Distance, transport mode, and road safety on school journeys in urban India

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DECLARATION BY CANDIDATE

I have written the entire thesis presented below. The manuscripts written for journal publications involved co-authors.

The work in Chapter 4 and 5 was published in joint names in 2015 (Tetali S, Edwards P, Murthy G, Roberts I. *Development and validation of a self-administered questionnaire to estimate the distance and mode of children's travel to school in urban India.* BMC Medical Research Methodology, October 2015, **15**:92.)

The work in Chapter 7 was published in joint names in 2015 (Tetali S, Edwards P, Murthy G, Roberts I. *Road traffic injuries to children during the school commute in Hyderabad, India: cross-sectional survey.* Inj Prev. 2015 Dec 23. pii: injuryprev-2015-041854. doi: 10.1136/injuryprev-2015-041854)

The work in Chapter 6 was published in joint names in 2016 (Tetali S, Edwards P, Murthy G, Roberts I. *How do children travel to school in urban India? A cross-sectional study of 5,842 children in Hyderabad.* BMC Public Health, October 2016, 16:1099)

For all three manuscripts, I collected, analysed and interpreted the data, and drafted and revised the manuscript. Phil Edwards guided the conception and design of the study, interpreted the data and made substantial contribution to drafting and revising the manuscript. Ian Roberts and GVS Murthy revised the manuscripts critically for important intellectual content.

I have read and understood the School's definition of plagiarism and cheating given in the Research Degrees Handbook. I have acknowledged all results and quotations from the published or unpublished work of other people.

I declare that no copy editing and, or, proof reading services were availed by me in the preparation of this thesis. I have exercised reasonable care to ensure that the work is original and does not to the best of my knowledge break any UK law or infringe any third party's copyright or other intellectual property right.

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ABSTRACT

Background- A third of a billion children travel to school every day in India, yet little is known about this journey. Increasing motorisation in India is likely to have implications for road safety of children. This thesis develops methods to measure distance to school, transport modes, and risk of road traffic injury, on journeys to school in Hyderabad.

Methods- Following a systematic review, a self-completion questionnaire was developed to estimate the distance and modes of travel to school in India. Its validity and reliability was assessed using the kappa statistic. A cross-sectional survey using a two-stage stratified cluster sampling design was conducted in government funded, government aided, and private schools in Hyderabad. The relationship between modes of travel and distance to school was analysed using logistic regression, adjusting for confounders. The prevalence of road traffic injury in the previous 12 months during school journeys was estimated, and the impacts of alternative transport scenarios on road injury was modelled.

Results- The questionnaire provided reliable information on the usual mode of travel to school, and road injury. Distance to school measured by asking for the nearest landmark to a child's home was found to be a valid measure of distance compared to a method based on in-depth interviews with children. Forty five schools including 5,842 children aged 11-14 years participated in the survey, with a response rate of 99%. Most children in Hyderabad walked or cycled to school. Others travelled by motorised 2-wheelers, auto-rickshaw, school bus, public transport bus, and car. Greater distance to school was strongly associated with the use of motorised transport. A sixth of all children reported a road injury during school journeys, which was strongly associated with travel mode and distance to school. The overall risk of road injury was 25/100,000 child km per year. Relative to school bus occupants, bicyclists, pedestrians and motorcycle passengers were more likely to be injured, for the same distance travelled. The model showed that road injuries can be prevented under transportation scenarios that restrict distance and motorised vehicles near schools.

Conclusions- The questionnaire reliably measured mode of travel to school and estimated distances to school in Hyderabad. Most children walked or cycled to school and if these levels are to be maintained, there is an urgent need to ensure that walking and cycling may be done safely.

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1 INTRODUCTION

Approximately a third of a billion children travel to school every day in India,[1] yet little is known about this journey. Children's journey to school has major public health impacts, but has received very little attention in research in India.

This thesis explores the public health impacts of children's daily travel to school in urban India. The focus is on journeys to school in Hyderabad: how and how far do children travel to school, with whom do they travel, and how they get back home? The other focus is on the public health impacts of these journeys on school children, specifically road traffic injuries. The undertaking of this research was motivated by the concern over increasing road traffic injuries in India. There is no published epidemiological research on road injuries sustained by children during the trip to school in India.

This chapter begins by describing the importance of the journey to school, as well as the public health impacts of such a journey. In order to understand the geographic setting within which this research was conducted, the next section describes the study area, i.e., the city of Hyderabad; the local context; the rapid urbanisation and motorisation; the city's past and current travel patterns, and future projection of transportation. The next section describes the school system in Hyderabad. This chapter ends with a discussion of the organisation of the thesis. The objectives of the thesis and the titles of the chapters are then outlined briefly.

1.1 Why is children's travel to school important?

Travel to school is a routine activity and a journey that children are obliged to make every day. School travel by children in India has rarely been studied. It does not seem to be an important agenda for policy makers, [2] and children's daily commute does not figure in any policy or political discussion, except perhaps, when a school bus is involved in a road mishap. Knowledge of children's travel is important, as it can inform policy in transport, mobility, environmental sustainability and public health, especially against the backdrop of the recent 'smart cities' initiative in India (described in section 1.3.2.6). Epidemiological research on the relationship between distance and mode, the determinants of children's school travel, or the association between neighbourhood environmental characteristics and children's travel, however, do not seem to be available in India.

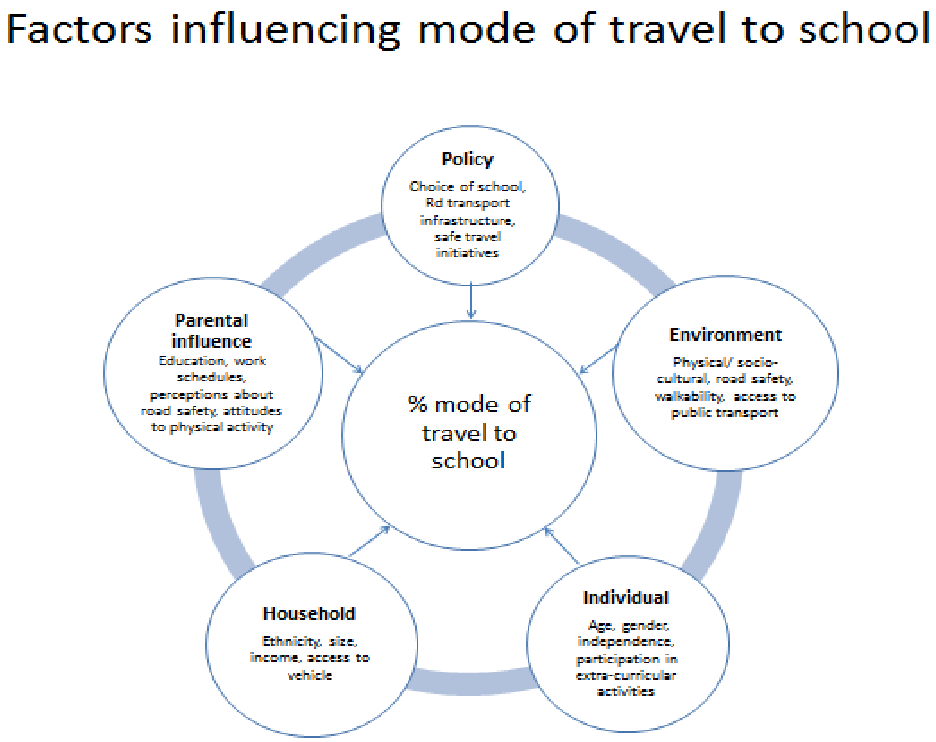
Children's travel to school and back home is a daily activity, which means that the route of travel to school and back home could provide an opportunity for individual exercise on a daily basis. Integrating physical activity while commuting to school is a good opportunity to increase overall physical activity levels, as argued by Mackett, et al (2005):

> "*Every event outside the home requires some form of travel, so the gain from travel in terms of physical activity, can be converted into health gain*". [3]

An estimated 30% of India's population is under 15 years old. [1] The daily movement of these estimated 300 million children, and perhaps their parents, is likely to lead to heavy traffic congestion during school drop-off time. With the explosive growth of motorised 2-wheelers and cars in low or middle-income countries such as India [4], it is important to ascertain the reasons behind the choice of school and the modes of travel to school. The only information we have on school travel in Hyderabad is from a report from the 1980s. [5] Primary data collection in Hyderabad was therefore necessary to provide such information, to eventually plan effective strategies to promote children's walking and cycling to school.

Evidence shows that travel to school is intricately linked to socio-demographic characteristics, household structure and income, car ownership, parental schedules, distance, type of school, cost of school bus service, environmental and other factors. [6] Policies regarding school location and choice also seem to play a vital role. Figure 1.1 summarises the various factors that influence the mode of travel to school that I found through my literature search (described in detail in Chapter 2).

Figure 1.1 Factors influencing mode of travel to school



Source: Literature search (Chapter 2)

Taking cognizance of a seemingly ordinary activity like school travel is important because of its profound implications on children's physical activity levels and independent mobility, and also local and wider environmental effects.

Further, it is important to understand that children's travel cannot be assumed by simply extrapolating from the travel patterns of adults going to work. School travel has a fixed start and end time. In most households with children, school travel may be closely associated with care-givers' travel patterns, and may even depend on their availability to accompany the child to school. Decisions on children's mode of travel to school are normally taken by parents or care-givers in households. [7]

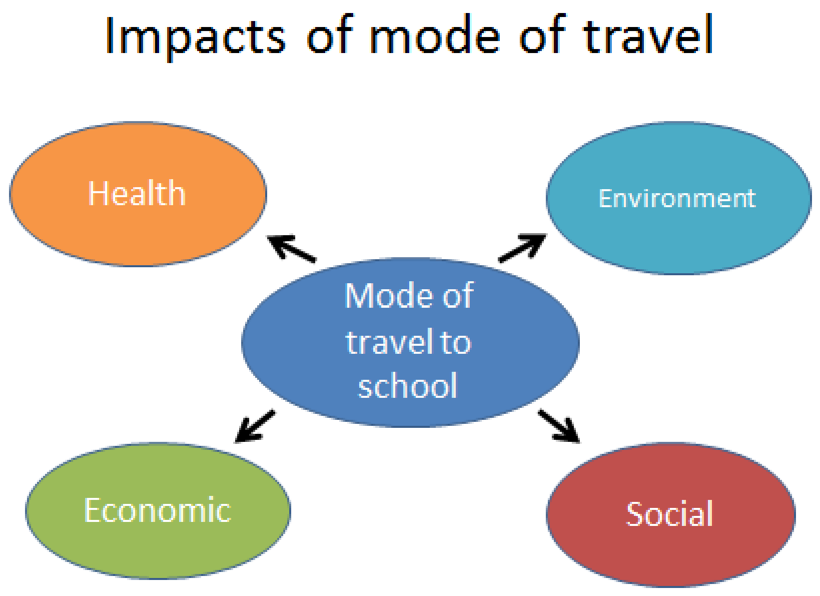
We do not know how far children travel to school in Hyderabad, or in India; and if the trips are short enough to be carried out by walking or cycling. If school trips are fairly short, say about 2 km, they can realistically be made by using modes other than by motor vehicles. [8] Further, children who walk and cycle may better appreciate the benefits of sustainable transport behaviour in the long run. [9]

There are several impacts of the mode chosen to travel to school, as described below.

1.2 What are the public health impacts of the travel to school?

Figure 1.2 shows the broad impacts of mode of travel to school. The detailed pathways are shown in figure 1.3. Health impacts could be due to road injuries or respiratory conditions as a result of air pollution. Economic impacts could be at an individual level, for example, catastrophic expenditure for healthcare because of disability due to road injuries, or at the population level, for example, the cost of road building. Social impacts could be in the form of an aspiration for a more comfortable mode of travel, or the pressure to buy a motorised vehicle, or alienation from the rest of the community because the new highway is going to cut across their village. Environmental impacts could be through depletion of energy, especially fossil fuels, oil resources, or the loss of agricultural lands for road building.

Figure 1.2 Impacts of the mode of travel



Source: Literature review (Chapter 2)

Transportation is the movement of people, animals, marketable raw and finished goods as well as products from one location to another. Transport is vital for enabling trade, which inspires urban development and economic activity. It provides for the easy flow of goods and people, leading to development of civilizations and societies. Faster transport options, like motorised transport by road, air, rail and freight are essential for wider spread of people and exchange of ideas and techniques. Motorisation also helps in easy access to jobs, education, recreation, and commercial activities, which has far reaching economic impacts.

But it also has negative impacts, especially on public health.

The pathways diagram (figure 1.3) attempts to describe the negative effects of motorised transport to school in terms of health, environmental and socio-economic effects. The focus of this thesis is on the health effects, especially on road traffic injuries.

Figure 1.3 shows that the mode of travel, especially using automobiles, is an important determinant of negative impacts on health: reduced physical activity, noise and air pollution, and traffic injuries. The current automobile based mobility trends need to be slowed or reversed, and high public transport and non-motorised transport mode shares need to be preserved, or Indian cities will continue to face a future of high energy consumption, poor air quality, chronic congestion, high road fatalities and unaffordable transport choices for the poor.

