Transport and land-use policies in Delhi[1]

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Abstract Current transportation policies in mega-cities worldwide lead to major threats to health through traffic injuries, air pollution, noise, reduction in physical activities, and adverse impact on urban quality of life. In addition, a large section of the population in cities in low-income countries has to live in informal-sector, substandard housing. Many transportation policies fail to take enough account of their impacts on poverty and social exclusion, and they neglect the access and transportation demands of the more economically disadvantaged groups of society, who rely mostly on public transportation, walking, and cycling. Delhi, the capital city of India, is an interesting case because failure to consider the broad spectrum of health effects that may result from transport and land-use policies and investments has resulted in decisions that penalize the least affluent groups of the population and make it more difficult for them to get to jobs, education, health care, amenities, and services.

Keywords Accidents, Traffic/prevention and control/statistics; Transportation/history/statistics/; Bicycling/injuries; Motorcycles; Walking/injuries/statistics; Motor vehicles; Urban health; Air pollution/prevention and control; Environmental health; Public policy; Social control, Formal; Urbanization; Housing; City planning/utilization; Quality of life; Social justice; India/epidemiology (*source: MeSH, NLM*).

Mots clés Accident circulation/prévention et contrôle/statistique; Transports/histoire/statistique; Cyclisme/traumatismes; Cyclomoteur; Marche/traumatismes/statistique; Véhicule motorisé; Santé urbaine; Pollution air/prévention et contrôle; Hygiène environnement; Politique gouvernementale; Contrôle social formel; Urbanisation; Logement; Urbanisme/utilisation; Qualité vie; Justice sociale; Inde/épidémiologie (*source: MeSH, INSERM*).

Palabras clave Accidentes de tránsito/prevención y control/estadística; Transportes/historia/estadística; Ciclismo/lesiones; Motocicletas; Caminata/lesiones/estadística; Vehículos a motor; Salud urbana; Contaminación del aire/prevención y control; Salud ambiental; Política social; Controles formales de la sociedad; Urbanización; Vivienda; Planificación de ciudades/utilización; Calidad de vida; Justicia social; Goa/epidemiología (*fuente: DeCS, BIREME*).

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Voir page 449 le résumé en français. En la página 450 figura un resumen en español. يمكن الاطلاع على الملخص بالعربية على الصفحة ٤٥٠.

Introduction

Urban transportation systems are complex systems defined by land-use and transport policies. A description of a complete transportation system must meet the following conditions:

- All modes of transportation must be considered.
- All elements of the transportation system must be considered — the persons and items being transported; the vehicles in which they are conveyed; and the network of facilities through which the vehicles, passengers, and cargoes move, including terminals where trips originate or terminate and transfer points where commuters transfer from bus to train or bicycle to train or bus etc.
- All movements through the system must be considered.
- For each specific flow — the total trip from point of origin to final destination — overall modes and facilities must be considered.

Such a comprehensive definition of a transportation system enables analysts to consider explicitly the assumptions introduced by eliminating individual elements of a highly complex and interrelated system. In cities in which the level of complexity increases because of large disparities between the city residents, however, often only selected elements are quantified and analysed. The existing traffic and transport indicators — such as kilometres travelled by vehicles, average speeds, and delays experienced by vehicles at intersections — are biased towards motorized travel. Bicycle and walking trips are not included with motorized vehicle trips for traffic analyses. Policies based on such limited analyses result in adverse health impacts for a large section of the population. This is evident from the study of transport land-use policies in Delhi, the capital city of India.

Historical patterns and trends

Delhi is one of the most discussed and documented cities in India. Within its large geographical area, it contains many cities and sub-cities. Delhi has more than its share of urban problems.

