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INDIAN INSTITUTE OF TECHNOLOGY DELHI

T R I P - CENTRE

BULLETIN

TRANSPORTATION RESEARCH & INJURY PREVENTION CENTRE

VOL 2 NO. 2

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Excerpts from: HEALTH EFFECTS OF LOW EMISSION AND CONGESTION CHARGING ZONES: A SYSTEMATIC REVIEW

Rosemary C Chamberlain, Daniela Fecht, Bethan Davies, Anthony A Laverty

Motorised transport poses risks for human and environmental health. Road transport is an important contributor to air pollution worldwide, as well as being responsible for 1·3 million deaths per year through road traffic injuries (RTIs).2 Increasing concern about these effects has spurred policy makers in some locations to implement schemes restricting private vehicle use in urban areas. Two main types of these schemes are low emission zones (LEZs) and congestion charging zones (CCZs). LEZs charge or ban vehicles that exceed specific exhaust emission standards and aim to reduce air pollution by encouraging use of lower emission vehicles or physically active forms of transport. CCZs focus on reducing congestion through charging financial penalties for the majority of vehicles, with little or no differentiation by emission standards (appendix p 6). Although there are some differences between them, both LEZs and CCZs apply to defined geographical areas and have the potential to improve health through reducing car use and encouraging a shift towards lower emission motor vehicles or active travel. LEZs and CCZs can also both be implemented at a city level; this is important as cities are at the forefront of both effects and solutions to climate change issues.

Although at least 320 LEZs had been implemented across Europe as of 2022,5 the global evidence base regarding their health effects is relatively limited. A review of the effects of European LEZs on air quality concluded there was some evidence that German LEZs had reduced PM10 and nitrogen dioxide (NO2) annual average concentrations, with a mixed picture across Europe overall. By 2019, Bradley and colleagues6 and Burns and colleagues7 had both conducted reviews assessing the air pollution effects of a range of interventions, including LEZs, concluding that the evidence regarding the effect of LEZs on air quality was inconclusive. Both these reviews also highlighted that evidence on health effects was sparse, although Burns and colleagues acknowledged that several studies had been published since their search. The evidence on the health effects of CCZs is also scarce; a 2021 scoping review8 identified some evidence of RTI reductions, but did not consider air pollution-related health outcomes. We therefore systematically reviewed the evidence for the effect of LEZs and CCZs on a range of physical health outcomes associated with air pollution or motorised traffic exposure.

We conducted our systematic Review in line with our pre-published protocol (PROSPERO CRD42022311453), with some minor changes (appendix p 31), and report results according to PRISMA guidelines.9 We designed the search strategy (appendix p 3) in consultation with an information specialist and based on a previous review.7 We searched six databases: Medline, Embase, Web of Science, IDEAS, Greenfile, and Transport Research International Documentation (TRID). Final searches were conducted on Jan 4, 2023, without date or language restrictions. Records were deduplicated using Covidence software, before two authors (RCC and AAL) independently screened in two stages, firstly using titles and abstracts and then full-text records. Non-consensus was resolved by a third reviewer. The reference lists of studies assessed during the full-text stage were reviewed to identify additional studies (backwards reference tracing).

We aimed to capture studies on the effects of LEZ or CCZ schemes on empirical health outcomes of resident populations compared with areas not affected by LEZ or CCZ schemes. Studies were eligible if they evaluated effects of a LEZ or CCZ on health conditions related to air pollution (birth outcomes, respiratory disease, cardiovascular disease, diabetes, dementia, lung cancer, or all-cause) or traffic exposure (RTIs; further details in the appendix [p 7]). We focused on these outcomes as there is existing evidence of their association with air pollution or traffic exposure. We did not include odd– even schemes that restrict vehicle access on specific days. Outcomes could be any measure of all-cause or cause-specific morbidity (ie, disease events or symptoms or health-care contacts such as hospital admissions) or mortality. Studies had to measure these outcomes using empirical data collected during the study period; studies that predicted outcomes using air quality or traffic changes and concentration–response or exposure–response functions were not eligible. We also excluded studies that only assessed intermediate factors such as air quality or congestion, without assessment of health outcomes.