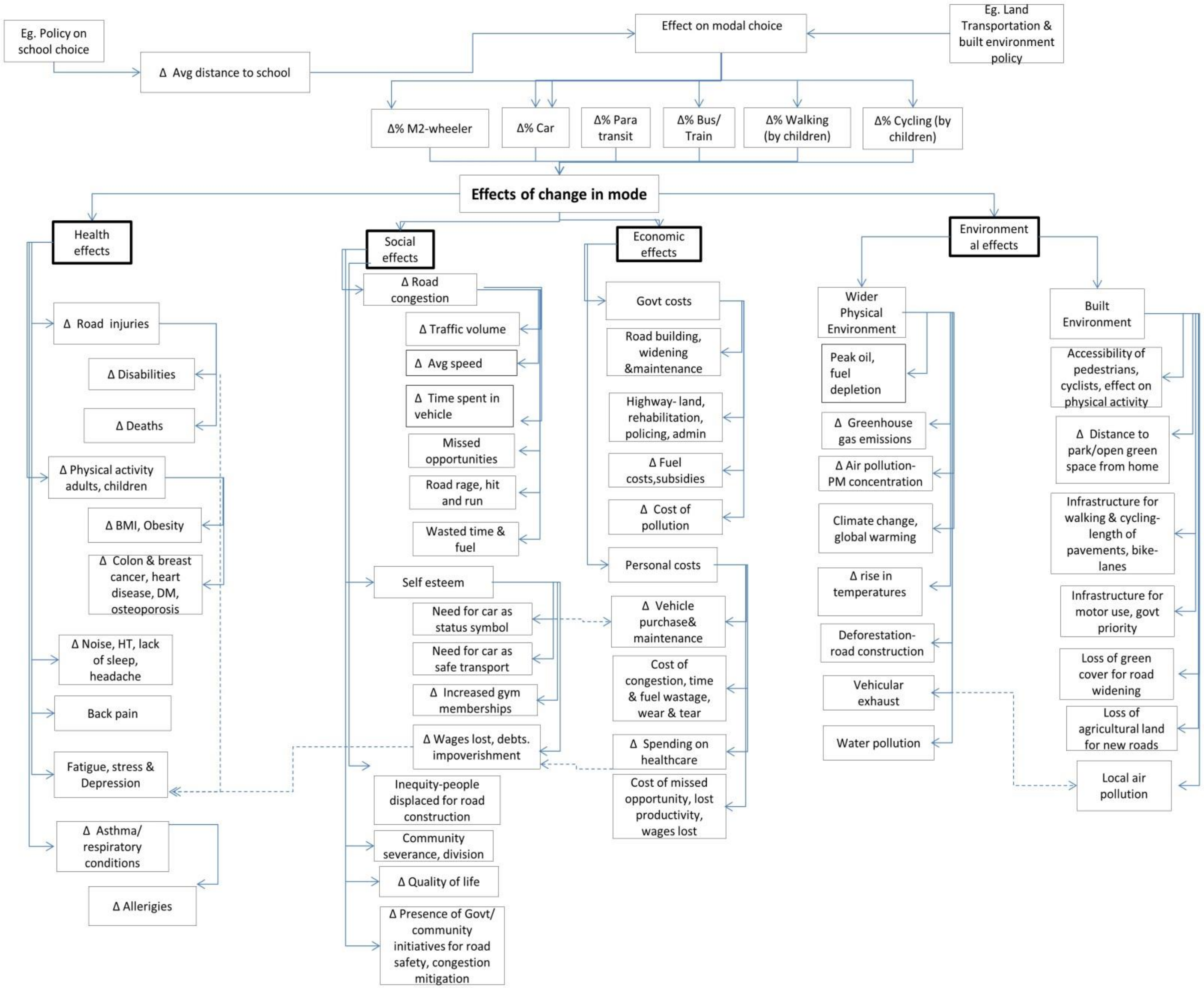
A country's policy on fuel import and usage for transport could also influence air pollution levels. For example, investments that favour automobile-based mobility in some countries has resulted in air pollution, fossil fuel dependence, inequitable access, neighbourhood disruption, and mounting congestion, which erodes economic growth and quality of life. [10]

Worldwide, energy use is increasing faster in the transport sector than in any other sector. From 1980 to 1997, transportation energy use and associated greenhouse gas emissions increased over 5% per year, compared to 1% of greenhouse gases from all sectors worldwide. [11] Physical infrastructure that supports motorised transport and subsequent vehicular emissions impacts both the local atmosphere as well as the wider physical environment. [12] Peak oil and fossil fuel consumption to power automobiles is shown to have far reaching consequences, including widespread water pollution.

The economic costs of road networks is huge even if we consider just the direct costs of highway land capital expenses, road building and widening, maintenance, administration and policing. Indirect costs include, but are not limited to, government subsidies for fuel, rehabilitation, and cost of pollution. Personal costs consist of vehicle purchase; maintenance; insurance; fuel, parking; and costs related to road congestion- vehicular wear and tear; missed opportunities; and wasted time and fuel. [13] Healthcare demands arising from transport impacts such as traffic injuries, disability or chronic diseases are staggering. Families can be pushed into poverty, especially if these are out-of-pocket expenses. [14] Road traffic injuries are discussed in more detail, in section 1.2.1

Similarly, social costs are enormous if we include the impacts of inequity, division, wages lost and poor quality of life of populations displaced for road construction. [15] [16] Social inequity and community severance is caused by major roads being built through a community, with a proportion of local residents being cut off not only from safe and easy access to shops, schools and other facilities but also from their social network. Studies demonstrate that the number and frequency of social contacts falls as traffic volume increases. [17]

Figure 1.3 Pathways diagram



Eg. Policy on school choice
Δ Avg distance to school
Effect on modal choice
Eg. Land Transportation & built environment policy
Δ% M2-wheeler
Δ% Car
Δ% Para transit
Δ% Bus/ Train
Δ% Walking (by children)
Δ% Cycling (by children)
Effects of change in mode
Health effects
Δ Road injuries
Δ Disabilities
Δ Deaths
Δ Physical activity adults, children
Δ BMI, Obesity
Δ Colon & breast cancer, heart disease, DM, osteoporosis
Δ Noise, HT, lack of sleep, headache
Back pain
Fatigue, stress & Depression
Δ Asthma/ respiratory conditions
Δ Allergies
Social effects
Δ Road congestion
Δ Traffic volume
Δ Avg speed
Δ Time spent in vehicle
Missed opportunities
Road rage, hit and run
Wasted time & fuel
Self esteem
Need for car as status symbol
Need for car as safe transport
Δ Increased gym memberships
Δ Wages lost, debts. impoverishment
Inequity-people displaced for road construction
Community severance, division
Δ Quality of life
Δ Presence of Govt/ community initiatives for road safety, congestion mitigation
Economic effects
Govt costs
Road building, widening &maintenance
Highway- land, rehabilitation, policing, admin
Δ Fuel costs,subsidies
Δ Cost of pollution
Personal costs
Δ Vehicle purchase& maintenance
Cost of congestion, time & fuel wastage, wear & tear
Δ Spending on healthcare
Cost of missed opportunity, lost productivity, wages lost
Environment al effects
Wider Physical Environment
Peak oil, fuel depletion
Δ Greenhouse gas emissions
Δ Air pollution- PM concentration
Climate change, global warming
Δ rise in temperatures
Deforestation- road construction
Vehicular exhaust
Water pollution
Built Environment
Accessibility of pedestrians, cyclists, effect on physical activity
Δ Distance to park/open green space from home
Infrastructure for walking & cycling- length of pavements, bike- lanes
Infrastructure for motor use, govt priority
Loss of green cover for road widening
Loss of agricultural land for new roads
Local air pollution

Research from high- income countries shows that travel distance to school and transportation infrastructure are two major barriers to walking and cycling to school. [18] Although we do not have epidemiological research studies that report the barriers to walking and cycling to school in India, the concern about poor road safety in India is likely to considerably affect the choice of mode of travel to school. We do not know the numbers of children injured on the route to school; whether children in certain age groups are particularly susceptible to road injuries, and whether travel mode choice is associated with injury risk.

Unfortunately, even the informal school transportation policy in India, as it exists, is confined to private schools which operate buses paid for by the parents. [19] It largely views school travel as isolated trips in private school buses. A government policy that is well thought of, and takes into account child road users of different modes of travel, not just the school bus, is needed urgently in India.

1.2.1 Road traffic injury

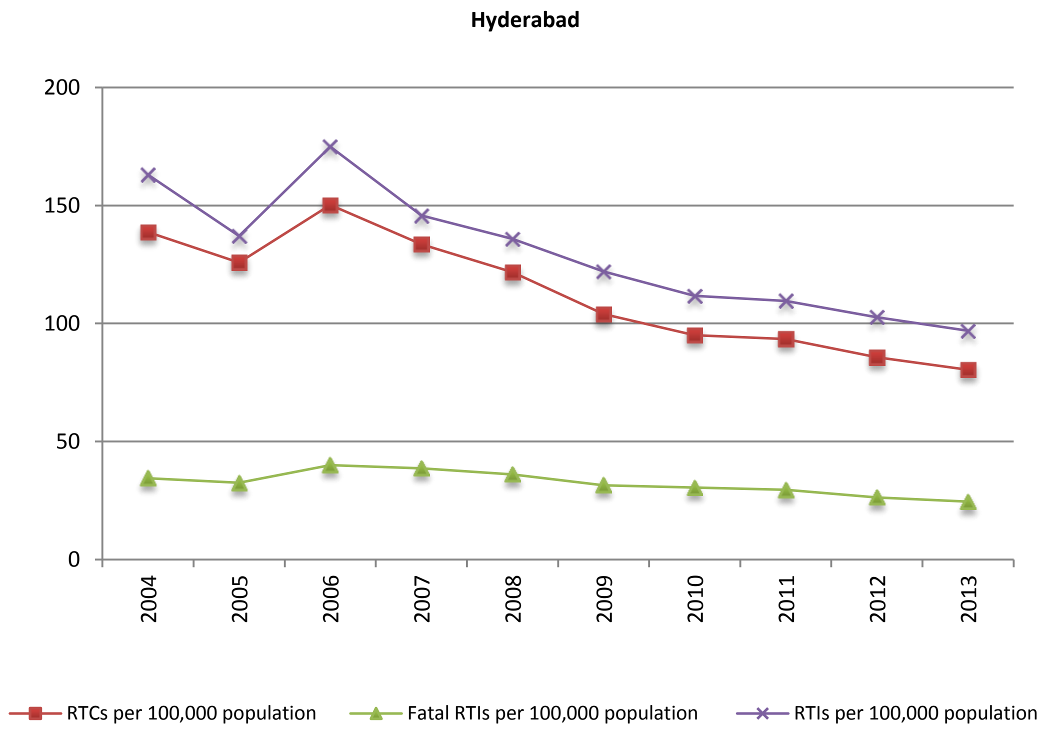
Globally, 1.2 million deaths and 20–50 million injuries are caused each year as a result of road traffic crashes.[20] The worst affected are young adults aged 15–44, and vulnerable road users like pedestrians, cyclists and motorcyclists. About 91% of global road traffic deaths occur in low or middle-income countries, despite having only half the world's vehicles. [20] Worldwide, road traffic injury is the leading cause of death among young people aged 15-19, and is the second leading cause of death among those aged 5–14. An estimated 180,000 children are killed annually, [21] with 93% of child road deaths occurring in low or middle-income countries. [22]

Road injury is a growing public health problem in India, a middle-income country in the WHO's South East Asia region. An estimated 231,000 fatal road injuries were recorded in India in 2010, [20] accounting for about 70% of all road traffic deaths in the region. [23] According to official statistics in 2013, the rate of road traffic crashes, injuries and deaths per 100,000 population in India was 38.9, 39.6 and 11.0 respectively. [24] Approximately half of all deaths on India's roads are among vulnerable road users - motorcyclists, pedestrians and cyclists. [20]

Road injury is a mounting concern for the government, parents and schools, especially in urban India. Hyderabad is one of the fastest growing urban areas in India [25] [25, 26]and is also motorising rapidly. [26] [27] Poor road safety is a cause for concern, [28] as road injuries have been increasing. The number of road injuries was up from 2294 in 2013 to 2540 in 2014 in Hyderabad. [29] In 2014, the number of road crashes and deaths in Hyderabad were 2585 and 358 respectively. The corresponding numbers for London in 2014 were 25,992 crashes, and 127 deaths. [30]

Previous studies have also documented a high burden of road injuries in Hyderabad. A population-based study among people aged 5-49 years in Hyderabad showed that nearly 1 in 14 people reported non-fatal road injuries annually, requiring a recovery period of over 7 days. An estimated 35 per 100,000 people are estimated to be disabled due to road injuries each year. [31] A study in Hyderabad on the road use pattern and risk factors for road injuries in children found that the annual rate of non-fatal road injuries requiring a recovery period of more than 7 days was 7% for boys and 4.5% for girls. [32] Figure 1.4 shows that Hyderabad reported 97 road traffic injuries per 100,000 population in 2013, with 24.5 deaths per 100,000 population.

Figure 1.4 Trend of road traffic crashes, injuries and deaths in Hyderabad (2004 – 2013)



Source: Data from Hyderabad traffic police, compiled in the final report of the Bloomberg philanthropies' Global Road Safety Programme (unpublished report) (32)

The effect of road traffic injuries in India is important: they are a major cause of hospitalisation, disabilities, and health related socioeconomic losses. This is because the economically productive age group is the most affected due to road traffic injuries. [23] [33] [34] About 2.2% of the Indian population is estimated to have some form of disability. [35] Injuries are estimated to be responsible for one-third of these disabilities, with road injuries contributing to nearly half of the total injury disability. [36] The high burden of road injuries has been documented to be associated with catastrophic out-of-pocket medical expenditure in Hyderabad. [37] Despite this huge burden, road injury is not considered a serious public health issue by policy makers in India. [2] A lack of regular and methodical data collection on road injuries could be one of the reasons for this. A large percentage of road injuries go unreported because of the lack of a systematic injury information system. [38]

1.2.2 Physical activity

'Physical activity', any form of muscular movement that produces energy expenditure [39] is credited with numerous health benefits for children and youth. [40] The dose-response relationship indicates that the more the physical activity, the greater the health benefit. [41]

Daily physical activity can be accrued through walking and cycling to school. Although active commute to school alone may not be enough to fulfil the physical activity requirement for a child, it can contribute to the daily overall amount of energy expenditure, and help prevent the development of chronic diseases. It is therefore important to encourage children to walk and cycle because it has been shown to have positive long-term health and societal benefits by promoting healthy behaviour from an early age. Lack of physical activity is now known to be a major risk factor for a range of non-communicable diseases, including heart disease, colon and breast cancers, diabetes and depression. The World Health Organisation estimates that as many as 3.2 million deaths each year are related to physical inactivity. [39] The Global burden of disease study (2010) further confirmed that lifestyle-related illness is a growing problem in both high and middle-income countries. [39] By 2030, it is estimated that Indians will be 14% less physically active than their 2000 levels. [42]

Physical activity among children in India has been examined primarily against a background of rising obesity and overweight levels, mostly in the urban areas. [43] [44] [45] 'Active commuting' to school by means of walking or by bicycle, a potential source of continuous moderate activity, has been largely ignored in surveys of physical activity. The Global School Based Health Survey to assess health behaviours among 13-15 year old children in 34 low and middle-income countries including India showed that only 23% of boys and 15% of girls met the physical activity recommendations. [46]

Literature from other countries shows that many factors may influence children's physical activity patterns. These factors range from physiological- age, gender, ethnicity; psychological- self efficacy, perception of sports competence, perceived barriers like lack of time; socio-cultural- parental level of physical activity, parental income and support; ecological- access to facilities and play areas, availability of equipment and access to transportation options. [47] These factors, including the mode of travel to school have not been studied in India.

