NODES, NETWORKS AND NEGOTIATIONS IN URBAN MOBILITY: METRO–ROAD INTERFACES AND SOCIO-SPATIAL HEALTH IMPACTS IN MUMBAI

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ABSTRACT

India is experiencing Rapid Urbanization. 40% of its population will live in its towns and cities by 2036 and will account for over 70% of GDP. India's goal of becoming a developed nation by 2047, would depend critically on how successfully it handles this urban transition. Resultant of this urbanization can be seen as development of infrastructure particularly in dense cities of India. This infrastructure is increasingly functioning as complex, intersecting systems where multiple transport modes, stakeholders, and spatial demands converge. Existing roads got super imposed by elevated metro corridors and have intensified spatial and environmental conflicts, affecting people. This study aims to investigate the negotiations emerging at existing roads and metro interfaces, conceptualized as urban nodes and networks where nodes are being key junctions or mobility spaces that shape user experience and networks are formal and informal connections that move the city. Study further delves into impacts on commuter's behavior and their health. Through analysis of various Mumbai Metro Lines and other elevated corridors, the research examines spatial configurations, mobility patterns, stakeholder interactions and environmental conditions.

KEY WORDS: Urban Mobility, Nodes, Networks, Metro–Road Interfaces, Conflicts, Stress, Commuter Health

INTRODUCTION

India's rapid urbanization has accelerated large-scale infrastructure investments, particularly in urban transport systems such as metro rail networks. However, these infrastructures are superimposed onto gradually evolved dense areas and urban road networks where multiple activities converge and create socio-spatial interactions . Here spatial intersections such as road junctions, pedestrian crossings, informal transport routes, interchanging spaces are nodes and the way in which interactions takes place among users and their infrastructures are networks. Further, any such areas, roads or junction with adjacent infrastructure if faces challenges like potholes, uneven patches, slopes or construction activities, results slowdown and or gridlock. Hence despite the growing scale of infrastructure including metro, cities like Mumbai has biggest challenge of commuter's speed. Result of such hampered speed is worth an attention towards commuter's health.

AIM

The aim of this study is to analyze how metro lines superimposed onto existing road infrastructures and generate spatial, functional, and governance dynamics at nodes and understand urban mobility and health-sensitive urban planning.

OBJECTIVES

- To identify how elevated metro lines interacting with current road infrastructures and created challenging(negotiated) socio-spatial environments.
- To assess how commuter's behavior and health is getting affected by negotiated special contexts.

RESEARCH METHODOLOGY

This research adopts a mixed-methods research design, combining quantitative and qualitative methodologies to examine socio-spatial negotiations at metro–road interfaces. Quantitative data was collected through structured commuter survey assessing spatial experience, travel behavior and health impacts. Semi-structured interviews with commuters, vendors and other stakeholders were done for perceived comfort and safety. Qualitative data was obtained through field observations. Case studies were undertaken along elevated corridors of Metro Line 1, 3 and 7 representing high-density urban contexts with complex infrastructural overlays.

Spatial analysis was done to understand nodes and networks, pedestrian conditions, and stressed-out zones.

LITERATURE REVIEW

Literature review (Anon., n.d.), helped to understand nodes or junctions giving direction to research and developing an understanding of interrelationships of various elements in urban mobility. News articles and documents for Metro Line 1, 3 and 7 helped understanding complexities and unintended conflicts existing or arising in Metro projects. According to Mr. Ramkumar, additional commissioner of police (traffic), when the number of vehicles on the road remain a constant but the width of the road reduces due to factors such as encroachments, construction and on-going infrastructure projects; and the number of lanes for a smooth flow of vehicular traffic are reduced there. Traffic department identify such areas as bottleneck. Such thirteen bottlenecks were identified in the city. Case study of Akurli subway widening along with commercial development threw light on commute time issue. While traveling from Andheri to Kandivali Akurli. Travel time got extended to 80 minutes instead of 20 minutes. This was due to shut down of three lanes for the widening of the Akurli vehicular subway work. This case specified snow ball effect of one activity over to adjacent connections (networks) in the corridor.