Studies could use any longitudinal study design with at least one data point before and one data point after LEZ or CCZ implementation, such as pre-post designs, interrupted time series analyses, and difference-in- difference designs. We have focused on these studies to include only robust evaluations of LEZ or CCZ schemes with the capacity to show the temporal direction of the intervention–outcome relationship. The intervention group was the resident population of the intervention area. The comparison population could be from areas not exposed to the intervention, areas exposed to a different version of the intervention (such as less stringent LEZs), or the intervention area pre-intervention (such as in uncontrolled interrupted time series). Studies without primary data, including reviews, were excluded.

Study characteristics were extracted by RCC using a Covidence template, and effect estimates and statistical significance measures extracted into an excel spreadsheet (appendix p 8). We extracted results from the most fully adjusted model reported—ie, controlling for the most covariates. Meta-analysis was a priori considered inappropriate due to heterogeneity in study designs and outcomes. Instead, we used a synthesis without meta-analysis (SWiM) approach, involving tabulation, graphical summary using harvest plots, and narrative synthesis. Our approach was informed by guidance on SWiM10 and narrative synthesis.11 We used a vote counting method based on effect direction and statistical significance, with classification of each result into one of three categories: (1) reduction (effect direction is a reduction associated with the intervention, with p value <0·05, or the 95% CI not including the null); (2) no clear effect (95% CI includes the null, and is therefore compatible with no effect, or p value ≥0·05); or (3) increase (effect direction is an increase associated with the intervention, with p value <0·05, or the 95% CI not including the null).

We used harvest plots to graphically synthesise the results based on these effect directions and grouped by intervention type and outcome category (eg, cardio-vascular or respiratory). When multiple results with different effect directions were reported for a single intervention–outcome pair (such as from different model specifications), the more conservative (ie, the highest number of the three categories above) is shown in the harvest plot. Subgroup analyses were tabulated but not included in the harvest plots. Where results were reported from multiple phases of an intervention (eg, of differing stringency) and from all phases combined, the combined phase results are shown in the harvest plots.

As a secondary synthesis we also considered the effect direction of the point estimates for non-significant results (ie, those classified as no clear effect), as recommended by Cochrane.12 When results for intermediate factors (eg, air pollutants or traffic) were reported in addition to health outcomes, they were also synthesised to give context to the health results. However, this is not a systematic review of these intermediate factors. For each study, the most relevant intermediate factors to report were selected according to a hierarchy (appendix p 8). These results were tabulated and categorised in the same way as for the health outcomes. However, if a study reported multiple factors at the same level of the hierarchy (eg, several pollutant species), the result included in the harvest plot represents the factor showing the clearest effect. For example, the result for a factor with a reduction or increase is shown in preference to one with no clear effect; this is because the intention is to indicate when there is clearest evidence of change in any relevant intermediate factor.

Risk of bias assessment of the health outcome results used the Graphic Appraisal Tool for Epidemiological studies for correlation studies (GATE). This tool includes assessments of external validity, selection of exposure and comparison groups, measurement of outcomes, and rigour of analysis methods. There is also an overall assessment of internal validity. Full details are in the appendix (p 16). Two authors conducted the risk of bias assessment independently. Searches identified 3588 studies, of which 2279 remained after de-duplication, and 14 after assessment against eligibility criteria. Backwards reference tracing identified one additional eligible study13 and five annual reports from Transport for London (TfL) on the London CCZs at different times post-implementation. Of these five reports, we included only the one14 with the most detailed analysis pre-intervention and post- intervention. Therefore, 16 studies were included in the final synthesis.

Study characteristics are summarised in tables 1 (LEZs) and 2 (CCZs). Eight studies assessed LEZs13,15–21 and eight assessed CCZs.14,22–28 Eight studies assessed RTIs,13,14,22–27 six assessed respiratory outcomes,16,17,19–21,28 six assessed cardiovascular outcomes,16–21 two assessed birth out- comes,15,17 two assessed diabetes,16,17 and single studies assessed dementia17 and lung cancer.21 Four studies assessed all-cause outcomes (mortality,20,21 hospital admissions,17 or doctor visits18).