Children who walk or cycle to school are found to have better energy expenditure and seem to meet physical activity guidelines. [48] [49] Everyday trip like the one to school has the potential to improve health by offering children the opportunity to perform activities that enable them to be physically active. Therefore “any trip outside home will be better for them than being at home, in terms of physical activity”. [3] Active travel should therefore be integrated into school trips. Active travel to school is shown to lead to non-sedentary behaviour after school too. A study found that boys who walked to school were more active after school and in the evening, compared with those who travelled to school by car. [50] This is perhaps because of positive attitudes to physical activity among active commuters. [3] European studies have documented significant relationships between greater active commuting and positive health indicators, including lower body mass index, healthier blood lipid profiles, and lower blood pressure. [51]

Studies have identified traffic as a major risk factor for the development of obesity in children. [52] The sharp decline in active commuting to school over the years is considered “an important loss of everyday physical activity for school students”. [53]

Positive parental attitudes to physical activity are likely to influence the child, and adult activity patterns appear to be established during childhood. [54] Physically active children are likely to continue to be physically active adults. It has been shown that physically active young people more readily adopt other healthy behaviours. [55]

1.2.3 Air pollution

India is reported to harbour 13 out of the world’s 20 most polluted cities. [56] Air quality of Hyderabad is also deteriorating [57] with the transportation sector being the largest contributor (70%) of emissions in the city. [58] Further, the annual particulate matter (PM 10) levels in the city are in the critical range of 106-119 µg /m^3, so much so that 90% of residents identified congestion to be the main problem in Hyderabad. [59] Another recent study confirmed that the air pollution in Hyderabad is on the rise. The ambient air quality levels for total suspended particulate matter at all the air quality monitoring stations of Hyderabad exceeded the prescribed limits of 140 µg /m^3. [60]

Studies indicate that children living near roads with heavy traffic are at greater risk of respiratory disease. [49] School location, surrounding built environment, mode choices for trips to school, and air emission impacts of those choices are intricately related such that centrally located schools that can be reached by walking and cycling have reduced local air pollution. [61] More than a third of the school children in four big cities of India suffer from reduced lung capacity, with Delhi showing the worst results. [62] In another study that was conducted in India, 11,628 school-going children (7757 boys and 3871 girls) from 36 schools in different parts of Delhi in different seasons were included, with 4536 children in another state as controls. Children in Delhi had almost twice the number of respiratory symptoms. The results showed a reduction of lung function in 44% of the schoolchildren of Delhi, compared with 26% in the control group. [63]

1.2.4 Noise

Road traffic noise is shown to affect communication, school performance, cardiovascular health, sleep, temper, and could lead to hearing impairment. [64] Analysis of traffic in Hyderabad revealed that four out of six traffic intersections had exceeded tolerable limits of noise. [5]

Other health effects of motorised transportation include respiratory conditions and allergies due to air pollution, low back pain due to time spent in vehicles, fatigue, stress, depression, obesity, and certain types of cancers, non-communicable diseases like diabetes, cardiovascular diseases and osteoporosis. [65-69] The wider physical environmental impacts of transport are through vehicular exhaust and greenhouse gases, leading to global warming and rise in temperatures.

For the reasons mentioned above, it is crucial to examine the public health impacts of transport in relation to children's mode of travel to school in India. For this, it is important to look at the present structure of transportation in India, since the inherent differences in the individual, socio economic factors, and built environment, have the potential to impact children's travel patterns. This is described in the next section, under 'study setting'

1.3 Study setting

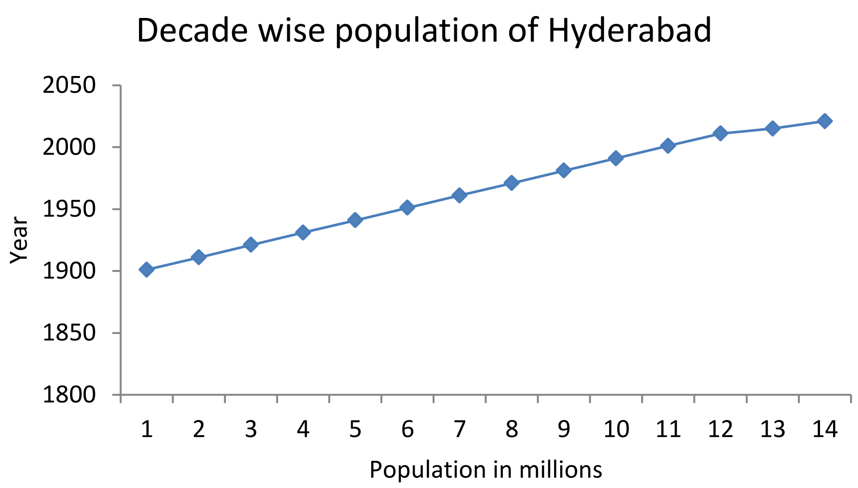
This section has two parts: Part 1.3.1 describes the study location, which is the city of Hyderabad, and its demographic features; Part 1.3.2 describes the broader setting of the transportation in Hyderabad; the past and current travel patterns, and what we already know about how children travel to school. This is followed by the context in which these journeys take place, especially the issues in urban transport.

1.3.1 The city of Hyderabad

Hyderabad, a large city in the Deccan area of south India was the capital of the unified state of Andhra Pradesh at the time this research began in 2011. The state has since been divided in June 2014 into two separate states: Telangana, and Andhra Pradesh. Hyderabad is the joint capital of the two states, and will remain so till 2024. Hyderabad is the fourth most populous city in India. It is also one of the fastest growing metropolitan cities of India.

Figure 1.5 shows the population in Hyderabad since 1901.

Figure 1.5 Decade wise population of Hyderabad



Current and estimated population, for Hyderabad metropolitan area

Source: [70, 71]

The major metro cities in India-Delhi, Mumbai, Kolkata, Chennai and Hyderabad- vary in terms of their population, area, urban form, topography, economic activities, income levels, and growth constraints.

These cities also differ to some extent regarding literacy rate and population. For example, Mumbai has the highest literacy rate of 91% among the major cities of India (compared to the national average of 74%). It is the most populated city of India with 20.5 million people. Chennai with 90.3% is the second highest literate metro city, and has a population of 4.7 million. Bangalore is next, with a literacy of 89%, and a population of 9.5 million. Kolkata has a literacy of 87.1% and a population of 4.5 million. Delhi has a lower literacy rate of 86.3% and a higher population of 16.3 million. Hyderabad has the lowest literacy rate of 83% among the metro cities of India, and has a population of 6.8 million. [72] Literacy in Hyderabad district is however the highest, (87% among males, and 79% among females), when compared to the State average of 66%. [73]

The large cities in India also differ with respect to car ownership. In descending order, the number of cars in Indian cities is as follows: Delhi 2.2 million, Bangalore 0.8 million, Chennai 0.6 million, Mumbai 0.6 million and Hyderabad 0.5 million. [72]

The unemployment rate in the urban area of Andhra Pradesh State is 43 per thousand, when compared to 40 per thousand in the State of Delhi (and 34 per thousand in urban areas at the national level).[74]

The percentage of population considered to be below poverty line in urban areas of Andhra Pradesh is 5.8 (compared to 9.8% in Delhi). The percentage of population below poverty line in rural Andhra Pradesh is 11%, compared to 12.9% in Delhi. [75]

The metropolitan regions of the three cities in South India (Bangalore, Hyderabad, Chennai) extend to areas much beyond the city and of the three, Bangalore has the largest area at about 8,005 sq. km followed by Hyderabad at about 7,200 sq. km and lastly Chennai at around 1,200 sq. km [76]

The economy and per capita income of the three large states of in South India are comparable. However at the metropolitan area level, the economy of the districts covering Hyderabad Metropolitan Areas is 23% more than the economy of the districts covering Bengaluru Metropolitan Area and 47% more than the economy of the districts covering Chennai Metropolitan Area [76] Hyderabad District is the administrative as well as the financial capital of the state of Telangana. It is the biggest contributor to the gross domestic product of the state.

The main challenges that rapidly growing metropolitan areas face is the provision of basic services and physical infrastructure to the growing population, which include affordable and comfortable transport services. Similarly, Hyderabad has huge areas of unused land, with an enormous potential for expansion of the city. The growth of the population in the urban areas of the State (for which Hyderabad is the capital) has been witnessing a significant increase. The population has grown by 38.12% during the decade of 2001 - 2011. In sharp contrast, the rural population in the State grew by a modest 2.13% as per the 2011 census. Out of the total urban population of the State, around 30% resides in Hyderabad. [73]

In 2007, the Andhra Pradesh State Government formed the Greater Hyderabad Municipal Corporation to aid the erstwhile Hyderabad Urban Development Authority to facilitate the management of its ever increasing land area. Hyderabad city has an estimated population of 8.7 million with a population density of 18,480 people per square kilometre, [26] compared to a population of 8.1 million and a population density of 5,510 people per square kilometre in London. [77] Table 1.1 shows the key demographic features of Hyderabad.

Table 1.1 Key demographic features of Hyderabad

Total Metropolitan Area Population in 2015	11.4 million
Hyderabad city Population in 2015	8.7 million
Area	7,000 sq. km
Per capita income	670 USD (in 2011)
Literacy Rate	83%
Sex Ratio	945
Number of *mandals (boroughs) in Hyderabad district	16
Estimated number of school going children	1 million
Estimated number of schools	2,000

Source: [26] [71]

*Mandal is an administrative division within an Indian city or town

1.3.2 Transportation in Hyderabad

Hyderabad has been home to traditional industries like heavy metal processing and pesticide manufacturing etc. For the past decade, it is emerging as a major hub for information technology, bio-tech and pharma industry. The lack of physical barriers to its growth in all directions, and the investment friendly policies of the government are aiding Hyderabad to be an attractive investment destination in India. However, these policies are not able to keep pace with the ever-increasing demand for transportation in the city. The rapid growth of the city, combined with rising income levels, and a weak public transport system is leading to a massive increase in the growth of personal vehicles. The result is recurrent traffic congestion, high levels of pollution and an increased risk of road traffic injuries.

Transport planning is intrinsically linked to land use planning and both need to be developed together in a manner that serves the entire population and yet minimizes travel needs. Yet, by the government's own volition, transport planning has not received the extent of attention it should have, in drawing up strategic development and land use plans. [78]

1.3.2.1 Past travel patterns in Hyderabad

One of the key studies on travel patterns in Hyderabad was carried out in 1988. It was the Hyderabad Area Transportation Study-HATS, [5] commissioned by the Hyderabad Urban Development Authority. Its aim was to study the immediate and long term requirements of transportation facilities for the Hyderabad metropolitan area. The population of the city (not the extended areas) at the time the study was conducted was 2.8 million. The report summarised that there were about 18,000 cycle rickshaws (non-motorised three wheelers) and 18,000 auto-rickshaws (motorised commercial three wheelers). The city had about 400,000 bicycles, which, according to the report, was the 'most popular' mode of travel. The study reports that there were 20,000 cars in the city then. Table 1.2 summarises the trip purpose and the mode used by people in the late 1980s in Hyderabad. It shows that bicycles accounted for about 22% of the total trips, while private cars accounted only for 1% of the total trips. [5]

Table 1.2 Numbers of trips by purpose and mode in Hyderabad in 1988

Trip purpose	Trip mode									
	Car	2-wheeler	Bicycle	Bus	Train	Auto-rickshaw	Cycle-rickshaw	Govt. vehicle	Other	Total
Work	12018	151944	234226	209526	5184	12204	14344	12450	100472	752368
College	990	7314	18986	109096	816	862	2856	222	14408	155550
School	1968	4714	11658	117048	2614	2852	27212	1864	115196	285126
Shopping	774	7786	11400	16786	0	4108	5958	386	13250	60448
Others	3148	15690	16106	31020	1204	11750	11546	92	14810	1055366
Total	18898	187448	292376	483476	9818	31776	61916	15014	258136	1359758

Source: [5]

Table 1.3 shows the mode split for travel to school in Hyderabad in the 1980s. It shows that cars accounted for only 0.6% of the school trips. Non-motorised vehicle trips (bicycles, cycle-rickshaws and others) accounted for 55% of the total school trips. The classification ‘others’ seems to be pedestrian trips.

Table 1.3 Mode split for travel to school in Hyderabad in the 1980s

	Mode of travel to school									
	Car	2-wheeler	Bicycle	Bus	Train	Auto-rickshaw	Cycle-rickshaw	Govt. vehicle	Others	Total
n	1968	4714	11658	117048	2614	2852	27212	1864	115196	285126
%	0.7	1.7	4.1	41.1	0.9	1.0	9.5	0.7	40.4	100%

Source: [5]

Literature on travel patterns in India mostly pertains to adults. [79-81] Previous surveys have reported that walking and cycling were found to be most important in smaller cities, accounting for over two-thirds of all trips. [82] Modal split in Hyderabad in 2003 showed that out of the total of 8.2 million trips per day, two wheelers accounted for 31%, car 2.2%, bus 27.6%, cycle 2.9% and walking 30.2%. [83] Modal shares of journeys to work by low-income households in Delhi showed that of the total trips made, 32% were walking trips, 42% were road based public transport trips, 11% were bicycles and cycle-rickshaw trips, 5% were car trips, and 12% were two-wheeled motor vehicle trips. [82] Their results suggest that the location influenced walking and cycling trips. Cost of travel, instead of attitudes towards travel, seemed to have a stronger association with the frequency of travel.

1.3.2.2 Current travel mode in Hyderabad

The Comprehensive Transportation Survey conducted recently in Hyderabad found that public bus transport (Road Transport Corporation, RTC) accounts for 44% of the vehicle trips made by people, while private cars and 2-wheelers together account for 40% of the trips. [84] Auto rickshaws account for 13% of the trips, and cycles account for only 3% of the trips. [85] For the population who don't own a vehicle, about 93% of trips were made by non-motorised modes (i.e. walk, bicycle, cycle-rickshaw) and public transport modes (i.e. RTC bus and suburban rail). For the population who owns a 2-wheeler, 78% of the trips were made by non-motorised modes. [76]

About 2.8 million personal vehicles are estimated to be plying on the roads of Hyderabad, and about 0.2 million vehicles are estimated to be added to this pool every year. Over 7.8 million motorised trips are estimated to be made every day in Hyderabad. Out of these, about 41% are made by public transport (RTC buses and local trains). Almost 50% of the total trips are made by personal vehicles. Congestion on city roads is thus common, leading to high levels of pollution and increased fuel consumption. [85]

Regarding public transport in Hyderabad, there are approximately 3,700 buses which travel about 1 million vehicle km daily, and account for 3.5 million passenger trips every day. [85] The government of Telangana considers than an 'efficient and safe public transport system is one of the pre-requisites of good living'. To support the ever-increasing demand for transport in Hyderabad, the government started the suburban rail service in a phased manner from 2001. The suburban rail system in Hyderabad currently carries approximately 75,000 commuters per day. The comparative figures for Delhi (with a population of 14 million) are 385,000 commuters each day. Considering the high demand for commuting options in Hyderabad, the government wanted to supplement the system's capacity to carry many more commuters. This led to the inception of the Hyderabad Metro Rail project in 2010, on a huge public-private partnership model, with an estimated cost of 14,132 lakhs INR (22 million USD). It is estimated to be operational in 2017-18, although there are delays due to land acquisition and clearances pending from the ministry of railways. [86, 87]

Hyderabad Metro Rail will be a 72 km elevated metro along three high density traffic corridors of Hyderabad city. It is planned to be integrated with existing transport options like the suburban rail and bus depots. 'Loop buses' are being planned between metro stations and the nearby areas to provide seamless travel on a common ticket. [88] It is expected to carry 60,000 passengers per hour, with a ridership of 2.2 million passengers per day by 2024. [87]

Experts, however, feel that devoting energy and land, in the form of a dedicated bus lane, to a bus transit system, is a more viable option for most Indian cities. Moreover, the per-kilometre cost of a bus transit system is estimated to be 15-20 times cheaper than the Metro. [89] [90]

1.3.2.3 What do we know about travel to school by children in Hyderabad?

There are no published epidemiological studies on the current mode of children's travel to school in Hyderabad. The Comprehensive Transportation Survey-CTS- of Hyderabad is more recent than the HATS survey conducted in the 1980s, and explored people's travel behaviour, trip purpose, trip length, etc. in 2011. But the information provided by the CTS, though useful for adult trip characteristics, is not very informative for children's travel. For example, there is no disaggregated data by age and trip purpose. Specifically, the survey reports the combined school and college trips under 'educational trips', and reports the travel mode by merging school aged children (5-17 years) and college going youth (18-22 years) in a single group.