Planned development of Delhi has been attempted since 1874, when the Delhi Municipal Committee was formed. In 1910, a town-planning committee was appointed by the British Government to plan an imperial city in Delhi. Soon after independence in 1947, the Ministry of Rehabilitation was entrusted with the task of resettling nearly 450 000 refugees as they arrived from the new border. Problems of pollution and

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housing in the new capital led to the establishment of the Town Planning Organisation and the Delhi Development Authority in 1955 and 1957, respectively, to slow down unplanned growth of Delhi (*1*). The Town Planning Organisation prepared the first master plan for Delhi in 1962 (DMP 62) and earmarked spaces for industrial units and other land uses for the city. The number of industrial units built exceeded the number proposed in DMP 62, however, and so did the number of people working in these units. This resulted in a large number of people with low incomes living in squatter settlements in Delhi. Since 1975, different governments have adopted policies to forcibly evict such people from the city centre of Delhi to the resettlement colonies at the city's peripheries. The master plan for Delhi is supposed to be the blueprint for developing the entire city, and it is supposed to be prepared by including active participation of the city's residents. The planning of the city has remained the prerogative of a few government officials and technical experts, however, with no role for the people to play. The master plan has been violated systematically by many governmental and semi-governmental agencies.

The systemic failure of planning is evident from the situation today. The "green belt" that was specified in DMP 62 has been exploited by land developers. The resettlement colonies and industrial areas, which were supposed to be a ring town under DMP 62, are now a connected suburb. Gurgaon, Faridabad, and Ghaziabad are contiguous urban sprawls, and the arterial roads and national highways are the most congested in the region. Constantly increasing numbers of poor people continue to live in informal settlements without services. Estimates suggest that over 1500 unauthorized colonies are without civic amenities and that as much as 60% of the population lives in substandard housing. The living conditions of the residents in these colonies are very poor, with 70% without sewage facilities and 60% with no separate space for cooking in their houses (*2*). The acute scarcity of land, shelter, and infrastructure means that many people put up shanties or substandard housing, known as jhuggi jhopri clusters or "jhuggies", on public land (and other vacant land). Well over 3 million people are estimated to live in jhuggies; this number is projected to increase to 4.5 million by 2011 and to 6 million by 2020 (*3*). The people from households with low incomes that reside in jhuggies, slums, and low-income, unauthorized, residential settlements in Delhi are "captive pedestrians".

Land use and spatial distribution

Delhi, like most Indian cities, has a mixed pattern of land use. This is partly because large numbers of people need to walk between their places of residence and their places of work. No clear-cut concentric zones of different activities exist. Central core areas comprise not only commercial development but also high-concentration housing, and working-class developments are found in the core and vicinity of the city. Manufacturing activity is spread geographically not only in the peripheral zone but also in the intermediate and inner zones.

Employment in industry grew from 17% of the work force in 1951 to 29% in 1981 and 33% in 1991. Between 1961 and 1971, the number of industries that employed less than 10 workers grew by 444% in Delhi, while Bombay recorded growth of only 51% and Calcutta just 18%. Industrial employment in Delhi increased from 215 000 jobs in 1971 to 1 136 000 jobs in 1999 (*3*). Along with this, a large section of the population is also employed in the informal sector in activities such as distributing newspapers and selling vegetables. The spatial arrangement of social zones in Delhi shows distinct patches of lower-class housing in the outskirts and the innermost commercial areas. The innermost areas are characterized by high population density. These areas of Old Delhi have been declared slums because of their old, dilapidated, and obsolete structures. People of the lower classes reside at the outskirts in resettlement colonies built by the government, those in the elite class are mostly concentrated in the peripheral zones, and middle-class areas are dispersed all over the city.

Traffic patterns

Unlike most Indian cities, the traffic in Delhi is predominantly motorized vehicles. The road space is shared by at least seven different types of vehicles, each with different static and dynamic characteristics (Box 1). The proportion of fast-moving vehicles — especially light, fast vehicles — has increased dramatically over the years. In direction-wise, classified, traffic volume counts between 06:00 and 21:00. on a typical weekday, the Central Road Research Institute showed that cycle traffic contributes 13–34% of the total traffic on roads (*4*). A study by the Indian Institute of Technology of classified volume counts at 13 different locations in Delhi in 1993–94 showed that the share of non-motorized modes of transport ranged between 8% and 66%, of motorized two-wheelers between 22% and 55%, and of cars between 15% and 44% (*5*).