The eight LEZ studies were published between 2011 and 2022. Four studies assessed schemes in several German cities,15–18 two in Tokyo, Japan,20,21 one in Milan, Italy,13 and one in London, UK.19 There were five difference-in-difference (DiD) designs,15–19 one interrupted time series without a control group (uITS),13 and two interrupted \time series with a control group (cITS).20,21 In risk of bias assessment (appendix p 13), three studies received a strong internal validity rating15,16,19 and five received a medium rating (ie, some limitations). Absence of a control group and insufficient control for possible confounding factors were key limitations for studies receiving medium ratings. The findings from the primary synthesis of LEZ studies are summarised in table 3 and the figure. The secondary synthesis results are in the appendix (p 14). Seven studies15–21 reported results for at least one intermediate factor, with this being a measure of air quality in all cases.

This systematic Review of the health effects of LEZs and CCZs identified benefits associated with these interventions. Studies of LEZs found consistent evidence of reductions in cardiovascular disease outcomes, although results were less consistent for other outcomes. Studies of CCZs found consistent evidence of reductions in total injuries or car-related injuries. The current evidence therefore suggests that schemes to restrict private vehicle use in cities could reduce cardiovascular disease events and RTIs. This Review advances previous work by adding greater certainty of cardiovascular disease effects of LEZ schemes and RTI effects of CCZ schemes. We followed a preregistered protocol and searched six databases as well as the references of included studies to ensure comprehensiveness. Of the seven LEZ studies con- sidering health effects other than RTIs, five had been published since the 2019 review by Burns and colleagues.

We included only longitudinal studies with data from pre and post LEZ or CCZ implementation, because of the capacity of these study designs to show temporal direction of the intervention–outcome association, as required for causal inference. Longitudinal studies are also at lower risk of unobserved confounding than cross- sectional studies.30 We focused on empirically measured health outcomes rather than predictions using exposure– response or concentration–response functions. Health outcomes considered here are influenced by other factors, so we extracted information on intermediate factors when reported, including air pollution and traffic flow, to strengthen causal inference. In many cases, the observed reductions in health outcomes were accompanied by reductions in these intermediate factors, although this work is not a systematic review of the effect of CCZs and LEZs on these factors. However, the included studies did not include data on other possible contributory factors related to the intervention, such as physical activity and road noise; further research could usefully investigate the pathways underpinning the health effects identified here. There are some potential limitations to our Review.

Although we searched a range of databases without language restrictions, papers outside of health or economic disciplines could have been missed. Additionally, we could not perform meta-analyses due to the small number of studies using comparable designs and outcomes. We instead used harvest plots and narrative synthesis to summarise findings. Although appropriate and valuable in synthesising the heterogenous studies, our vote-counting synthesis approach based on effect direction and statistical significance does not take account of effect magnitude. We also conducted a secondary synthesis describing the effect directions of results indicating no clear effect, but this should not be overinterpreted, as the uncertainty in these estimates means they are compatible with a null effect. Finally, we took a conservative approach in selecting which estimates to include in harvest plots to minimise the risk of falsely positive conclusions, but this approach could have led to underestimation of effects. Reviews are necessarily constrained by the available evidence. The included studies came from a range of quasi-experimental designs in a range of locations, and 15 of 16 had moderate-to-strong internal validity. There were some discrepant results; six of seven studies on RTIs in the London CCZ found overall reductions in total or car RTIs, whereas one study identified increases in cyclist and motorcyclist injuries, and one identified an increase in serious or fatal injuries. Although increased cycling injuries could be linked to increased cycling, this remains to be fully ascertained.31 Available studies did not consider potential inequalities in effect by socio-demographic factors and gave little consideration to \potential effects on bordering areas. Additionally, future evaluations of such schemes should adhere to best practice recommendations.32 Key issues for the research base include an overall low number of rigorous evaluations of schemes in different contexts and minimal research using comparable outcomes. An expansion of evaluations of future schemes using routine data systems and standardised mechanisms for capturing outcomes would enhance the evidence base and make future reviews more comprehensive through approaches such as meta-analyses.