I had requested for disaggregated data on the Comprehensive Transportation Study (CTS) but it was not available. The reason cited was the method of data collection where the trip purpose was presented as ‘educational trips’ or ‘trips to work’ or ‘shopping’ or ‘others’. All trips from home to educational institutes, including schools and college were combined under ‘educational trips’. For example, the CTS main report finds that travel in Hyderabad is mainly limited to three main purposes, going from home to work, (54.2%), home to place of education (33.2%) or home to other places (10.6%). [76]

Grey literature shows that a variety of transport modes, such as, walking, cycling, 2-wheelers, auto-rickshaws and seven-seaters, RTC buses, cars, etc. are used to meet children’s travel needs. There is a paucity of data on children’s school journeys in India, with a lack of importance accorded to children’s daily trips to school.

“Every time a child is killed or seriously injured in a bus crash (in India) it becomes a major cause of concern and also the media plays up these events. Hardly any studies exist in the region that document the epidemiology of injuries sustained by children in the journey to school. It is possible that most of the deaths and injuries are among children who walk to school, but in the absence of such data those getting hurt in bus accidents get much more attention than the others. In such a situation the parents, the press, and the civic authorities focus on issues like overloading of vehicles as the main problem. When the cost of the journey becomes higher, some parents may opt to have their children walk to school or transport them on two wheelers. In such a situation the total number of injuries and deaths may increase rather than decrease”. [91]

Children’s travel to school in urban India can be an arduous journey.

“In any Indian city or village, school children can be seen hunched under heavy backpacks in matching uniforms, dodging traffic as they walk to or from school or a bus stop. For many children, the journey to school is often filled with hazards. Roads are poorly planned and rarely maintained. Only half are paved. Drivers often lack formal training and recklessly navigate through choked city streets. Crosswalks, road signs and even sidewalks may be missing. School buses are only part of the scrambled student transportation network. Several thousand students cram into vans. Others are ferried in auto-rickshaws, a popular three-wheel vehicle in the country that has no doors, with children often spilling from the sides”. [92]

Distance is important in choosing the mode of travel. Evidence (which will be discussed in detail in the next chapter) shows that there is some association between distance and mode. There are some distances that children are unlikely to walk or cycle. It is important to know about distance and mode, and how transport choices are made, to be able to plan for appropriate travel options.

Table 1.4 shows the various travel options available in Hyderabad, and the fare per kilometre. The suburban train seems to be the cheapest mode of travel, while travel by the school bus is the most expensive.

Table 1.4 Mode-wise cost of travel per km, in Hyderabad

Mode	Cost per kilometre (Indian rupee)
Suburban train	0.5
RTC bus	1.5
2-wheeler	3.5
Car	8.0
*School bus	10-30 (depending on the school)

*Only in private schools

Source: literature search (Chapter 2)

Decreased walking and cycling have been reported in high-income countries as motorised transport increases. Motorised transport is rapidly increasing in India, with the threat of a similar situation repeating itself in India. As motorisation increases, road injury is predicted to increase. When combined with the low importance accorded to road safety in India, it could lead to serious consequences.

1.3.2.4 Motorisation

India is motorising rapidly. Increasing household incomes, easy availability of loans for purchase of vehicles, and an aggressive automotive industry are leading to a substantial increase in motorised transportation. Passenger cars are growing at 12% annually and 2-wheelers registered a growth of 14% in 2013. [4] The high rate of motorisation is estimated to be associated with more than 500,000 road traffic injuries and about 120,000 deaths each year, according to official reports. [93] [93] Road injuries are projected to increase with increasing motorisation and road deaths are predicted to increase two and a half times by 2020. [94]

The increased travel demand has resulted in rapid growth in the number of motor vehicles in the cities. This growth is largely driven by the growth in the number of 2-wheelers. It is especially high in cities without a mass transit system like Hyderabad. Also, as income levels go up, the transition is made from non-motorised transport and public transport, to motorised 2-wheelers like scooters and motorcycles. Studies have shown that when per capita income grows by 1%, the level of car ownership grows by 1.7%. [95]

India currently has about 15 million cars, which is equivalent to 13 cars per 1,000 population (157 cars per 1,000 population in Delhi and 72 cars per 1,000 population in Hyderabad). [96] While this by itself is not high when compared to 450 cars per 1,000 persons in USA and Japan, it is likely to increase three times by 2025. Estimates are that there will be about 35 cars per 1,000 population on average, and in some cities, more than 300 cars per 1,000 population. This would amount to about 45–60 million cars on Indian roads. This exponential growth in the number of cars will have serious implications for energy security; air pollution; road safety; equitable allocation of road space; and will accentuate problems related to parking and congestion, which many Indian cities have already started witnessing. Transport sector in India is the largest consumer of petroleum products at 55% and cars presently consume nearly 20% of fuel. [96]

1.3.2.5 Urbanisation

Urban India is witnessing phenomenal growth. According to the 2011 census, India has a population of 1,221 million with approximately 32% (390 million) living in urban areas. The share of the urban population is estimated to increase to between 40-75 % of the total population by the year 2021. [97] Many cities in India have experienced rapid growth in the past few years. This has opened many opportunities, especially in terms of business and commerce. It has also lead to several challenges for the governance of these megacities, especially in the provision of safe and efficient transport connections.

The shift from non-motorised to motorised transport, especially 2-wheelers and cars in India is seen as a positive self-image, that of progress and success in life. Cars are perceived as a representation of affluence and higher status in society. On the other hand, public transport in India is perceived as lacking flexibility and comfort, it is crowded, and the timing is not dependable. The feeling of safety while traveling in motor vehicles leads to a bigger reliance on motorised transport. This leads to increased congestion, which, on the one hand increases the vulnerability of those walking and cycling, but on the other hand, reinforces the travel behaviour of those continuing to use motorised transport.

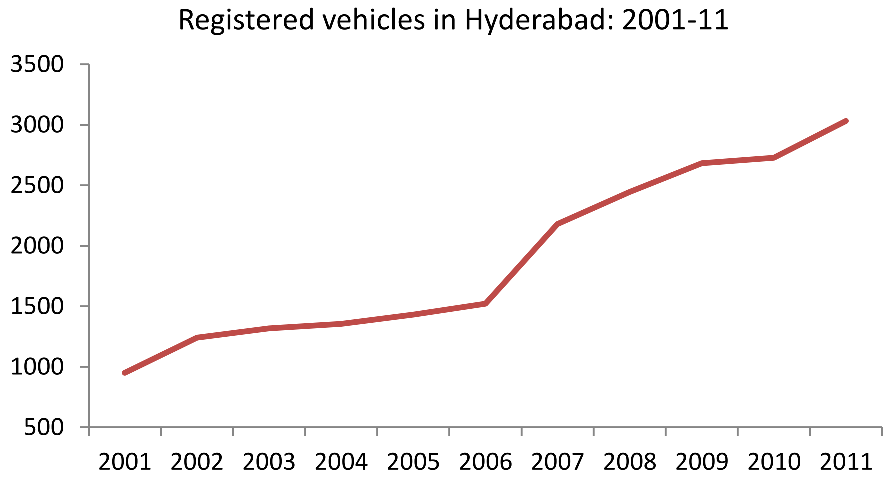
Transport demand in Indian cities is increasing rapidly due to urbanisation and an increase in population. Travel demand is determined by a number of factors, the primary factor being the size of the population. Other determinants include: average number of journeys performed by a resident each day (per capita trips) and the average length of each such journey (trip length). Travel demand has grown phenomenally because of the rising number of trips undertaken by the growing population as well as increased trip lengths necessitated by the expanding city size. People tend to travel more as the per capita income levels go up.

1.3.2.6 Issues in urban transport in India

Congestion of vehicular traffic is a common occurrence in Hyderabad. Congestion is mainly an outcome of two factors, (a) growth in number of vehicles on road, (b) limitations to expansion of road space. [65] The average speed of vehicles in Hyderabad is consistently decreasing. In 1981, the traffic in Hyderabad moved at 15 km per hour, and now, the average speed is approximately 9 km per hour [98] Every day over 600 new vehicles are added to the city roads, which is about 200,000 new vehicles per year. The density of vehicles in Hyderabad is reported to be the second highest in the country after Delhi. For every 2.5% growth in population, the vehicle density growth is estimated to be 20%. Another impact of congestion is the idling of the engine, adding to emissions.

Figure 1.6 shows the steady growth in the number of registered motor vehicles in Hyderabad, over the past 10 years, with a compounded annual growth rate of 11-12%.

Figure 1.6 Growth of motor vehicles in Hyderabad (in 1000s)



Source: [99]

Table 1.5 shows the distribution of registered motor vehicles in Hyderabad in 2011 versus 2010, by vehicle type. 2-wheelers seem to be the most popular vehicles, followed by private cars.

Table 1.5 Distribution of registered vehicles by vehicle type in Hyderabad

Vehicle category	2010	2011
2-wheelers	1,929,000	2,145,000
Cars and jeeps	446,000	501,000
Buses (local carriages)	23,000	25,500
Buses (long distance)	23,000	26,000
Taxis	26,500	30,000
Light duty (passengers—3-seater)	82,500	90,500
Light duty (passengers—4–6-seater)	3,000	3,000
Light duty (goods—3-wheeled)	16,500	19,500
Light duty (goods—4-wheeled)	60,000	65,500
Heavy duty vehicles	107,000	115,000
Tractors and Trailers	8,000	8,500
Others	6,500	7,000
Total	2,731,000	3,036,500

Source: [58]

Figure 1.7 Road traffic in Delhi

Source: [100]

Figure 1.8 Road leading to the Charminar in Hyderabad

The inadequate transport infrastructure is struggling to keep pace with the rapid increase in transport demand (figures 1.7 & 1.8) The share of mass transport is much less than the desired range, while the share of personalised transport is already above the optimal level in most Indian cities. [82] Traffic composition in India is of a mixed nature, with several slow and fast vehicles moving on the roads simultaneously. The growing traffic and limited road space have led to severe road congestion. There is no facility to separate motorists from walkers and cyclists in most Indian cities and walkability is quite low because of a lack of pavements for pedestrians. [101] For example, in the Hyderabad metropolitan area, pavements are found to be available for only 7.8% of the road network. [26] The few stretches of pavements that are available for walking are encroached by moving and parked vehicles and garbage dumps. As a result, motorised and non-motorised users compete for the same limited road space. This leads to road traffic injuries, especially among vulnerable road users, which has a negative impact on their lives. [102] [103]

1.3.2.7 Policy initiatives on transportation

Indian states and local municipal bodies have always known to favour, and still continue to favour, road expansion as the primary tool to address transport needs. [10] In December 2005, the central government of India initiated the Jawaharlal Nehru National Urban Renewal Mission. The premise was that rapid urbanisation was leading to a major inequality, and that the urban poor living in slums were paying the price for the 'acute urban crisis'. The policy was to assist the renewal of urban areas, with a funding of INR 100,000 crores (US$160 million) for seven years. The mission proposed to develop 63 Indian cities, including Hyderabad, with a big thrust on urban infrastructure projects, instead of improving sustainable mobility.

The State governments are known to have hurriedly prepared 'development plans'. Within 90 days of the launch of the mission, over 23 infrastructure projects worth 87% of the total funding had been approved. The hasty manner in which some infrastructure projects especially in the transport sector were sanctioned has been criticised. For example, three mega projects of fly-overs in Hyderabad were approved, against the vision of the National Urban Transport Policy (2006), which instead proposes to strengthen the public transport system. [78] The assigned funds are concentrated in road infrastructure, favouring general traffic and not necessarily sustainable transport investments.

Experts have questioned the economic and financial viability of the mission, stating that while one group that owns motor vehicles enjoys the infrastructure facilities, everyone pays for it. Also, only 35% of sanctioned projects are known to have been completed. [97] According to the analysis by the Centre for Science and the Environment (CSE), 70% of the mission's transport investment has funded roads and flyovers, while only 15% has been allocated to mass transit. [97]

The government of India launched the National Urban Transport Policy in 2006, for aiding the transportation issues in urban areas, with a focus on 'moving people, not vehicles'. The policy's main objective is to encourage integrated land use and transportation planning in all cites of India, with an emphasis on sustainable transport. In addition to providing financial assistance to promote multimodal public transport and non-motorised transport, the policy claims that it aims to bring about a more equitable allocation of road space for people, rather than vehicles. [78]

Recently, the central government planned to identify and develop 100 potential 'smart cities' with a funding of US$15 billion. In addition to improving the supply of water and electricity, and tackling solid waste management, the smart city mission aims to provide efficient urban mobility and public transport- especially creating walkable localities, reducing congestion, air pollution, and promoting transit oriented public transport including last mile para-transport connectivity. [104] How the smart city mission plans to achieve these goals is however not clear.

In recent times, there have also been examples of policies that are encouraging the use of public transport. For the past year, car-free days and similar events (described in Chapter 8 in more detail) are being conducted in India, during which cities close some of their streets to motorised vehicles for a few hours to encourage walking, cycling and outdoor recreation (box 1.1)

Box 1.1 Bus day initiatives in Bangalore

"'Bus Day' is a day-long event organised by Bangalore Metropolitan Transport Corporation to promote public transport in Bangalore, India. This is a social campaign where people are encouraged to use public transport for daily commuting. The idea behind this initiative was to change peoples' perception towards public transport and eventually help in improving the traffic congestion in the city and have a positive impact on the environment. The first Bus Day was first observed in 2010 and since then, it has become a tradition to observe Bus Day usually on the 4th of every month".

Source: [105]

1.4 School systems: India and Hyderabad

Given this background of transportation issues in urban India, the following section describes the types of schools in India, to help with an understanding of the school system in India, and the ages when children attend these schools.