FINDINGS

Field study was conducted on Western Express Highway (WEH) and Eastern Express Highway (EEH).

Observations of critical junctions (nodes) at Malad-Dindoshi, Goregaon, Jogeshwari, Vileparle-Santacruz, Bandra were recorded. Malad-Dindoshi stretch always

face congestion due to the high density of residential and commercial structures accommodated with shopping outlets along the roadside. In Goregaon: concentration of commercial offices near NESCO, the actual crowd spilling over highway during exhibitions and events at NESCO and the Oberoi Mall directly pushing crowd on WEH causes major slow downs. HUB mall with service road intersecting the inner aisle of Goregaon East Road is reflection of traffic flowing inside out to WEH. Area surrounding the Andheri flyover, stretching towards the Jogeshwari-Vikhroli Link Road (JVLR), is highly congested. Vileparle-Santacruz area with multiple business parks and hotels, combined with outlets of airport vehicles turn short commutes into long during peak hours. Area near the Vakola junction and the Santacruz-Chembur Link Road (SCLR) extension seem like a merging conflict for traffic, with cars exiting onto the highway creating significant chaos on Western express highways. Lane from Santacruz railway station till WEH get cloggedup as resultant of traffic jam on highway. (Refer Figure 1)

(Figure-1 Junction heading from WEH to Santacruz Railway Station)

Junction connecting the WEH and Bandra-Kurla Complex (BKC) shows volume of commercial traffic in and out of BKC causing major slowdown.

(Figure-2 Junction of D.N. Nagar and Andheri West Metro Station intersecting at Link Road, Image source: Author)

To study Planned key interchange hubs, a junction of Andheri West (Line 2A, Dahisar-Andheri West) and D.N Nagar (Blue Line 1 Versova-Andheri-Ghatkopar) is studied. . (Refer Figure-2)

This junction experiences a regular traffic jam due to Metro infrastructure and roads narrowing on interior side towards Jain temple road. Vehicular intrusion creates confusion as well as insecurity to pedestrians crossing the streets. Encroachment of vendors and beggars on adds to it. Exit of huge crowd out of station either to connect workplaces on Link Road or S.V. Road or do further transitions to eastern Mumbai, experience remarkable congestion at the junction morning and evening during peak hours.

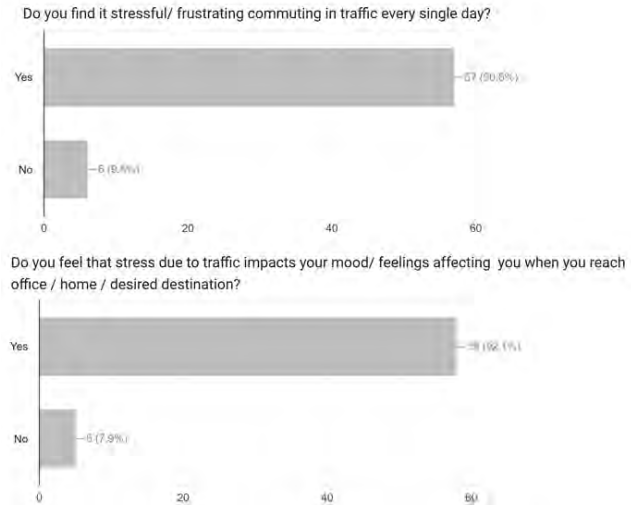
Mith Chauki cross section also displays classic conflict. (Refer Figure-3) There is 3 layer system existing there: Cross road of Malad Marve -Link road, bridge flying from Malad Marve to Malad west Link road and Mumbai Metro passing above all running from Andheri to Gundavali. There is major chaos below with dominance of vehicular traffic over pedestrians. Pedestrians are under tremendous stress while crossing streets everyday, a great struggle of traffic management is visible there. Lanes get clogged all the way towards Malvani gaon on west of Link road and till Kanchpada junction on south of Link road. Encroached footpaths and congested roads creating confusion and insecurity among pedestrians and fierce bikers making people stressed everyday while crossing the roads or walking along the sides.