Although both CCZs and LEZs restrict private vehicle use within cities, they are in practice different; CCZs ban or charge most vehicles and aim specifically to reduce congestion, whereas LEZs aim specifically to discourage the use of high-emission vehicles. This difference in focus is reflected in the fact that the majority of CCZ evidence focuses on RTIs, whereas the majority of LEZ evidence examines air pollution-related health effects. It should be noted that other schemes to reduce or restrict the use of private vehicles within cities do exist, such as odd–even restriction schemes, which restrict vehicle use to alternate days based on registration numbers and are in place in cities such as Jakarta, Indonesia, and have previously been used in New Delhi, India.33,34 We considered such schemes as out of our scope, but they might have similar health effects to those seen here and this could be a fruitful avenue for future research. We did not include other possible effects, including on congestion, residents' quality of life, or long-term disease development; these effects probably strengthen argu- ments for such schemes.35 The observed heterogeneity in design and implementation highlights the fact that there is no standard for LEZs or CCZs; the design and implementation of any future schemes will be important in determining their effect. Nonetheless, both environmental and human health require comprehensive solutions to our reliance on private motorised transport, and the largest health benefits are likely to come from schemes that integrate approaches to support both a reduction in private motorised traffic and increases in active travel and public transport use.

Available evidence suggests observable health benefits from schemes restricting private vehicles in cities. Evidence for LEZs is most consistent for cardiovascular disease, whereas evidence for CCZs is restricted to RTIs in London. Further research could usefully investigate how to optimise the design of such schemes to improve health.

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NEWS

Why does demand-based transport planning persist?
Insights from social practice theory
The article explores the predominant epistemic framework underlying local public transport route planning practices in Western Visayas, Philippines. The analysis aims to uncover the extent to which equity considerations are integrated into the transport planning process.
The authors highlight that the central rationale for transport planning in the studied context is primarily demand-supply oriented, focusing on optimizing transport supply to match travel demand. This approach is referred to as rationalization, where transit networks are optimized to ensure an adequate supply of services to meet the demand.
The authors note that rationalization's prominence is affirmed by transport planners and consultants, who emphasize that transport issues often revolve around the lack of services in remote areas and the concentration of services near activity centres.
The demand-based approach is preferred due to its straightforwardness in determining the required supply and assessing service viability. Transport planners acknowledge that estimating demand is the foundation for determining service supply, viability, and franchise issuance.
The significance of accessibility is also recognized, especially concerning access to socioeconomic activities and amenities, and some mention is made of promoting equitable access for people with disabilities and the elderly.
Despite accessibility being acknowledged as a principle, the article underscores that there is no established norm for defining 'good' accessibility or equitable distribution of transportation benefits. Equity is rarely explicitly considered in the planning process. Although there's a collection of socio-economic data and demographic information, they are primarily used to forecast trip demand, not to analyse access equity among different socio-economic groups. This indicates a lack of explicit consideration for the equitable distribution of benefits and burdens in transport planning.
The data collection step in transport planning predominantly focuses on demand-based data. Existing public transport routes, passenger demand estimates, and transport facility inventory are key data collected. However, there's minimal collection of data guided by equity considerations. Access-related data are sometimes collected but usually for post-planning evaluation, not for equity-based planning.
The study examines the three elements of practice: meaning, material, and competence. In the realm of meaning, the authors identify two main perspectives. The first perspective aligns with a market-driven approach, where transport service is seen as an economic commodity responding to demand and supply. The second perspective emphasizes a state-led approach, considering equity and prioritizing the mobility needs of disadvantaged groups. The first perspective prevails in the Philippines, and the study reveals that equity considerations are often treated as optional rather than necessary.
The material element refers to the tools, technologies, and data collection forms used in the practice. The analysis indicates a heavy bias towards demand-based materials, tools, and technologies, with limited incorporation of equity considerations. Most planning software and data collection forms are designed to support demand-based modelling, and while they can potentially facilitate equity analysis, there's little assessment of fairness in the distribution of accessibilities.
Competence, the skills and techniques of planners, reflects a similar pattern. Planners are more proficient in demand-based modeling techniques compared to equity-based analysis. While there is some capacity to conduct equity analysis, it's less prevalent.
In conclusion, the study highlights the dominance of demand-based rationalization principles in local public transport route planning practices in Western Visayas, Philippines. Although there is a recognition of the importance of accessibility and equity, these considerations remain on the periphery of the practice. The authors suggest a shift towards a dual epistemic framework combining demand-based and equity-based approaches, along with changes in the meaning, material, and competence elements, to better incorporate equity considerations into transportation planning.
Sunio, V., Fillone, A., Abad, R. P., Rivera, J., & Guillen, M. D. (2023). Journal of Transport Geography, 111, 103666.