With more than 1.4 million schools and more than 230 million enrolments, India has one of the largest and complex school education systems in the world. [106]

The Indian Parliament recently passed the Right to Education law, under the provisions of the *Right of Children to Free and Compulsory Education Act, 2009*. Schooling is free for children in government-funded schools and is compulsory for all children from the ages of 6 to 14. [107] Transport to school, is however, not free. Elementary education consists of primary level (for 6-10 year olds) and upper primary level (for 11-14 year olds) while secondary education consists of secondary level (for 14-16 year olds) and higher secondary levels (for 16-18 year olds). The Act also describes the distance limits of the neighbourhood within which a school has to be established by the state government. [108]

- A Primary school within 1 Km from each habitation
- An Upper Primary school within 3 Km from each habitation
- A High School within 5 Km from each habitation

But despite the good intentions, and the valuable concept of 'neighbourhood schools,' government-funded schools are still grappling with poor quality of education, low sanitation, and high student dropout rates, especially among girls, and poor teacher attendance. Low resources and high teacher absenteeism could have encouraged the rapid mushrooming of private schools in India, especially in urban areas. Enrolment into private schools in India is rapidly increasing, to an estimated 30-70%. [109] [110] A study by Oxford University examining children's schooling in Andhra Pradesh revealed a dramatic rise in the number of parents opting for fee-charging private schools over government -funded free schools. [111] This perhaps reflects the low faith in government funded schools, and the willingness to invest in a child's education by parents who very often are themselves illiterate.

Government schools have some semblance of order in the way they are instituted, in neighbourhoods. There is no such compulsion, however, for private schools to be established at a convenient distance from neighbourhoods. Relative to government schools, private schools draw children from fairly wide geographic locations, with unintended consequences, as described below.

School choice, in the sense that parents are free to choose a school for their ward, is implicit in India. Parents choose what they feel to be the most appropriate school for their children to attend, and not necessarily the one closest to home. 'School choice policy', with voucher schemes for empowering poor students and parents is not common practice in India, the way it has been in the US, New Zealand and UK. [109] Although studies have examined factors influencing parents' choice of school, [112] there is no formal government policy either restricting or promoting access to school based on geographic location. This has serious implications because school choice markedly influences school travel behaviour, mainly due to increasing distance, leading to motorised travel modes.

Previous studies examining the effect of school choice found that it led to longer commute distances and lower walking and cycling rates to school. [113] By choosing private schools, irrespective of distance, children may simply be living too far away to be able to walk or cycle to school. Only private schools have a paid bus service. Payment for transport may itself therefore influence mode choice. Anecdotal information reveals that many parents in India prefer auto-rickshaws (motorised 3 wheeled vehicles) over the otherwise expensive school bus service. Children and their accompanying parents travel to school in two, three and four wheelers, possibly exacerbating the rush hour traffic congestion.

The Indian school education system can be segmented in either of the following ways:

a. By means of levels of education:

   (Kindergarten, Primary school (6-10 year olds), Middle school (11-13 year olds), Secondary school (14-16 year olds), higher secondary or pre-university (17-18 year olds)

b. By means of educational board affiliations:

   National curriculum boards (Central and State syllabus) and

   International boards (International Baccalaureate, Cambridge International Examinations, etc.)

c. By means of ownership of educational institutions:

Government educational institutions: These are run by the Central Government or state governments, public sector undertakings or autonomic organisations and are wholly financed by the government. Examples of these types of schools include State Government schools, Central schools, Military schools, Air Force schools, Naval schools, Police schools and Railway schools etc.

- Government (Local body) institutions: These are run by municipal committees or corporations; Examples of these types of schools include those run by Cantonment Board, etc.
- Semi-private institutions (government aided): These are managed privately but receive regular maintenance grant from the government, local body or other public authorities. The template of rules and regulations followed here is similar to the public schools.
- Private unaided institutions: These are managed by individual or private organisations and do not receive maintenance grants either from government, local bodies, or any other public authorities. The fee structure for the students may vary greatly from that of the government institutions and is totally under the control of the private management.

The type of schools in Hyderabad is similar to that outlined above. For my study, I chose schools based on ownership: Government funded schools, government aided schools (semi-private) and private unaided schools. This was to ensure that children from various economic backgrounds are included. The type of school a child attends is a reasonable proxy for the economic status of the parents (figures 1.9 and 1.10).

Each school has ‘grades’ 1-5, or 1-10 or 1-12. Each grade normally has one to three ‘sections’, comprising 20-40 children in each section. The details of the selection of the sample of schools in Hyderabad are described in the methods chapter.

1.5 PhD aims

This thesis aims to study the transport mode, distance, and road safety of the journey to school in Hyderabad, India.

Specific objectives are the following:

1. To develop a self-administered questionnaire, and examine its reliability and validity in estimating the distance, and mode of travel to school in Hyderabad.
2. To examine the distribution, and determinants of school travel in Hyderabad, and to estimate the relationship between distance and mode of travel to school.
3. To estimate the prevalence of road traffic injuries among children travelling to school, by usual mode of travel and distance to school.
4. To estimate (using a spreadsheet model) the impacts of alternative transport scenarios in Hyderabad on the risk of road traffic injury during school journeys.

1.6 Organisation of thesis

Within the geographical and policy contexts discussed above, this thesis explores various aspects of children’s school travel in Hyderabad. Chapter 2: ‘How does distance influence mode of travel?’ reviews the international literature for evidence on distance and mode of travel to school, with a view to finding relevant studies in low and middle-income settings. Chapter 2 has two objectives: (1) to identify the determinants of children’s mode of travel to school in other countries; and (2) to describe the relationship between distance and choice of mode.

The next chapter, Chapter 3: 'Methods', describes the methods for the primary study in Hyderabad (a cross-sectional survey). Part 1 of Chapter 3 describes the iterative process of the development of a self-administered questionnaire that aims to estimate the distance and mode of travel to school. Part 2 describes testing the reliability and validity of the questionnaire in estimating distances to school and measuring the modes of travel to school.

Chapter 4: 'Can we measure mode of travel to school reliably?' describes the results of the questionnaire development, and the results of the reliability studies. The objective of the chapter is to present the iterative process which led to the development of the final questionnaire that was used in the primary study.

Chapter 5: 'Can we measure distance to school reliably?' presents the results of the validation of the estimated distance from home to school, using the questionnaire.

Chapter 6: 'What is the relationship between distance and mode?' presents the results of the relationship between distance and children's mode of travel to school in Hyderabad, which are the results of the cross-sectional survey.

Chapter 7: 'What is the risk of road traffic injury on the school journey?' describes the results of children's self-reported road traffic injuries on journeys to school, the information for which was gathered during the cross-sectional survey.

Chapter 8: 'Modelling public health impacts of travel to school: Road traffic injuries' examines the issue of the public health impacts, especially the risk of road traffic injury on the way to school. Chapter 8 has two main aims: (1) To estimate the risk of road injury per child kilometre travelled; and (2) To use these estimates of risk to model the impacts of future transport scenarios on road traffic injuries, for planners to consider for Hyderabad. This chapter provides exposure-based road traffic injury risk for all major modes of travel to school (motorised and non-motorised), in Hyderabad.

Finally, Chapter 9: 'Discussion and Conclusions' summarises the key results from this thesis. The implications of the findings for future policy are discussed, along with some directions for future research focused on children's exposure to air pollution, mode and distance to school in rural areas, physical activity in children, and parental influences and attitudes regarding children's travel to school.

1.7 Summary

School journey is a routine activity and a journey that children are obliged to make every day. School travel by children in India remains under-studied. Knowledge of children's travel is essential to inform policy in transport, mobility, environmental sustainability and public health. High-income countries have regular national transportation surveys. They have information on what percentage of daily travel is attributable to school travel, and out of that, what percent is due to, say, the use of the private car. They know that children's walking and cycling to school is steadily falling. We do not have such information in India on school travel behaviour, if it is changing over time, or if it is becoming more reliant on motorised transport.

The urban spaces in India are such that most people have little or no way of choosing walking or cycling for transportation. It is important to ascertain the reasons behind the choice of school and the modes of travel to school. Such information is vital to initiate policy measures. Only recently, the comprehensive transportation surveys have been initiated by state governments and the baseline data has just come in for Telangana state where Hyderabad is situated. But it still does not have the specific school travel component. Primary data collection in Hyderabad is therefore necessary to provide such information, to eventually plan effective transportation strategies, or to promote children's walking and cycling to school.

We specifically need information on children's mode of travel to school and their risk of road injury. This can advance our understanding on children's injuries. The improved understanding can be used to develop interventions to improve road safety. The goal of this thesis is to study how children make these journeys, and how many are injured on account of the school trip, and inform the public health policy and practice focussed on children's road safety.

This thesis begins to address these gaps in the existing literature on children's transport to school in India. It is expected that the findings from this thesis will inform the development of specific interventions that might improve child road safety in Hyderabad and in similar urban areas in India.

Figure 1.9 A private school with a large play-ground

Figure 1.10 A government school in a shed

2 HOW DOES DISTANCE TO SCHOOL INFLUENCE MODE OF TRAVEL?

2.1 Why it is important to do this review

In the previous chapter, we saw that school travel is an everyday activity that children undertake throughout their school years. Walking and cycling provides a regular opportunity for school children to accumulate physical activity. [3] Physical activity is inversely related to obesity in youth, and an unhealthy body composition in childhood is found to be associated with an increased risk of coronary heart disease in adulthood. Evidence shows that habitual active travel to school (walking and cycling) has the potential to improve health related fitness among active commuters. [114] Considering the health benefits of daily walking and cycling to school, it is important to know how children travel to school. Most of the information on children's travel to school is through research on active commute from high-income countries. Little is known about how children in India travel to school.

I wanted to understand what research evidence is available on the relationship between distance and mode of travel to school in low or middle-income countries. The topic is particularly relevant to the low and middle-income country settings because many such countries like India are undergoing rapid economic and social changes. The increasing urbanisation along with rapid motorisation is likely to lead to changes in the way people (and children) travel in these countries.

The review aims to search the international literature for evidence on distance and mode of travel to school, and to highlight the need for future research, particularly in low or middle-income country settings. This review may also help with understanding the factors influencing the use of motorised and non-motorised transport to school. The determinants of mode of travel, and especially distance, identified through this systematic review, will form the basis to assess the role of distance in the mode of travel to school in India. For example, it will enable me to find out if the distance to school reported in this review is comparable with the distance travelled to school in India, and if the relationship between distance and mode is similar to what it is in India.

2.2 Objectives of the review

The objective of this systematic review is to identify the determinants of children's mode of travel to school and to describe the relationship between distance and choice of mode.

2.3 Methods

The protocol for this systematic review was prepared in compliance with the structured format outlined in the Cochrane Handbook for Systematic Reviews [115]

2.3.1 Eligibility criteria

2.3.1.1 Types of studies

Any epidemiological study (observational or interventional) from any country, on children's mode of travel to school, was eligible for inclusion.

2.3.1.2 Types of participants

Participants were defined as 'any person who travels to school, either to study, or to work, or to accompany children to and from school' and included:

- School aged children 5-18 years (excluding children with disabilities or special needs)
- Their parents or guardians
- Teachers, school administrators and school governors, if their opinions on travel to school were elicited, as some studies have done. [116]

Parents or guardians were included as participants in this review because they were included as participants in some studies: Parents and guardians either filled the questionnaires or reported their child's mode of travel to school or gave an estimate of the distance that their child travelled to school. [117] [8]

2.3.1.3 Types of interventions/ exposures

(i) Studies reporting school transportation in children/ and or adolescents, by any mode

(ii) Studies documenting distance between home and school

Studies had to satisfy both (i) and (ii) to be included in the review. To capture information from as many countries as possible, the type of included studies was deliberately kept broad.

2.3.1.4 Types of outcomes

Studies had to report proportions of participants using each mode of travel, with respect to distance to school, or to report the numbers of children such that proportions could be calculated if not provided in the study report.

The main factor of interest was to describe or estimate the relationship between distance to school and mode of travel.

2.3.1.5 Exclusion criteria

Because of the particular issues involved, travel to school by children with special needs and disabilities were excluded from this review. Children with special needs and disabilities may have varied additional requirements, including the need for support or provision of an escort to school. Proxy reports for distance, for example, long distance as a barrier to commuting, were not included. Studies that examined distance to evening classes and other after-school-activities were not included.

2.3.2 Search methods for identification of studies

Studies published between January 1990 and August 2012 were considered, irrespective of their publication status. No language restrictions were placed, to ensure that literature from low or middle-income countries was not missed. The search strategy for PubMed was developed for specificity and sensitivity with advice from an information specialist. It was tested against a small set of studies known to be eligible and adapted to the specifications of each database.

2.3.2.1 Electronic searches

Five electronic databases were searched for potentially relevant literature: Ovid Medline (January 1990- June 2012), PubMed (January 1990- August 2012), Web of Science (January 1990- July 2012), Zetoc (January 1990- July 2012) and TRID (Transportation Research Board of the National Academies) (January 1990- August 2012). Key words and MeSH terms were used to identify relevant publications that contained at least one term from each of the three categories:

- ‘school-age children or adolescents’
- ‘transportation to and from school’
- ‘distance of school travel’.

Figure 2.1 Search strategy

(((child* OR adolesc* OR youth OR young people OR student* OR pupil* OR teenage* OR young person OR boys* OR girl*s OR pediatri*))) AND ((((((distance[Title/Abstract]) OR length[Title/Abstract]) OR miles[Title/Abstract]) OR kilometres[Title/Abstract])) AND ((((((journey[Title/Abstract]) OR travel[Title/Abstract]) OR auto[Title/Abstract]) OR bike[Title/Abstract]) OR rickshaw[Title/Abstract]) OR motor[Title/Abstract]))

2.3.2.2 Searching other resources

Searches of the grey literature were achieved by searching the websites of Government Transport Departments/Ministries, Google*, Google Scholar* and Indian newspapers. Due to time and availability constraints grey literature search was only limited to India.

1. Websites searched (June-August 2012)
2. https://www.google.co.in/
3. https://scholar.google.co.in/
4. http://morth.nic.in/
5. http://www.thehindu.com/
6. http://indianexpress.com/
7. http://timesofindia.indiatimes.com/

2.3.3 Selection of studies

The titles and abstracts of all study records were screened for relevance. The eligibility of each record was determined based on the answers to the screening questions (Appendix i). References were included only if they addressed all of the inclusion criteria. The search results were collated in Endnote reference manager and any duplicates were removed. The remaining studies were independently screened by me with two research assistants. The study was included only if all three reviewers agreed to include it. If necessary, study records were re-examined and agreement was reached by consensus. Unresolved disagreements were to be resolved by a fourth reviewer. Full texts were obtained for studies meeting the inclusion criteria.

2.3.4 Data extraction and management

Data from included studies were extracted by one reviewer. The following data were entered into an Excel spreadsheet: mode of commuting to school, distance to school, proportion of children using different modes of travel, a description of the relationship between mode choice and distance, the study sample size, the participants' age range or grade, gender, and the country in which the study was conducted.

