should prioritize longitudinal study, accelerometry-based physical activity measurement, multi-station air quality monitoring, and objective productivity assessment through employer records, to build a more robust causal evidence base for transit health impact evaluation.

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About Foundation for Bengaluru Science & Technology (BeST Cluster)

BeST - Bengaluru Science and Technology Cluster is an initiative by the Office of Principal Scientific Adviser to the Government of India, which focuses on leveraging scientific expertise to address critical societal needs of Bengaluru and create replicable models for other cities. Anchored at the Indian Institute of Science (IISc), the Cluster has been incorporated as a Section 8 not-for-profit company in May 2024, co-founded by IISc, NCBS, JNCASR and ICTS, under the name “Foundation for Bengaluru Science and Technology Cluster”. Operating on an inclusive hexa-helical model, which brings together academia, industry, government, non-profits, investors and strategic sectors, BeST fosters multidisciplinary multi-stakeholder collaboration, shared ecosystem, designs and implements frameworks that strengthen science-society engagement, aligned with regional and national priorities for an Aatmanirbhar Bharat.

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