ANNUAL LECTURE ANNOUNCEMENT

Transportation Research and Injury Prevention Centre is organizing the Annual Dinesh Mohan Memorial Lecture on 21st September 2023 at the Seminar Hall, IIT Delhi from 4:00 – 6:00 pm.

Speaker: Dr. Iderlina Mateo-Babiano, Associate Professor in Urban Planning, Faculty of Architecture, Building and Planning, University of Melbourne

Lecture Title: Walk with me: Embracing Intersectional Equity to support Just Walkability Transitions.

COURSE ANNOUNCEMENT

The Transportation Research and Injury Prevention Centre (TRIP Centre), Indian Institute of Technology Delhi, is organizing its 33rd International Course on Road Safety at the IIT Delhi Campus in Hauz Khas, New Delhi, India, from the 23rd of November to the 7th of December 2023. The first three days will include a common module (Module 1) for all participants, followed by parallel modules on Road Safety (Module 2A), Road Safety & Field Audits (Module 2B), Vehicle Safety Technology (Module 3), and Governance of Road Safety Policy and Planning (Module 4). Details of the course can be accessed from - http://tripc.iitd.ac.in

The Transportation Research and Injury Prevention Programme has been operational for two decades. On May 21st 2021 it was established as TRIP Centre. It is based at the Indian Institute of Technology (Delhi) and is an interdisciplinary academic unit focusing on the reduction of adverse health effects of road transportation. researchers at TRIP Centre seek to integrate all issues concerned with transportation to promote safety, active mobility, cleaner air, and energy conservation. They are involved in planning safer urban and inter-city transportation systems and developing designs for vehicles and safety equipment.

Endowments for perpetual Chairs
CONFER, India: TRIPP Chair for Transportation Planning
Ford Motor Co., USA: Ford Chair for Biomechanics and Transportation Safety
Ministry of Urban Development India: MoUD Chair for Urban Transport & Traffic Planning
MoUD Chair for Urban Transport and Environment
MoUD Chair for Urban Traffic Safety
VREF: Volvo Chair for Transportation Planning for Control of Accident and Pollution

Establishment funds have been received from
Ministry of Industry, Government of India
Asian Institute of Transport Development, India
Tata Motors Limited, India
Volvo Research and Educational Foundations (VREF), Sweden

CONTACT
Phone: 91-11-26596361, 26596557
Fax: 91-11-26858703, 26851169
hodtripc@iitd.ac.in
http://tripc.iitd.ac.in
Transportation Research and Injury Prevention Centre
Room MS 815 (Main Building)
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110016
INDIA

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Abstract: M.Tech Thesis

EVALUATION OF CURB SIDE BUS LANE ENFORCEMENT ON BUS PERFORMANCE - *Mukesh Kumar*

Bus travel in mixed traffic usually causes delays and inconvenience to passengers because of low speed and uncertainty. Designation of bus lanes by pavement markings and signs can lead to better travel experience for bus travellers apart from enhanced safety for all road users. In the current study, efforts have been made to evaluate the effect of curb side dedicated bus lane on the bus performance.

The study has been done to observe the movement of buses in the curb side lane and its deviation from the designated lane along the inner ring road in Delhi. The performance has been evaluated in terms of finding the average travel speed of buses between two consecutive travel segments and the percentage of time the bus was deviating from its designated curb side bus lane.