(Figure-3 Junction of Mith Chauki, Image source: Author)

Field visit and newspaper articles helped study the metro corridor Line 1 Versova-Ghatkopar-Versova. This corridor being the first metro project of Mumbai, relevant issues related to it are studied for spatial and environmental relations.(Refer Figure-4).

(Figure-4 Space outside of Line 1 Versova-Ghatkopar-Versova Metro stations- Image source: Mid Day 25 July, 2025)

Despite a design for safe pedestrian exit, footpaths WEH station area have been overrun by hawkers and food stalls, forcing thousands of commuters to walk on the road, jostle through crowds, or risk standing in traffic. Remaining stretch is taken up by people queuing for buses or autos, leaving no room for safe pedestrian movement. This makes chaotic and dangerous conditions at city's busiest junctions. Outside Asalpha station, footpaths are occupied by vendors, with the remaining space taken by people lining up for autos or office buses. Outside Ghatkopar station, footpath is blocked by vendors and stalls. The stalls extend onto the walkway, and customers eating in front of them force bus passengers to queue up on the road. The bus stop, about 10 meters apart have the railway station exit right between them, leaving no space for a bus line to form. All of this causes congestion on roads resulting in traffic slowdown. Saki Naka station is a major junction near hotels and restaurants, has food stalls clogging the footpaths, pushing pedestrians onto the road. Though the bus stop is not directly outside the station exit, it does crowd from nearby eatery's spill over. Asalpha station's footpaths are lined with two-wheelers, flower vendors and food stalls. Hence pedestrians often walk on the road to avoid the static crowd in front of these stalls. Outside WEH metro station, the space on footpath is reduced due to hawkers. People feel risking life walking on the road. Outside Andheri station, the crowd is pushed straight into traffic outside the station, also vendors block the entire footpath especially dangerous when cooking is done using gas stoves. People constantly get strike by crowd waiting for buses. Ladies have insecurity due to unpleasant. Outside Chakala station, condition is relatively better due to wider footpaths, but during peak hours footpaths have food stalls and gas stoves on one side and bikers breaking the traffic rules are on other side. Behavioral and health evaluations are done by conducting survey. Sample size taken was 70, out of which 63 participants participated in the survey. Survey covered various age groups and both genders and included questions for mapping Physical and emotional responses of commuters. 92% of the population out of total participants informed that they commute to work through Mumbai roads and highways and there is 100% agreement on traffic jams during the peak hours. 95% of the commuters mention that there are certain Street junctions show traffic jam particularly under metro lines, metro stations and or near metro columns/ infrastructure. 93% of the population agreed that despite the metro running parallel to the highways or certain streets, there is a remarkable traffic jam and confirmed that it is stressful



and frustrating to commute through such traffic jam areas on everyday basis. (Refer Figure-5)

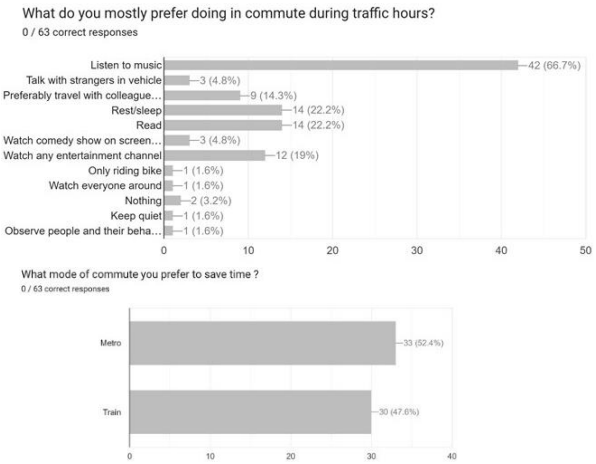
(Figure-5 Survey for mapping commuter's emotional response)

96% of the population reported that relocating near workplace or commuting for a very short distance would be an appealing option for them. 90% of the population shows that going through traffic situations impacts their moods and feelings when they reach their desired destination. When detailed out this question, 66% of the population mention they would like to listen to music while travelling through traffic hours, 22% would like to rest or sleep, 22% would like to read, 19% would like to watch entertainment channels and 14% of the population said they would preferably like to travel with colleagues.