Mobility patterns

Nearly 32% of all commuter trips in Delhi are walking trips. Road-based public transport, including chartered buses, accounts for 42% of all trips. Of the total commuter trips, around 11% are by slow modes of transport, such as cycles and rickshaws, 5% by cars, and 12% by motorized two-wheelers. Table 1 shows the changing modal share of trips in Delhi between 1957 and 1994. The share of trips by motorized two-wheelers increased significantly from 1981; during the same period, the share of bicycle trips declined considerably. The decline in overall share of bicycle trips does not reflect reduced demand for bicycles because, as the population has increased, the absolute number of bicycles on the road has also increased.

Recent sample surveys from the resettlement and unauthorized colonies and the jhuggi jhopri clusters (in which 60–70% of the population is estimated to live) indicate that these citizens still depend largely on walking (19%) and cycling (38%) to get to work (Table 2). The average modal share for the whole city in 1999 (Table 2) was calculated based on the following assumptions. The total population of Delhi is 13 million, and 60% (7.8 million people, or 1.4 million households with an average household size of 5.6 people) have low incomes ($\leqslant$2000 rupees per month). The remaining 40% (5.2 million people, or 1 million households) belong to high-income groups. In 1994, the trip rate including walking trips was 1.13 per capita and including mechanical modes of transport only was 0.79 per capita. These rates are estimated to have increased to 1.8 and 1.2 per capita, respectively, by 2000.

Estimated modal shares for the whole city in 1999 show very different trends compared with modal shares from

Box 1. **Seven types of transport used in Delhi**

1. Public transport buses, normally 12.5 m long
2. Rural transport vehicles originally designed for rural operations that are 6 m long, have high floors, and can carry 12–15 people
3. Minivans and large commercial vehicles are used as route taxis
4. Small three-wheeled scooters are used as taxis
5. Small- and mid-size passenger cars and motorized two-wheelers used as personal motorized transport
6. Motorized two-wheelers: scooters and motorcycles
7. Bicycles, three-wheeled bicycle rickshaws, and walking

Box 2. **Measures suggested to reduce pollution from vehicles in Delhi**

- Construction of expressways and grade-separated junctions (also known as flyovers because one road is elevated to avoid traffic signals)
- Introduction of one-way streets, synchronized signals, and traffic-control systems
- Construction of a metro rail transport system
- Phasing out of older buses and increased number of buses
- Conversion of 100% public transport fleet to compressed natural gas — the clean fuel

Table 1. **Shares of transport modes in Delhi 1957–94 (*13*)**

Mode	Share (%)				
	1957	1969	1981	1994	1994[a]
Cycle	36.00	28.01	17.00	6.61	4.51
Bus	22.40	39.57	59.74	62.00	42.00
Car	10.10	15.54	5.53	6.94	4.74
Scooter/motorcycle	1.00	8.42	11.07	17.59	12.30
Three-wheeled scooter taxis	7.80	3.88	0.77	2.80	1.91
Taxi	4.40	1.16	0.23	0.06	0.04
Rail	0.40	1.23	1.56	0.38	0.26
Other vehicles[b]	17.90	2.19	4.10	3.62	2.47
Walking	NA	NA	NA	NA	31.77
Total	**100**	**100**	**100**	**100**	**100**

[a] Includes walking trips.
[b] Includes cycle rickshaws and *thelas* (human powered vehicles).

1957–94. The two most important factors that contribute to this change may be a rapid increase in the share of the low-income population and major changes in Delhi's bus system. The introduction of private buses that are more expensive than public buses and that might be financially out of the reach of many people resulted in a decline in the share of bus trips and an increase in the number of bicycle trips.