The current study has analysed impact on average bus travel speed after enforcement of curb side bus lane in Delhi and suggested measures to improve the performance and efficiency of buses for a better and safe travel experience for daily commuters/passengers. This study has observed and incorporated the reasons and side frictions faced by the buses resulting in curb side bus lane deviation along the inner ring road in Delhi. In this project, the observed bus travel data has been modelled by using multiple linear regression model as well as logistic regression model.

The regression modelling results have shown that illegal parking of vehicles, presence of slow moving NMTs and encroachment of curb space by vendors have a significant effect on the performance of buses. After analysis and interpretation of data, results have been discussed and measures are suggested like provision of MUZ (Multi-Utility Zone) along curb side of bus lane and strict bus lane enforcement discipline by transport department to improve the bus performance while travelling in the curb side dedicated bus lane along inner ring road in Delhi.

The traffic scenario in India is quite different from other parts of the world. Here, the traffic is composed of mixed type of vehicles ranging from light vehicles like two wheelers / cars to heavy commercial vehicles such as buses and trucks etc. These vehicles ply on roads with free-flow speeds generally varying between 40 to 100 km/h. The vehicles normally do not exhibit very good lane disciplined behaviour. Many factors are responsible for this poor performance about lane discipline. The slackness on the part of enforcement agencies and lack of awareness and education regarding rules/regulations among Indian drivers further contribute in worsening the situation.

As a result, most drivers are interested in overtaking the vehicles along their travel path to improve their journey speed rather than sticking to their lanes. Coming from different background and lack of education, they generally fail to understand the importance of lane discipline and its consequences. Since, at present there are hardly any central monitoring system and the video cameras have also been installed at select few locations, the violations by the drivers often go unreported. Therefore, along the lateral width of roadway, all categories of vehicles can be seen plying and competing with each other to move faster. Since these vehicles possess different static and dynamic traffic characteristics, mixing of various class of traffic result in a longitudinal and transverse dispersion of different types of vehicles on the same roadway width during their movement.

Mostly roads in India are not designed to address the needs of non-motorized road users, and other activities such as intermediate transport (three wheelers) movement/parking, vending spaces, etc. These functions are generally forced on the carriageway, occupying the curb side edge, which means they overlap with the designated bus lane. In addition, unregulated or enforced parking of vehicles also often occupy curb side edge of the carriageway (TRIPC, 2022).

In April 2022, Transport Department, Govt of Delhi, initiated enforcement for buses to use the left most lane of the carriageway. While other vehicles were permitted to drive in this lane, buses and heavy goods vehicles faced steep fines if they were found driving in any other lane of the carriageway. To avoid steep fines, most bus drivers tried to remain within the bus lane, and minimize their exit from the bus lane unless forced to do so because of any obstruction (parked vehicles, stalled vehicles, vendors or breakdown vehicles etc.) or at the turning movements.

Unforeseen eventualities such as vehicle breakdown, requiring emergency parking or maintenance, also occupy curb side edge of the carriageway. This means that buses faced significant number of obstructions in their operations and their effort to minimize the length for which they can remain outside the designated bus lane, leads to frequent decelerations. This kind of regulation only for the buses to remain within the designated bus lane, leads to frequent decelerations due to number of obstructions faced along the curb side.

This has resulted in significant loss of operational speed and efficiency of buses in completing their daily transit schedules.
The role of bus lane discipline observed by drivers becomes very important for an effective and safe traffic management (Shirke et al., 2017) particularly during periods of high traffic congestion. During the recent study done on National Highway 8 (NH 8) on a stretch of around 40 kilometres between Kamrej and Ankleshwar (Shirke et al., 2014), it is found that in mixed traffic flow conditions, both the slow-moving vehicles and heavy commercial vehicles have an inherent tendency to ply either on median-side lane or on middle lane on the carriageway. Due to this reason, lot of frictions / obstructions are being faced by the fast-moving vehicles in the dedicated lane meant for them. This adversely affects the efficiency, safety and performance of mixed traffic on the road. Unfortunately, very few studies have been carried out in India to evaluate the effect of heterogeneous traffic flow on multi lane roads in urban areas.