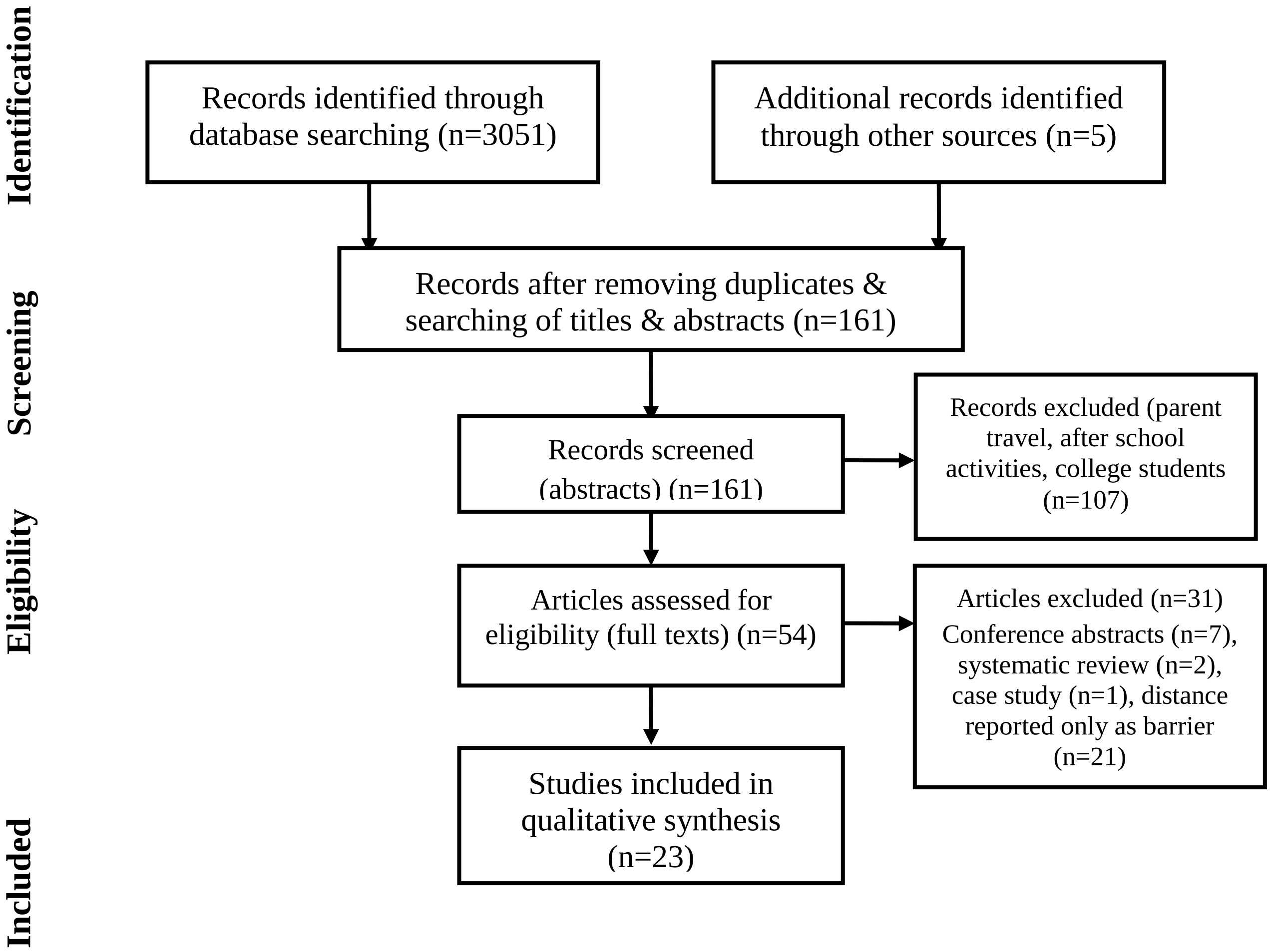
2.3.5 Methodological quality assessment

The methodological quality of the included publications was assessed independently by two reviewers, with any disagreements in ratings resolved by a third reviewer. The STROBE statement (Strengthening the Reporting of Observational Studies in Epidemiology) was used as guidance for assessment of methodological quality. [118]

2.4 Results

The search strategy retrieved a total of 3051 studies. Of these, 1961 were from PubMed, 34 were from Zetoc, 857 were from Web of Science, 148 were from the transportation database TRID and 51 were from Ovid Medline. Figure 2.1 describes the screening, review and exclusion process, which was adapted from the PRISMA statement [119]

Figure 2.2 Flow chart of the systematic review process



On reading the abstracts, 107 studies were excluded, yielding 54 studies that met the eligibility criteria. These included studies from the reference lists of two systematic reviews, which were excluded after retrieving 14 potential and three eligible studies. On reading the full texts, 31 studies were excluded. The final list had a total of 23 studies. Figure 2.1 portrays the search, selection, and exclusion process. Appendix (ii) shows the characteristics of the 23 studies that met the inclusion criteria and Appendix (iii) shows the excluded studies, with reasons for exclusion. All studies were published after 1990 and examined travel to and/or from school.

In total, 31 studies were excluded because of the following reasons: twenty one studies described the distance to school only in the context of distance being a barrier to walking or cycling, and were subsequently excluded. Seven studies were found from conference proceedings, but they had to be excluded because full texts were not available. Two systematic reviews and one case study were also excluded due to lack of relevance to the objective of the review.

A narrative approach was adopted to describe the results of the systematic review, instead of a meta-analysis. This was because of the heterogeneity of outcome variables as well as the methods used to describe associations in the included studies.

2.4.1 Included studies

The majority of the studies were conducted in USA (n=13), followed by UK (n=4), Australia (n=3) and Europe (n=3). Studies varied in their primary objective. The objective of most of the studies was to determine the predictors and factors associated with active commuting to school (n=10). Some studies examined travel patterns of school children or changes in travel patterns across the years (n=5), while others set out to understand the factors affecting the mode choice for the trip to school (n=6). A few studies examined physical activity, adiposity and lifestyle factors in relation to the commute to school (n=2).

Design – All studies were cross sectional in design.

Sample sizes – Sample sizes ranged from 164 to 130,000 children.

Setting – Studies were conducted in various settings: urban (n=5), urban and rural (n=2), suburban (n=2) county/ town (n=5), or across the country (n=5).

Participants - The participants in the studies ranged from only children (5-13 years), [53, 120] [121], only adolescents (13-18 years) [122] [123] [124] or both children and adolescents. [121, 125] [121] [126, 127] Other studies included only parents [117] [8] [128] [129] [130] or both parents and children [18] [131] [132] [133] [134] or parents and adolescents. [115] [8]

2.4.2 Outcomes

2.4.2.1 Distance

The most frequently examined physical environmental determinant was increased distance to school. Distance to school was found to be inversely associated with walking and cycling, and was directly associated with motorised transport to school. Distance was discussed in relation to: (i) mode choice, (ii) active commute to school, (iii) changes in travel patterns over time, or (iv) physical activity levels.

Measure of distance – Many studies used a self-reported measure of distance, which was varyingly expressed as miles or kilometres, using different categories of distance. Five studies used objective measures of distance like geographical information systems [135] [8] [117] [122] [134]. One study used travel time as a proxy for distance [125] and two studies measured the 'straight-line' or Euclidean distance between school and home. [117] [122] Two studies used fixed or criterion distance of 3 km [8], and 2.5 miles. [123]

Distance from home to school – Two studies reported that 14-50% children lived 1-2 miles away. [18] [135] The mean distance to school in some studies ranged from 2.96 km [8], to 3.5 km. [124] Distance travelled to school differed depending on the child's age: Younger children stayed closer to school, the average distance being 3.6 miles for elementary school children and 5.5 miles for high school children. [120] One quarter to one mile was considered to be a distance that can be walked or cycled by children, according to the US National Center for the Safe Routes to School [136] and up to 800 metres according to Babey et al. [122] It was found that families were opting to live further away from school over the years: 66% of children lived less than 3 miles away from school in 1969, reducing to 49% in 2001. The trend of an increasing distance from home to school is reported to have occurred during 1969-1977, which also seemed to coincide with the declining rates of walking and cycling, and the first reports of rising rates of childhood obesity. [125]

2.4.2.2 Mode of travel

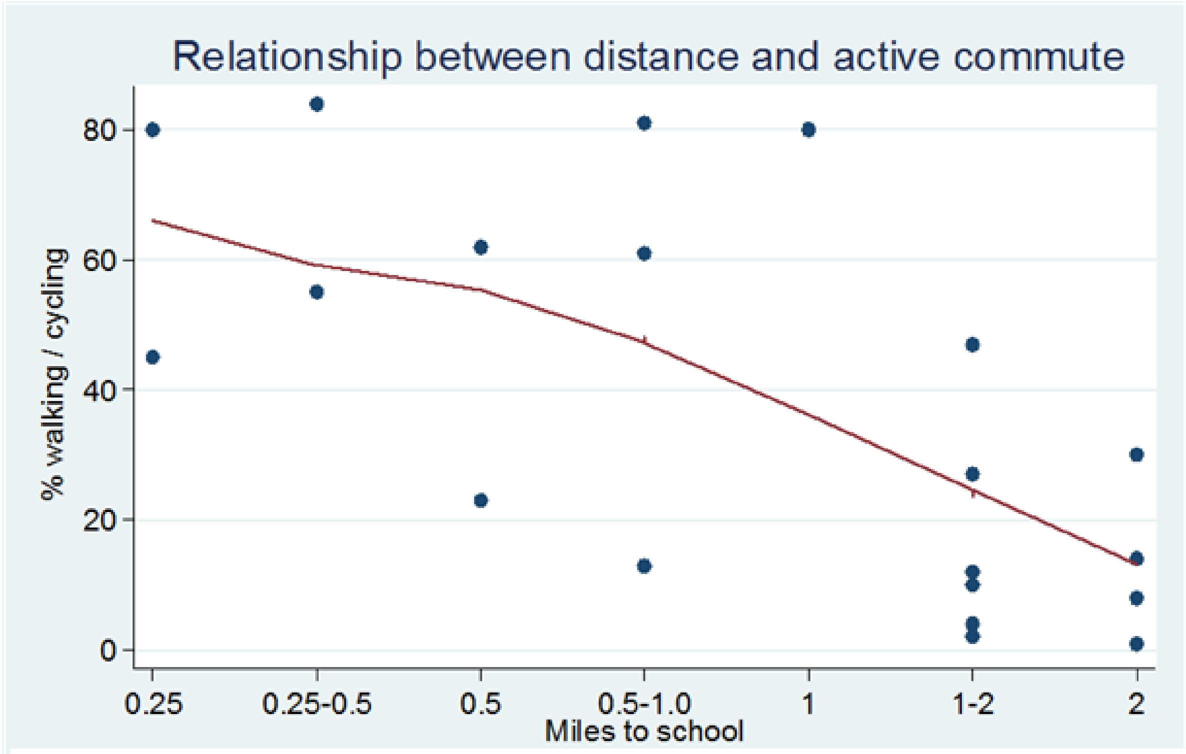
There was little uniformity in the way the mode of travel to school was measured and described across studies. For example, mode of travel was expressed as 'usual mode' or 'number of days of walking or cycling the previous week' [122] or in 'different seasons' [135] [117] or 'mode for five consecutive school days' [131] or on the 'day of the survey'. [12]

2.4.2.3 Shift from active commute to motorised travel

Figure 2.2 describes the relationship between distance to school and the prevalence of walking or cycling (appendix iv). As distance to school increased, the prevalence of walking or cycling decreased. As distance to school increased, the use of motorised transport also increased and the shift from walking or cycling to motorised transport became evident. [137] In Australia, the proportion of walkers reduced from 62% to 8% when distance increased from 1km to 3 km. [132] Similarly, in California, private vehicles were found to be the dominant mode of travel (50%), when distance was greater than 1 mile [127]. The same study also showed that a 10% increase in distance resulted in a 3% higher probability of taking the bus.

A survey conducted in the inner London boroughs found that the multivariate odds ratio (OR) of being driven to school when compared to walking increased from OR 4.9 (95% CI 3.4 to 7.2) to OR 82.1 (95% CI 28.1 to 239.8) when the distance increased from the '0.5 - <1 mile' category to '>2 mile' category. [12] The level of precision seems to be low, because of the wide confidence interval. Similarly, Dalton and colleagues in the USA found that as distance increased from 1 mile to 1-2 miles, active commuting reduced from 80% to 47%. [135] Another study in the United States showed that car use increased from 45% to 70% as the distance increased from 0.5 miles to 2 miles. [127] Likewise, distance was significantly related to the usual mode of travel to school in Switzerland [117] Analysis of time trends from 1969 to 2009 in the United States showed that car use increased from 15% to 44% when the distance was greater than 2 miles. In Norfolk, UK, motorised travel increased from 18% to 87%, as distance increased from under 1 km to over 2 km [134] Similar results emerged from other studies (appendix iv). [125] [138]

Figure 2.3 Relationship between distance to school and active commute (walking/cycling)



Source: Results from included studies

One study in the United States used a multinomial logit model to investigate the mode choice for the trip to school and also used travel time as a proxy for distance. [125] It reported that a 10% increase in walking travel time leads to a 7.5% decrease in the probability of walking. Living half a mile from school greatly increased the probability of walking or cycling. [53] In the same study, living 0.5–1 mile from school was found to be associated with a 37% decline in walking to school compared with living within 0.25 miles of school.