Transport land-use relation

Figure 1 presents a simplified model of the relation between transport and activity system. Transport system includes modes of transport, different technologies of transport, the infrastructure, institutional set-up, and policies concerned with transport system. The activity system consists of the socio-economic and demographic characteristics of the region. It also includes land-use policies and characteristics. In other words, activity system determines the demand for travel, and transport system determines the supply to fulfil the current demand.

Transport systems are disaggregated and consider modes of transport as private motorized vehicles, public motorized vehicles, and non-motorized vehicles. Activity systems also are disaggregated, but by income groups. Socioeconomic and physical characteristics of land-use patterns tend to be homogeneous for people of similar income levels. Activity systems are modelled as overlapping or interconnected subsystems — one for each income level in the society. The transport network involves several levels of flow: that is, the vehicles and modes of travel have very different characteristics. Each mode has different requirements for efficient and safe movement. The various types of flow have not only different but often conflicting requirements: for example, buses need frequent stops to pick up and drop off passengers, but private cars need uninterrupted movement. If the public transport system and private cars have to use the same infrastructure, a decision has to be made on whether the design should focus on bus transport or on fulfilling the needs of car owners.

Fig. 1 shows a feedback loop from a flow subsystem to a transport system as well as an activity system. The types of flows should determine the characteristics of transport systems and the modes and infrastructures required in the future, as well as the land-use patterns and the spatial and temporal spread of activities. After this, future improvements in transport systems should be such that they can fulfil the varied demands of various flows. For example, if cars face congested conditions, and pedestrians inconvenient and unsafe road designs, future improvements to road designs should address both of these concerns.

Similarly, planning of land use should reflect the demands of people with low incomes (shorter distances to travel and high-density mixed land use) as well as the demands of people with higher incomes (low-density large residential plots, infrastructure for private vehicles, etc.). As shown in Fig. 1, however, the feedback loop has a filter. The policy-makers, decision-makers, and "technical experts" weigh up the various options and the trade-offs involved and permit only a few flow patterns to be fed into the overall transportation and activity system. Often transport and land-use policies are designed to address the concerns of people in high-income groups who are dependent on private motorized vehicles. Although 30–70% of the residents in many low-income cities are dependent on informal sector work, the relation between the formal and informal sectors is poorly understood. Often a job in the formal sector requires services provided by the informal sector: each high-income household is dependent on between five and six low-income households for various services. Formal plans do not take into account these relations, however, and a very visible informal sector comprising low-income households is viewed as encroaching on the city. A large proportion of the population that is dependent on the informal sector and on walking, bicycling, and public transport has to face hardships created by inappropriate policies. This is evident from the policies adopted in Delhi in recent years.

Our process of transportation planning creates safe environments for some at the cost of others. Is it possible to resolve this conflict?

Table 2. **Estimated shares of transport modes in Delhi in 1999 (*14*)**

Mode	Share (%)		
	Low-income population	High-income population	Total population
Cycle	39	3	24
Bus	31	36	33
Car	0	28	12
Scooter/motorcycles	3	29	14
Three-wheeled scooter taxis	1	2	1
Taxi	0	0	0
Rail	1	0	1
Other vehicles[a]	3	0	1
Walking	22	2	14
Total	**100**	**100**	**100**

[a] Includes cycle rickshaws and *thelas* (human powered vehicles).

Health impacts

Air pollution and traffic injuries are the two most important adverse impacts of transport land-use policies. Increased air pollution in Delhi — which affects the health of all citizens, rich and poor equally — has become a major public concern, as is evident from the policies and investment patterns in the city, and has been recognized as a public health issue. Recent land-use policies and transport policies have been focussed towards addressing air pollution in Delhi.