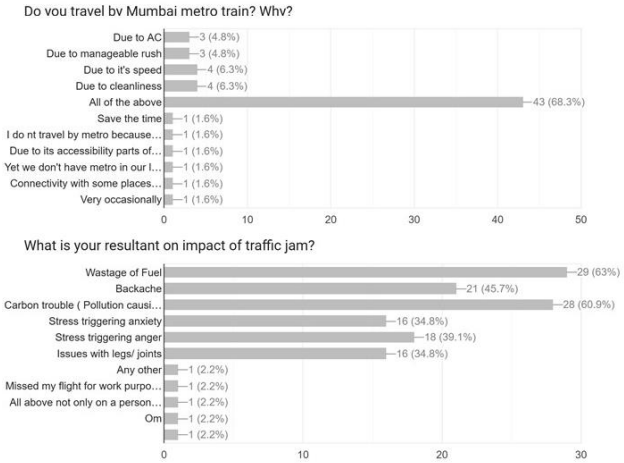
A rare 1% population that responded to just commute quietly being idle. (Refer Figure-6)

68% of the population said they would prefer metro over any other mode of transportation and reasons for those are speed, manageable rush, air-conditioned space, cleanliness, accessibility and less time. The impact of traffic jam was measurable and recorded for various impacts. 63% of population said traffic jam is a wastage of fuel for them, 60% population said its pollution causing

various health issues, 45% population reported health issues like backache, 39% population said it triggers their anger, 34% population said it creates anxiety for them, 34% population said they got issues with legs and joints because of immovability through the traffic jam. (Refer Figure-7)



(Figure-6 Survey for mapping commuter's choices in commute)



(Figure-7 Survey for mapping commuter's reaction on Traffic)

DISCUSSION

While being an aid for mass transit, Metro infrastructure create set of challenges that can be observed under categories: walking population, daily train commuters, bike and automobile riders, general vehicular flow and actual Infrastructure issues. Vendors and unauthorized parking is an obstacle for walking population, daily train commuters feel that long and inefficient pedestrian routes to access stations are tiring, bike and automobile riders face congestion and limitation of parking near transit corridor, vehicular flow experience that Metro station structure, station entrances and supporting columns are shrinking existing road space and leading to congestion or bottlenecks. Overhead or underground crossings become a challenge to elderly and physically challenged people if not maintained properly.

Analysis through survey, interviews and field study shows that viaduct columns, service roads, construction buffers, and changed junction geometry significantly reduce the effective right-of-way. Many commuters report longer journey times because of walkability and last-mile connection towards their desired locations.

(Figure-8 Issues of Metro infrastructure with respect to Privacy, Property access, Noise pollution, Parking on roads, junctions without signals, Image source: Author)