The 'Safe Routes to School' travel data further illustrated this association. The percentage of children using the bus increased almost linearly with distance: 9% of children living less than 0.25 miles used the bus versus 54% amongst those living 1 to 2 miles away. [136] Merom and colleagues [138] also found that as distance increased from 0.75 km to 1.5 km, the proportion of those performing no active commuting trips doubled (from 22% to 43%)

An inverse association between network distance and walking and cycling was found, even for children living less than a mile away from school. [126] [126] [126] [126] Schlossberg and colleagues observed that children living beyond 1.5 miles were most likely to use the bus. But no such relationship was observed between distance to school and travel by a private car. The study reported that distance to school did not predict whether children would be driven to or from school: a child who lived within 1 mile of school was as likely to be driven to school as a child living 3 miles away. [130]

In some countries, children were found to use motorised transport even for short distances. In the United States, the private car is the leading mode of transport even among students living within 0.25 to 1 mile away, a distance considered walkable/cyclable. [18] Among children who were regularly driven to school, 47% lived less than 1.5 km away. [131]

2.4.2.4 Shift from walking to cycling

Two studies specifically reported the shift from walking to cycling, with increasing distance. As the distance increased from 0.25 mile to 0.5 mile in the United States, the prevalence of walking reduced drastically (41% to 2%), whereas cycling reduced more slowly (4% to 2%). [136] In another study conducted in Belgium, a sample of active commuters was taken and a criterion distance of 3 km was set. It was found that actively commuting children living further away from school- but still within the criterion distance of 3 km- preferred cycling instead of walking. Within the group of all active commuters (n= 369) living within the criterion distance of 3 km, distance from school was significantly associated only with cycling instead of walking (OR 7.2; 95% CI 2.5 to 20.5). [8]

2.4.2.5 Morning and afternoon travel modes

A difference in travel mode during the morning and afternoon was found, especially in studies reported from the United States. A larger proportion of American children across all distance categories chose to walk and use the school bus in the afternoon, compared to using the car in the morning. [136] Similar results were found in Oregon, where twice as many students walked back home from school (20%), compared to those who walked to school (10%). [139] Merom and colleagues reported similar results from Australia. [138]

2.4.2.6 Parental influence

Parental attitudes were identified as an important independent predictor of children's mode of travel. [131] Parental walking was associated with their children regularly walking to school. Distance was cited as the main reason by parents, for not allowing their children to walk or bicycle to, or from school. [136] [135] [134] [133] Parental concerns about safety, their worry about traffic and personal safety, including fear of abduction, were frequently documented. [12, 117, 132] Parents' own history of travel to school, their perceptions of the importance of physical activity, and the weather, also seemed to influence their decision on their children's travel mode. [132] Gender and maternal travel mode were found to be associated with children's walking or cycling. [134] The same study found a moderating effect of distance, whereby parental attitudes were shown to be important for short commutes and safety concerns were important for longer distances. A Swiss study reported that parents preferred to drive their children to school either due to 'distance', or 'having the same way to go', or due to 'bad weather' or the 'child being late'. [117]

2.4.2.7 Age differences in modes of travel

Students' travel to school was found to change with age. Walking and cycling increased from 16% in Kindergarten to 24% in 5th grade, and reduced to 18% in 8th grade. [136] Similarly, older children were more likely to actively commute to school, peaking at 6th grade. [133] In Switzerland, older children travelled longer distances. [117]

2.4.2.8 Other factors influencing mode of travel

Characteristics of the individual and family, and social and physical environments were other predictors of mode choice. Variations occurred in mode of travel and the proportion of walking and cycling differed by socio-demographic, socioeconomic status and race/ethnicity. [12] [122] [121] Hispanic and African-American children were more likely to actively commute to school than white children. [122] [121] Seasonal differences in active commuting were reported in one study,[135] while cultural differences were noted in another. [117] Findings of the influence of gender on active commuting were not very consistent. Boys were more likely to cycle to school (15%), versus girls (1%), who were instead driven more often, (27%) than boys (3%). [134] [123] No such association was, however, found in another study. [126]

Physical environmental factors include road and pavement infrastructure; traffic safety; and urban, versus rural location. Studies examining characteristics of the built environment suggest that children walked or cycled to school more in urban areas [122] with increased directness and connectivity [132] and in dense residential neighbourhoods with pavements. [135]

2.4.2.9 School siting and school policy

Only one study discussed the importance of the link between school location and school policies on mode choice. The shift in the spatial distribution of students living further away from school was found to be the likely explanation for the overall increase in motor vehicle usage, and declining walking rates. [125]

2.4.2.10 Excluded studies

Several potentially useful studies had to be excluded because they did not quantify distance while describing the mode of travel to school. [46] [140] [141] The reasons for exclusion are summarised in Appendix (iii). Two systematic reviews were excluded because the factor of interest was not relevant to this review (environmental factors or objectively measured built environment correlates and its influence on active commuting). There were 2 studies from low or middle-income countries, but they could not be included. One study compared objectively monitored physical activity of Filipino adolescents for different modes of travel to school, but distance was not a factor of interest. [142] Similarly, a global school health survey in 34 countries including some low or middle-income countries reported active travel to school, but it did not include distance to school. [46] Other studies from low or middle-income countries were not included because they either compared active commuting and inactivity patterns, or they focussed on whether or not children met the physical activity recommendations. Neither of these had distance as a factor of interest.

2.4.2.11 Selective reporting

One study declared that only mothers were selectively asked information about their children's commuting. [135] While the other studies mentioned that parents completed the questionnaires or answered the interview, it was not explicitly stated whether it was the father or the mother who participated in the study.

2.5 Discussion

2.5.1 Principal findings

This systematic review looked at the association between distance and mode of travel to school and it showed that how far children lived from school heavily influenced their mode choice.

2.5.2 Summary of main results

Twenty three studies were reviewed. A definite inverse relationship between distance and walking or cycling to school, and a direct relationship between distance and the use of motorised transport was found. Studies from low or middle-income countries were notably absent in the review. Additional research is needed to fill this gap, in the form of primary surveys on children's mode of travel to school in India.

The review noted that children are strongly influenced by their parents' attitudes and practices, as found previously. [143] [144] [145] Parental and family attributes and circumstances influenced children's commuting to school. Children were more likely to walk or cycle when their parents themselves valued physical activity. Parental schedules affecting children's mode choice was evident in the substantial shift in mode choice between morning and afternoon commutes. Parents were perhaps at work, and were not available to pick up their children in the afternoon. Parents did not allow many children living close to school to walk or cycle due to traffic and safety concerns. [18] Similarly, parental concern about road safety is also common in India. [146]

Long trip lengths are one of the primary reasons many students do not walk to school. One study even reported that half the decline in active commuting is attributable to increased distance to school. [120] The falling rates of walking and cycling were accompanied by an increase in motorised transport. Most of the decline in active commuting in the United States happened between 1969 and 1983, with the largest proportion between 1969 and 1977, coinciding with the rise in car use and obesity levels in children. School siting and conglomeration of schools into larger units were cited as possible explanations. School location was inextricably linked to distance and time. Similarly, travel time has been shown to have the strongest effect on the decision to walk to school, with a 10% increase in walk travel time leading to a 7.5% decline in walking. [147] [120]

Vehicle miles travelled, which is the total number of miles driven by all vehicles within a given time period and geographical area, has been found to be increasing over the years. Urban sprawling neighbourhoods requiring extensive use of personal vehicles.[148] for everyday needs led to 20-40% higher vehicle miles travelled, than mixed land use neighbourhoods. [149] In the United States, school travel was found to account for 5-7% of peak time vehicle miles travelled in 2009-10, and 14% of all vehicles on the road during school drop-off times. [53] Although most studies did not elaborate on school siting and choice issues, an increased emphasis on school choice was found to be accompanied by a 20% increase in the average distance travelled to school. [12]

The studies appraised revealed that the mode of travel to school is influenced by many factors such as individual, family, socio-demographic, socio economic and access to resources, both finances and time. Further, more active commuting among boys has been noted before. [46] Higher rates of walking to school among boys may reflect cultural factors and social tendencies like parental shielding of girls and stricter monitoring of their independent mobility.

The studies reviewed concluded that school journey is a great way to promote physical activity, particularly for those living 0.5 mile to 5 miles from school. The impact on physical activity levels was not significant; however, if the distance travelled was less than 0.5 miles, since the association between distance and physical activity is known to be stronger with increasing distance [129] Studies that looked at the effect of active travel on body mass index (BMI) found that active travel per se does not decrease fat mass or BMI, unless distance was considered. Only active commuting for longer distances led to lower fat mass. [124]

2.5.3 Quality of the evidence

The methodological quality assessment is summarised in Appendix (v). Five studies used GIS based objective methodologies. [8, 117, 122, 135, 140] and the other studies used information of self-reported distance and mode of travel. Although all studies were cross-sectional, and attributing causal relationships is an inherent deficiency of the design, some studies usefully looked at changes over the years (7 studies).

Additional limitations include the lack of uniformity in measurement of both distance and mode of travel to school. Studies used either parent's estimates of their children's frequency of walking or bicycling to school; or travel diaries; or children's reports; or hand-counts of those who walked or cycled to school on a particular day. Some studies directly observed school premises or documented usual modes of travel, mode of travel on the day of the survey, or the previous day.

Considerable variation in the definition of active travel was also noted, with more generous definitions used in the United States. For example, even if the child was driven five out of ten times a week, such journeys in the United States were classified as 'non-car travel' [131] and walking or cycling at least once during the past week was considered as active commuting. [122] On the contrary, studies from Europe had a stricter definition of active commute: walking or cycling to and from school both in summer and winter, while travel was considered as 'regular car trips' if the child was driven to school even once a week. [117]

In many studies reviewed, households with children were 'invited' to participate in surveys. Self-selection of families could therefore have influenced their responses about the mode of travel [125, 150]. Selective inclusion of mothers or primary carer givers, who are likely to be women, could also have influenced the findings, especially on subjective topics like perceptions, attitudes about safety, neighbourhood and school characteristics. [135]

Systematic reviews that specifically looked at environmental correlates of active commute expressed concern that the range of different methods used to categorise active commute could confound results. In this review, though, the broad outcome of 'any mode of travel to school' did not require such precise measurements of distance.

2.5.4 Comparison with other studies or reviews

This review was deliberately kept broad, with the intention of including studies from all settings including low and middle-income. Other reviews looked at more narrow outcomes, such as objectively and subjectively measured environmental correlates of active commuting to school. [141, 151]

2.5.5 Overall completeness and applicability of evidence

All included studies happened to be from high-income countries, questioning the generalisability of this review. Only one study discussed the increased motorised travel and decreased walking or cycling by the diminishing proportion of students living close to school. [125] Future research will benefit from a thorough examination of school choice policy in India.

Mode of travel to school is context specific. In the United States and Australia, results were different from that found in Europe, especially in terms of lower rates of active commute. Cultural variation in active commute found in this review reinforced the findings of another systematic review which emphasised the importance of viewing findings within their national context. [141]

Research from low and middle-income countries is missing in this review, and along with it, the country-specific social, political and cultural milieu of travel to school. Environmental characteristics are also likely to be different, given the conditions of haphazard land use and built environment policies in India. [82] Other context specific factors need to be explored. For example, in India, we do not know the effect of active commuting in malnourished children who may already have low energy levels. It may not be correct to assume that active commuting is always beneficial for all children irrespective of their nutritional status. It is common to see children of lower socio-economic background walk to government schools in India. Walking long distances, when combined with poor nutritional status that is common in such children, may further deplete their energy reserves and exacerbate malnutrition. [152]

2.6 Conclusions

All studies appraised reported an inverse relationship between distance and walking and cycling to school, and a direct relationship between distance and use of motorised transport to school. There was a notable absence of studies from low and middle-income countries. School travel is a routine activity with a regular pattern, like an adult's commute to work. Further research is warranted, especially in low and middle-income countries, to examine the reasons behind the choice of school, and the modes of travel to school, in the larger context of the region's social, economic, environmental and political setting. This information is essential to eventually plan effective strategies to promote safe paths to school, including children's walking and cycling to school.

It follows from the systematic review that there are no published studies on distance and mode of travel to school among children in India. Therefore there is a strong need for research on children's travel to school in Hyderabad. Information on distance and mode of travel in Hyderabad is necessary, for city transport planners to develop relevant proposals and allocate appropriate resources based on the transport choices. I therefore decided to design and undertake a cross-sectional survey to understand the mode of travel and distance travelled by children to school in Hyderabad.

3 METHODS

3.1 Introduction

In Chapter 2 my systematic review identified no studies on distance and mode of travel to school from low or middle-income countries. Given the evidence to suggest that everyday travel by walking and cycling has positive health benefits among children, [3] [114] we need information on children's travel to school in India to understand the public health impacts of the journey to school. Developing methods to measure children's travel to school for use in low-resource settings is therefore important.

A range of methods have been used in high-income countries to measure distance from home to school. These are: Geographical Information Systems (GIS); [135, 153] Geographical Positioning Systems (GPS); [154] travel time; [155] or the 'straight-line' between school and home. [8, 117] In some studies, distances have been calculated using the shortest route possible along the road network, [156] or by asking children to draw their routes to school on image maps (which were digitised and measured using GIS). [157]

Such information on the distance travelled by children to school in India is not available. The reason is perhaps because researchers in many low-income settings may not have the financial resources for proprietary GIS software, or adequate human resources for objective distance calculation.

Furthermore, in many areas in India, postcodes and addresses often do not identify dwellings and cannot therefore be used to reliably estimate the distance to school. This is because several urban areas in India, including numerous localities in Hyderabad, are growing rapidly, the city population is estimated to be growing by about 8% every year. [158] As a result, we do not have uniformly structured or geocoded searchable addresses on the web. [159] However, there is a strong need for accurate estimates of distance and mode of travel in Hyderabad, and it is an essential component of this study. I therefore wanted to develop and test an alternate method to estimate distance travelled by children to school in Hyderabad.

This chapter is organised into two parts: Part 1 describes the iterative process of the development of a self-administered questionnaire that aims to estimate the distance and mode of travel to school. Part 2 describes testing the reliability and validity of the questionnaire in estimating distances to school and measuring the modes of travel to school.

The chapter begins with describing the methods for the development of the questionnaire in three phases. It then describes the methods for the testing of the questionnaire. It then elaborates the methods for conducting the cross-sectional survey, data collection, data management, and statistical analysis.

Table 3.1 summarises the chronological order in which the various methods were used.

Table 3.1 Chronological order of the methods

Steps	Phase	Activities	Time-frame
(i)		Developing the questionnaire	
	1	Literature search	Nov 2012-April 2013
	2	Testing the face validity: Focus groups with five children	May 2013
		Testing the content validity: Focus groups with four public health experts	May-June 2013
	3	Pre-pilot using the draft questionnaire in a private school	June 24, 2013
(ii)		Testing the questionnaire (estimating mode of travel to school)	
	1	First reliability study in the 8th grade of Government Zilla Parishad High School, Gachibowli (Test)	July 10th, 2013
		First reliability study in the 8th grade of Government Zilla Parishad High School, Gachibowli (Re test)	July 18th, 2013
	2	Conducting cognitive interviews among seven children	October, 2013
	3	Revising the questionnaire based on the feedback from the cognitive interviews	October, 2013
	4	Second reliability study in the 8th grade of Government High School, Shaikpet (Test)	October 23rd , 2013
		Second reliability study in the 8th grade of Government High School, Shaikpet (Re test)	November 1, 2013
(iii)		Testing the questionnaire (estimating distance from home to school)	
	1	Estimating distance by measuring polyline and crow-fly distance during the first reliability study	July 10th, 2013
	2	Map exercise during the second reliability study	October 23rd , 2013
	3	Validity of the estimated distance using the 'in-depth' method and 'nearest landmark' method	October-November 2013
(iv)		Cross-sectional survey in schools	November 25th 2013-25th January 2014
(v)		Data management and analysis	February-June 2014

3.2 Development of the questionnaire

The questionnaire was developed in three phases; phase one was to conduct a thorough literature search; phase two was to test the face validity and content validity of the questionnaire using focus groups; and phase three was to conduct a pre-pilot using the draft questionnaire.

3.2.1 Literature search

In phase one of the iterative process to develop the questionnaire, I searched the literature to identify questions from previously published work on children's independent travel. [145] [12] I wanted to adapt relevant questions so that they could be applied in the context of a low-resource setting like India. The questionnaire was developed to be used in children aged 11-14 years, as this is typically an age when children may be expected to travel independently. [145] In school terminology in India, it refers to children in grades 6-9. I reviewed literature identified from searching five databases (*Ovid, PubMed, Web of Science, Zetoc, and TRID,* which is the transportation database) (Box 3.1).