Most of the research work in this field can be found in the developed countries from the literature review. Unfortunately, very few studies have been carried out in India to evaluate the effect of heterogeneous traffic flow on multi-lane roads in urban areas. Most of the research work in this field can be found in the developed countries from the literature review. In view of the above, present study aims to evaluate the effect of curb side bus lane enforcement on the performance of buses travelling on inner ring road in Delhi as a case study.

CYCLING IN PERI-URBAN AREAS: CHARACTERISTICS AND INJURY RISK FACTORS - *Rasagna Paturi*

Bicycles are a significant mode of transportation among industrial workers. In Delhi's peri urban areas where many industries are located, a large number of captive cyclists use highways to reach their destinations, but little research has been conducted on this topic.

Our study investigates the characteristics of cycling in peri-urban areas of Delhi and examines the impact of road infrastructure attributes on cyclist injury risks using a modified case-crossover approach. We defined peri-urban areas as the buffer space between Delhi’s peripheral areas and its adjoining cities in Haryana. The intercept survey found that most cyclists in peri-urban areas have a monthly income ranging from ₹ 10,000 to 15,000 and travel an average distance of 12.2 km per trip.

In the modified case-crossover approach, we intercepted three cyclists on the locations of each of fatal cycle crash. Using the origin locations of the respondents, we modelled their route to the crash location, and selected a random location on that route. For 50 fatal crash locations (cases), we used a total of 150 control locations. Binary logistic regression models are then employed to examine why certain road locations have higher likelihood of fatal cycle crash than

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others.

We present both unadjusted and fully adjusted models. We found that higher volumes of bicycles, vans, and cars are associated with an increased likelihood of injury. Conversely, higher volumes of motorized two-wheelers are linked to a lower likelihood of injury. We found a strong effect of the presence of U-turns on roads on the greater likelihood of a fatal cycle crash.

We conducted questionnaire surveys with 165 cyclists that we intercepted in order to gather information about their origin locations and to gain insights into cycling patterns in peri-urban areas. Additionally, we included questions about age, gender, destinations, and monthly income to understand the characteristics of the cyclists. Later on, we expanded the survey to include questions about education and vehicle ownership, and we interviewed a subset of 117 cyclists to gather this information. We derived a descriptive analysis from these surveys and key findings show that 41% of the cyclists fell within the age range of 30-44 years, and all were male. Monthly income of 48% of the cyclists was in the range of ₹ 10,000-15,000. Furthermore, 46% of the cyclists had completed high school, and a significant majority of 91% owned only a bicycle. The average reported trip distance was approximately 12.2 km.

Interestingly, these results align with the descriptive statistics of peri-urban crashes, where approximately 50% of the crash victims were also within the age range of 30-44 years and also all victims in peri urban crashes were male. The impacting vehicles in both peri-urban and urban crashes were primarily trucks and cars. Notably, peri-urban crashes showed a higher involvement of M3W as impacting vehicles, while urban crashes were characterized by a higher presence of M2W. The analysis of crash times revealed that peri-urban crashes were most frequent between 4 am and 7 am, coinciding with the majority of the interviewed cyclists' start times.

In contrast, urban crashes occurred more frequently between 8 pm and 12 pm. These findings provide valuable insights into the characteristics of both the surveyed cyclists and the peri-urban crash data, highlighting factors that influence cyclist safety in different areas.

The significant findings from this case-crossover design analysis, indicates that the presence of U-turns is strongly linked to an increased likelihood of crashes. Moreover, the study demonstrates that National Highways and expressways exhibit a higher crash risk compared to local roads. Additionally, high traffic speeds and wider roadways contribute to an increased risk of crashes. The presence of medians, on-street parking, flyovers, bus metro stops, and junctions also amplifies the probability of injuries. Specifically, locations in close proximity to bus stops and flyovers pose a greater crash risk for cyclists. Furthermore, elevated volumes of cars and heavy vehicles correlate with increased odds of injuries.

Conversely, in the presence of service roads and higher volumes of M2W and M3W the likelihood of a crash is reduced. We observed a counter-intuitive finding indicating that higher bicycle volumes are associated with a higher crash risk, contradicting the commonly observed "safety in numbers" effect.