Other observed challenges include spilling of crowd at the metro station during office hours (peak hours), disturb surrounding vehicular and pedestrian movement, bike rider's invasion onto footpaths and beggars and hawkers near metro station outlets and poses safety issues particularly at night times, privacy issue due to proximity of metro stations, disturbance in traffic flow due to vehicular entry from main street into individual premises. (Refer Figure-8).User perceptions and environmental assessments show that under-viaduct spaces have higher heat build-up, pollution trapping and noise levels. Heavy traffic running below metro viaduct confines the noise and gets amplified. Many a times lack a proper traffic system, inadequate law enforcement and indiscipline of drivers result in chaos. People honking for a significant distance out of their total travel creates high noise levels. According to Mr. Nagendra R Velaga, Assistant Professor at the Civil Engineering Department of Indian Institute of Technology – Bombay (IIT-B), Mumbai experience highest commute in the country where commuters are exposed to excessive noise during travel. To verify this, researchers chose 6 routes in the city and noise data was collected inside buses, cars, and autos during day-time peak travel hours covering 112 km driving distance by making 22 trips in different types of vehicles equipped with GPS devices and noise-level meters. The research team took into account noise levels related to interactions between the road surface and tyre. (Konbattulwar, 2016). Noise levels in all Indian metro cities were higher than the permissible limits (CPCB, 2008) Under the Noise Pollution (Regulation and Control) Rules (2000), permissible noise levels in India during daytime (6 AM to 10 PM) limits are 55 dB for residential, 65 dB for commercial, and 75 dB for industrial areas and nighttime (10 PM to 6 AM) limits are 45 dB residential, 55 dB for commercial and 70 dB for industrial areas. But according to study by the IIT-B, commuters in the city are subjected to noise levels of more than 90 decibels(dB).(world-news, 2026). Noise affects the physical and psychological characteristics of people exposed to this kind of volume. Road traffic noise has an adverse effect on the human sleeping cycle, such as

observed short-term effects, prolonged sleep latency, shallow sleep and reduction in overall sleep (Ohrstrom, 2006). Depending on the level of noise and its duration, the effect of noise on human health can be divided into four categories, Physical effects leading to hearing defect, Physiological effects like high blood pressure, irregularity of heart rhythm and ulcers, Psychological effects like Sleeplessness, irritability and stress, and effects on work performance for example reduction of productivity and misunderstanding what is heard etc. (Pachiappan, n.d.) Also, children exposed to road traffic noise for a long period of time face an increased risk of chronic stress hormone regulation disturbances (Ising, 2002) Long-term exposure can cause behavioral, psychological and physiological stress (Babisch, 2001). Stress is a reaction to an apparent danger or pressure, which can essentially affect both physical and emotional wellness. Chronic psychological stress is associated with a greater risk of depression, cardiovascular disease (CVD), diabetes, autoimmune diseases, upper respiratory infections (URIs), and poorer wound healing. (Cohen S, 2007)

CONCLUSION

The findings indicate that elevated metro corridors significantly reconfigure spatial and behavioral dynamics at metro–road interfaces. Infrastructure interventions, when seen as spatial compression, disturb daily mobility patterns and bring behavioral adjustments. This alteration impacts human feel more struggled and stressful (angry and anxious) impacting their behavior and performance which implies that mobility infrastructure affecting their well-being. Findings support the idea that urban mobility infrastructures are negotiated socio-spatial assemblages that are influenced by institutional frameworks, daily practices, and power dynamics (Pucci, 2015). By having nodes and networks as negotiated urban processes, this research advances in relationship of urban mobility planning towards public health perspectives. There is a strong relation seen among amount of time spent in commute via roads, traffic jam, resultant stress, anger and anxiety establishing a proportion among commute time and wellness of people. The study contributes empirical evidence on unintended conflicts and highlights the necessity for coordinated governance and health-sensitive planning measures for inclusive and sustainable urban mobility transitions in rapid urbanization.

RECOMMENDATIONS

Conceptualizing infrastructures as negotiated socio-spatial assemblages, this research work underlines issue of wellbeing of city in urban mobility. By establishing a connection between infrastructure, behavioral pattern and health consequences, the nodes–networks–negotiations paradigm expands discussions in health realm. Within integrated mobility, a policy framework should improve collaboration between traffic departments, public health organizations, metro authorities and municipal agencies. Last-mile connectivity ,multimodal integration and pedestrian infrastructure needs more attention to avoid fatigue due to longer walks and longer travel time. Health deterioration due to stress generated in traffic, pollution and noise should be minimized through implementation of health-conscious design elements for wellbeing of entire city.

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