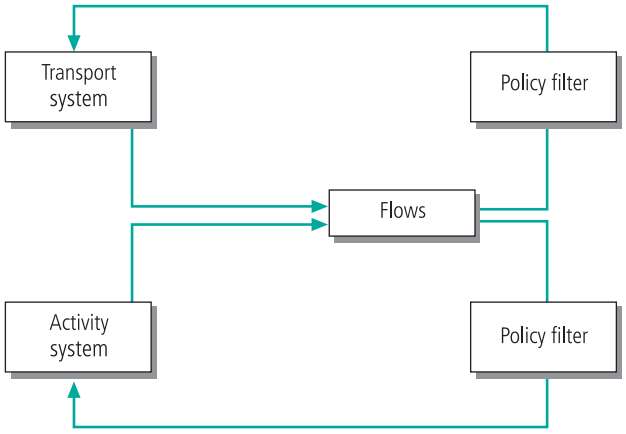
Land-use policies

Two important aspects of land-use policies in the recent past included the relocation of 90 000 industrial units from the city centre for reasons related to pollution and the resettlement of poor people evicted from their original location to the city's outskirts.

The relocation of industrial units may have reduced pollution in the city; however, almost 50 000 people lost their source of income and have faced immense hardships. The court instituted a rehabilitation package for the affected population, but implementation has been very weak and largely remained on paper only. Similarly, the unprecedented large-scale evictions of people from unauthorized and illegal constructions in Delhi from the year 2000 have affected poor people — who are the most vulnerable. The people of the slum communities in Delhi are being removed from their places of self-created living to yield space for six major development projects backed by judicial activism and initiated by the rich and the middle class. Plans to turn Delhi into a clean city seek to evict the poor to the outskirts in favour of commercial complexes, flyovers, recreational parks, and roads for the well off.

The report of the Habitat International Coalition showed that the relocations conducted since 1975 have created a number of irresolute social problems (*6*). It observed that Delhi has a history of illegal and forced eviction and an equally long history of migration into the city. The city needs cheap labour for menial jobs to keep production costs low and maintain the standard of living of the better off — and the poor

Fig. 1. **Transport and activity system**



are the source of that labour. As the city expands and its land increases in commercial value, the "unpropertied" poor are pushed to the periphery. In this way, they are the first to subsidize the current development process at the cost of their own access to regular employment and livelihood opportunities, education, health care, and other social necessities. Since 2000, more than 100 000 jhuggies in Delhi have been displaced 10–25 km away from their original location. This not only reduced opportunities for employment but also increased dependence on motorized transport that is often too expensive for households that survive on limited casual income from the informal sector. Longer pedestrian and bicycle trips also increase the risk of road traffic injuries.

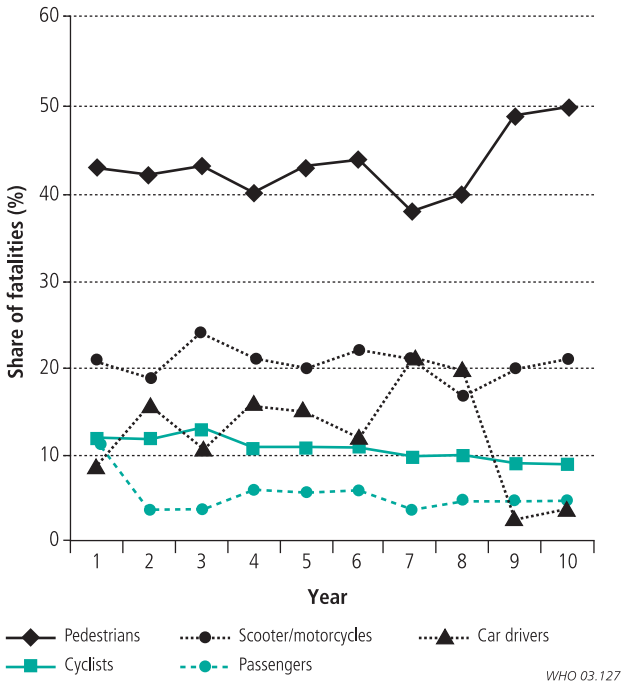
Transport policies

The Government of India in 1997 prepared a white paper on pollution in Delhi (*7*). Subsequently, the Environmental Pollution Control Authority was set up for the city and suggested measures to reduce vehicular pollution (Box 2). These measures do not consider the second major health impact of transport and land-use policies — traffic injuries. In Delhi, pedestrians, bicyclists, and motorized two-wheelers are involved in 75% of the total fatal road traffic crashes (*8*). Because bicyclists and pedestrians continue to share the road space with motorized vehicles, which include buses, cars, three-wheelers, and scooters, in the absence of infrastructure specifically designed for them, bicyclists and pedestrians are at high risk of being involved in road traffic crashes.