GROWTH IN MOTORCYCLE USE AND ITS CONTRIBUTION TO EMISSIONS OF AIR POLLUTANTS AND GREENHOUSE GASES IN A MEDIUM SIZE CITY - *Siddharth Tiwari*

In India, Motorised two-wheelers (MTW) account for 75% of all the registered vehicles. The increase in MTW ownership is 3 times higher than the car ownership in India. A large proportion of transport emissions is from MTW. The purpose of this study is to examine the growth of motorcycles, relative to other modes of transportation and the contribution of MTW to emissions of air pollutants specifically in a medium size city. The methodology includes primary surveys and secondary data sources to estimate in-use fleet size, the annual average distance travelled, fuel efficiency, fuel share and emission factors for urban and rural Bhopal.

A primary survey was conducted in rural and urban areas to examine the fleet composition, fuel efficiency, fuel share and annual average travel distance. The present study employs a methodology aimed at generating a comprehensive inventory of exhaust emissions in Bhopal, India. Specifically, the methodology involves the assessment of vehicle activity, fuel efficiency, and fuel share across various vehicle types, fuel types, and age groups. The survey methods and analysis techniques are simple and quick to implement, and they can provide a useful data source for estimating on-road transport emissions in both urban and rural areas.

The objective of the current investigation is to assess the levels of fuel consumption and vehicular emissions within the urban and rural regions of a city of moderate size, specifically Bhopal, located in the state of Madhya Pradesh. The assessment of vehicular fleet emissions involves the examination of various categories and subcategories of vehicles, each utilising distinct fuels and technologies, and belonging to diverse age cohorts. The present investigation aimed to estimate vehicle emissions in a medium-sized city by considering several parameters, including the quantity of vehicles utilised, the average annual mileage, and the fuel efficiency.

The fuel efficiency of powered two-wheelers within the age range of 0-10 years is approximately 40 km/l in both urban and rural regions of Bhopal. Research indicates that the mean yearly distance covered by individuals decreases as the age distribution increases, owing to the fact that newer vehicles are utilised more frequently in comparison to their older counterparts.

The findings suggest that the overall fuel usage in both urban and rural regions during the past five years was approximately 11.74 metric tonnes (MTW). Petrol consumption has experienced a nearly ten times increase in the past decade, primarily attributed to the proliferation of vehicles powered by petrol among the fuels that have been scrutinised. The estimated vehicle emissions of total carbon dioxide (CO_2), carbon monoxide (CO), particulate matter (PM), and nitrogen oxides (NO_x) are projected to be 37 Tg and 1755.7 Gg respectively. Additionally, the estimated emissions for the MTW is 1755.7 Gg for the year 2021.

The aforementioned observation serves as a clear indication that the emissions level is on the rise in the medium-sized city, thereby necessitating the implementation of mode-specific strategies to effectively mitigate the emission levels. The management of emissions can be attained through the utilisation of alternative fuels such as CNG/LPG and the ownership of electric vehicles for passenger mobility. Additionally, the transition to BS-VI norms and the implementation of a scrappage policy for vehicles exceeding 15 years of age can also contribute to this objective.
The growing population and economy of India are anticipated to result in a surge in passenger numbers and heightened mobility, thereby engendering a corresponding escalation in transportation emissions, oil requisites, and health issues associated with pollution. The fleet predominantly comprises of MTWs, cars, however, the swift proliferation of motorcycles has incurred certain expenses. Motorcycles, particularly those equipped with outdated engine technology, have a tendency to discharge a greater number of atmospheric pollutants and greenhouse gases in comparison to alternative means of transportation.

The issue of exhaust emissions from vehicles has gained significant attention in the context of air pollution and climate change. Consequently, it is imperative to enhance our comprehension of the vehicles and their occupants in urban and rural areas. Vehicle emissions pose a challenge not only in urban areas but also in other locations. Considering that over 60% of India's populace resides in rural regions, it is imperative for the research to incorporate these areas in the computation of emission levels and their associated impacts. The impact of emissions on medium-sized cities is a crucial matter that warrants additional research. This can be accomplished by analysing the age profile distribution of vehicles in centralised PUC data for various comparable medium-sized cities, as well as collecting similar primary survey data to determine the extent of emissions.