Fig. 2 shows the rates of road traffic fatalities in Delhi from 1990 to 1999. Pedestrians constituted the largest share of total fatalities. Most alarming was the trend for this share to increase over the years, while those of other groups either remained constant or declined. Buses and trucks were involved in >60% of fatal crashes. On two- and three-lane roads, fatalities during peak hours were low but not eliminated. On the other hand, during non-peak hours, vehicles that travel at $\geqslant$ 50 km/h killed a large number of pedestrians and bicyclists (*9*). The top ten locations for fatal accidents in Delhi are all on major arterial roads on straight stretches and at intersections; such fatalities predominantly involve pedestrians (*6*).

In Delhi, a major conflict exists between speed and trends in fatalities. Average speed has declined over the years, but congestion on the roads in Delhi is worsening, despite several

Fig. 2. **Road traffic fatalities in Delhi, 1990–99**



local, road-improvement programmes. Average speed during peak periods ranges between 10 and 15 km/h in central areas and 21 and 39 km/h on arterial roads. As average speeds decrease, the number of fatalities would be expected to decrease — the number of total fatalities does show a marginal decline; however, the share of pedestrian fatalities continues to rise.

The decline in average speed of motor vehicles and the pollution levels in Delhi seem to be the two most important factors to influence the type of investment in road infrastructure in the city. The safety and mobility needs of most road users — pedestrians and bus commuters — are not considered in future improvement plans. This has two major impacts on the city traffic and travel patterns. First, the share of pedestrian and public transport trips as a percentage of total trips has decreased over the years. In both cases, the people who walk and use public transport despite the hostile environment only do so because they have no other option. Second, the socioeconomic context of our cities means that pedestrians cannot be removed and motorized vehicles thus

Wide roads, expressways (especially elevated sections), and grade-separated junctions also divide the urban landscape into separate zones, and it is very difficult for people to cross these arterial roads on foot or with other non-motorized modes of transport. This discourages the use of public transport, as commuters who use buses must cross roads at least twice for every round trip — at the origin and the destination.

Numerous experiences from very different locations suggest that the construction of more high capacity roads can unintentionally reduce the use of public transport and bicycles without increasing vehicle speeds or reducing congestion on city roads (*10, 11*). Reductions in bus and bicycle use would result in higher pollution levels and possible increases in traffic congestion. No detailed studies have been done to understand the effect of these changes on the behaviour of road users in cities of low-income countries. In such countries, the construction of high-capacity roads at the expense of facilities for public transport and non-motorized traffic could make the situation worse for everyone by resulting in more congestion for motorized traffic, a higher risk of accidents for non-motorized traffic, and reductions in public transport and non-motorized traffic.

Metro rail systems

The Delhi Government considers construction of metro rail systems as an important countermeasure to reduce congestion and pollution. A rail line 8.3 km in length was opened to the public on 25 December 2002. Delhi Metro Rail Corporation repeatedly said that once the metro was completed the number of buses, environmental pollution, and the number of road traffic crashes would reduce. A careful look at the details tells a different story, however. At present, Delhi Transport Corporation runs at least 650 bus routes in the city. A metro system of 200 km could not match the catchment area covered by an extensive bus system such as that of Delhi Transport Corporation. Environmental pollution and the number of traffic accidents would be reduced only if the road design changed and if lower average speeds at non-peak hours could be ensured on the city's roads.

Phasing out of older buses

Phasing out of older buses to reduce air pollution can result in higher operating expenses and increases in costs for bus users. A study from Delhi showed that 3% of the passengers on the city's bus services own cars and 18% own scooters and motorcycles (*12*). About 11% of the bus users in Delhi travel