Box 3.1 Literature search

Databases searched (1990- 2012)
Ovid, PubMed, Web of Science, Zetoc, TRID
Search strategy:
1. (child* OR adolesc* OR youth OR young people OR student* OR pupil* OR teenage* OR young person OR boys OR girls OR pediatri*)
2. (walk* OR active OR bicyc* OR bik* OR rid* OR cycl* OR travel* OR mode OR trip OR transport* OR commut* OR journey* OR car OR bus OR train OR auto OR rickshaw OR motorcycl* OR two wheel* OR independen*)
3. (distance OR length AND ("school") AND (develop* countries OR rich OR high AND middle AND low income countries OR nations)
4. (question*OR tool)
5. (1), (2), (3) and (4)

The domains were chosen after reading earlier literature on various determinants of children's school journeys. [12, 145] The domains were: mode of travel to school including travel during hot or cold weather; non-fatal road traffic injuries during school journeys; parental permissions for independent travel; perception of safety; and physical activity. Previously validated questionnaires were reviewed and approximately 25 items were identified from the specific domains, giving importance to questions on mode, followed by the other determinants of mode choice.

From the 25 items, questions were narrowed down for relevance to the local Indian context, such that my draft questionnaire had 21 multiple-choice items. Of these, four questions were on demographics, nine questions were on mode of travel and travel during hot or cold weather, two items were on parental permissions for independent travel, three questions were on children's perceptions of safety, including road traffic injuries, and three items were on physical activity after school. I also explored accompaniment to school, in the form of questions on independent travel, which was measured by asking whether the child travels to school alone, or whether the child is accompanied; or if the child is allowed to cross or cycle on main roads alone These domains and questions were included because of my interest in children's commuting to school in Hyderabad, and its impacts on health.

The questionnaire was prepared in English and printed on both sides of the paper. It was translated into Telugu, which is the first language (mother tongue) spoken by about 80 million people in India and is the local language in Hyderabad, where this study was to be conducted. To ensure the correct interpretation of the questions, the questionnaire was back-translated into English. The questionnaire was structured in such a way that it was kept fairly short, and could be completed in approximately 15-20 minutes during a regular school period (typically lasting 45 minutes). (See Appendix vii for English questionnaire and Appendix viii for Telugu questionnaire).

3.2.2 Focus groups

After preparing the draft questionnaire, I undertook the testing of the face and content validity of the questionnaire. Focus groups were conducted among five children aged 12- 15 years to test the face validity (i.e. to see whether children felt that "on its face" the questionnaire seems like a good way of studying the construct being explored- here, the journey to school). [160] The focus groups were conducted in the evening, in the lobby of the residential complex where the children lived. The aim of the focus group was to hear comments on the sequence and wording of questions, and on the best way to capture the information on the trip to school.

Another focus group was conducted among four public health experts on content validity (i.e. to check the operationalisation against the relevant content domain for the construct). [160] The focus groups were conducted in the office of the participants, during office hours. The aim of the focus group was to assess the suitability of the questions for the target ages, and to assess the acceptability of the wording, as well as the sequence of the questions. Table 3.2 describes the profile of the participants of the focus groups

Table 3.2 Profile of the participants of the focus groups

Participants		Number	Age range (years)	Total
Children	Male	2	12-14	
	Female	3	13-15	5
Public health experts	Male	1	38-42	
	Female	3	35-40	4

The focus groups were based on a guideline for discussion which included the items in box 3.2 below.

Box 3.2 Guideline for focus groups

Would you think this questionnaire captures the required information about the trip to school?

Would you think the questions are appropriate for the children?

Are there any words that might be difficult to understand?

Do you have any suggestions for the order in which the questions could be arranged?

Do you have any other comments on the questionnaire?

3.2.3 Pre-pilot

After modifying the questionnaire based on the suggestions from the two focus groups, I conducted a pre-pilot to field-test the questionnaire (i.e. test in its intended setting). The objective of the pre-pilot was to gauge the response rate, to estimate the time taken to complete the survey, and to obtain children's reaction and feedback regarding any difficulty with questions. I wanted to find out if the questionnaire is acceptable to the school principal and the teacher, whether children filled in all questions, and whether I will be able to read all the responses. I also wanted to ascertain whether the children's understanding of the questionnaire items was the same as mine; and whether there was any disagreement regarding their comprehension.

The pre-pilot was conducted in a private school. English questionnaires were administered to a ninth grade classroom in the presence of a teacher. I recorded my observations on whether the children appeared to have a good sense of the flow of questions since they were printed on both sides of the paper. I also took notes to record any requests for clarifications.

3.3 Testing the questionnaire in measuring the mode and distance to school

The reliability of the questionnaire in estimating the mode of travel to school was assessed. I distributed Telugu translated questionnaires to children, with the help of a research assistant. For the first reliability study, we conducted the test in the grade eight of a government school (Zilla Parishad High School, Gachibowli). We conducted the re-test one week later, in the same class and the same school.

3.3.1 Measuring the mode of travel to school

After the first reliability study, I carried out cognitive interviews with seven children. The objective of conducting the cognitive interviews was to obtain feedback on those questions which generated many requests for clarifications during the reliability study. The cognitive interview methodology was designed to assess the thinking processes underlying children's comprehension, and the generation of answers to the questionnaire items. I wanted to understand what the child thought while choosing a response, and what specific words and phrases in the questionnaire would mean to the child. I requested seven children aged 11-12 years to complete the questionnaire in its current form. I then interviewed each child for 15-20 minutes. Table 3.3 lists sample questions that were asked during the cognitive interviews. For example, the questions probed the meanings of items measuring ‘physical activity’, ‘physical training’ or ‘PT’ periods, ‘feeling safe’, and ‘crossing main roads’.

Table 3.3 Cognitive interview questions

What does this question mean to you?
What did you think of while answering this question?
Was this question easy to understand?
Are there any specific words that are difficult to understand?
How did you choose your answer?
Were the instructions easy to follow?
Do you have any other comments on the questionnaire?
Questions regarding the instructions for completing the survey
Are the instructions clear?
How can the directions be more clear/easy to understand?
What does "…in the past 7 days" mean to you?
When you see "the last 7 days", what days did you include?
Questionnaire items
In your own words, what do you think this question is asking?
What does this question mean to you?
What did you think of when answering this question?
Was this question easy to understand?
Are there any specific words that are difficult to understand?
How would you want the words to be changed, to make the question clearer?
Was this item hard to answer? If yes why?
How did you choose your answer?
Domains
In your own words, what do you think this group of questions is asking about?
How do you think these items are related?
Are there any questions that do not belong in this group?
Response Choices
What do you think about the response choices?
How would you make the response choices clearer or easier to understand?
Overall Assessment
Are there things that we forgot to ask about that you think are important?

Overall thoughts or opinions of the questionnaire

Based on the feedback from the cognitive interviews with the children (which are described in the next chapter), I revised the questionnaire and conducted the second reliability study.

The second reliability study (test) was conducted in the eighth grade of another government school (Government High School, Shaikpet, Hyderabad). The re-test was conducted in the same class and in the same school, one week later.

3.3.2 Estimating the distance from home to school

3.3.2.1 Polyline and crow- fly distance

As explained in the introduction to this chapter, the estimation of distance from home to school is an essential component of my study. Ideally, the distance from children's home to school would be measured objectively, to obtain accurate estimates of the distance. But since I did not have resources for GIS or GPS for the measurement of distance, I realized that direct information on the distance travelled would not be available for the main survey. I tried other methods to estimate the commuting distance, and are described below.

During the first reliability study, I gathered information from children, through questionnaires, on their home addresses, as well as the time taken for them to reach their school. Using this information, I attempted to estimate the distance from each child's home to school. However, most addresses were not searchable in any of the available online maps, or the locations were not recognisable, even with web tools. I therefore used *Google maps* to calculate the 'crow-fly' distance and the 'polyline' distance. 'Crow-fly' distance is the straight line distance from point 'A' to 'B' on *Google maps*, where 'A' is home and 'B' is school. [161] 'Polyline' distance is the route based distance, based on the most probable path that would be taken by the child from home to school. [161]

For the crow fly distance, I placed the cursor (using Google maps on the laptop) on the area that the child lives, and drew a straight line from that area to the school. For the polyline distance, I placed the cursor on the area where the child lives, and tried to retrace the child's route to school. (It was a series of connecting lines to the school, to form a route that the child may take to get to school).

Assumptions

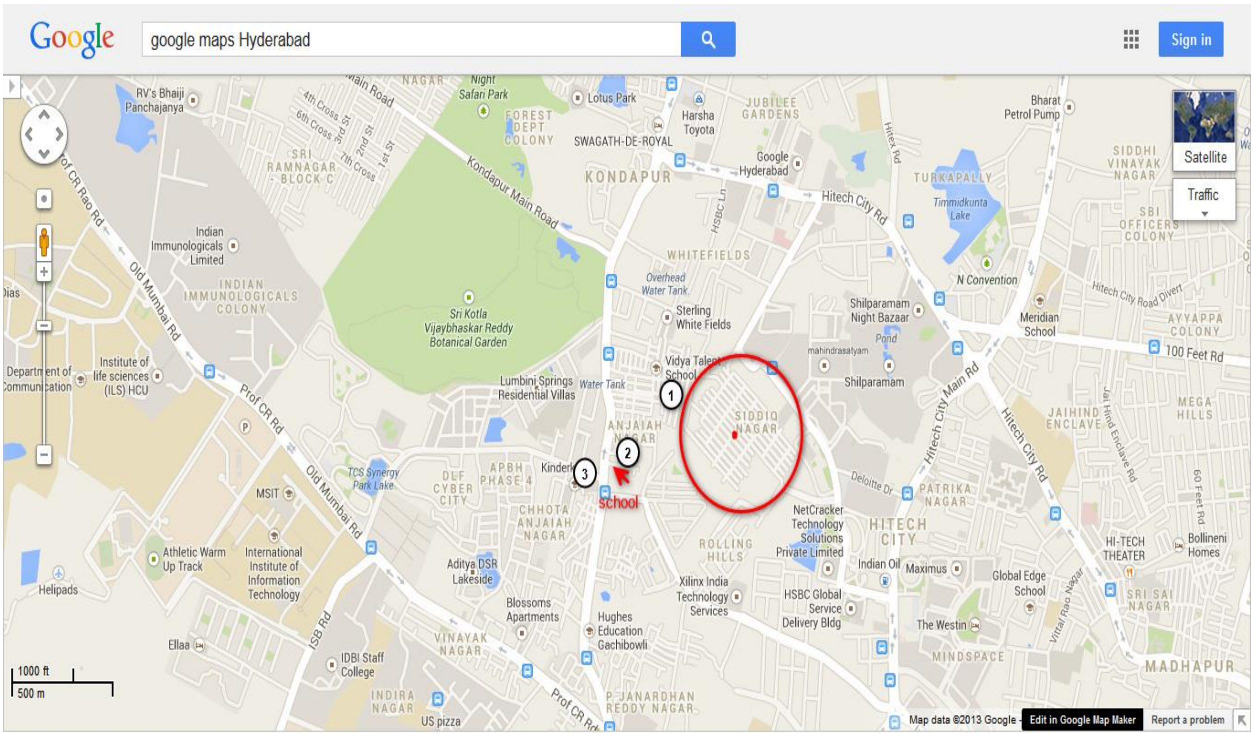
1. If the address mentioned by the child did not have the door number, and only a broad location was mentioned, for example 1 '*Siddiq nagar*', 2 *Anjaiah nagar* and 3 *Chhota Anjaiah nagar* (Figure 3.1) I assumed the child's house to be in the centre of that area (Figure 3.1).

2. If the address had a door number, but it was unusable because *Google maps* did not have the level of detail to include the street or door numbers, I assumed the same distance for children living in the same residential area, possibly under-estimating or over-estimating the true distance.

3. The decision of the route for calculating the 'polyline' distance was based on assumptions based on my familiarity of the streets, observations of children travelling to school, and my own experience as a mother of two school-going children. To my knowledge, it is also is the shortest distance, and one that a child may be expected to take, to get to school.

The polyline distance and the crow-fly distance were compared for each of the children who participated in the reliability study.

Figure 3.1 Assumption that the child's house is in the centre of an area



Assuming that all children from an area come from the centre of that area provides only a crude estimate of distance from home to school. One way to improve on this would be to distribute street maps of that area to children, during the survey, with an instruction to mark a cross where the child lives. Similarly, the "crow fly" distance is not very accurate, since I was assuming that the child was coming from the centre of an area approximately 1-5 km in radius. A more informative method would be for the child to put a cross indicating where his/her house is, on a map.

I decided to test the possibility of using maps for a better estimate of distance, by piloting the method in another school. In this method, I attempted to estimate the commuting distance in one school, where children attempted to mark the location of their house on a printed street map. This was conducted immediately after the first reliability test, and is described below.

3.3.2.2 Map exercise

After the first reliability test was completed and the questionnaires were collected, the map exercise was conducted to estimate the distance from children's homes to school. I explained to the children that we needed information on how far their home was, to be able to estimate how far they travel to school. Maps were distributed and instructions were given not to mark anything on the map until they were instructed to do so. This is because the children were not used to looking at maps, and we wanted them to mark their house only after being oriented to the map. After explaining the area on the map and details of the streets, I waited for 10 minutes to help them familiarise themselves with the map.

Two research assistants discussed the map individually with about 15-18 children. Each child was asked to mark a cross on the map where his/her house was, and the route that they normally take, to get to school. The children needed assistance in marking their house. The research assistants guided them through the maps. Through an iterative process of looking for the nearby landmark, the children were able to recognise the area to estimate where their house was. They also mentioned the route they take by drawing an imaginary straight line between their home and their school, with their index finger. When encouraged to include the details of road turns, they tried, but requested the research assistant do the drawing. Boys appeared to be able to complete the map exercise easier than girls, and required less help.

3.3.3 Validation of the estimated distance from home to school

Two methods were used to measure the distance from home to school: the 'in-depth interview' method and the 'nearest landmark' method. Information on the nearest landmark was obtained from the questionnaire, after giving detailed instructions to children on how to identify the landmark nearest to their home (see section 3.5.2 'instructions for completing the survey'). The 'in-depth interview' method was a face-to-face interview with me, and a map exercise with 50 children in selected schools.

Both methods were conducted using the *Google* search engine, which was used because it is available for free, is easy to use, and because of lack of access to other GIS tools.

The validity of the distance estimates was assessed based on the 'nearest landmark to home' method, and was compared with a 'gold standard' measure, based on in-depth one-to-one interviews with children in grades 7, 8 and 9, using detailed maps of their neighbourhood and routes to school.

Selection of schools - One mandal was chosen where I had a good familiarity with the streets and locations of the landmarks to ensure reasonable accuracy of the distance estimates. From this mandal one school of each type was purposively selected.

Selection of participants - The class teacher asked the children to raise their hands if they (usually) walked to school. The teacher then asked children to raise their hands if they travelled by car, and so on, for each mode of travel. A few children were randomly selected by the teacher, from each mode used, and were instructed to gather at a designated spot chosen by the principal. The participant selection process was repeated in the three schools that were chosen.

3.3.3.1 In-depth interview method

I prepared in advance by loading *Google Earth* [162] on my laptop, with a place mark put on the map, corresponding to the school location. An internet access data-card was used to ensure uninterrupted connection to Google Earth. I visited one school of each type (i.e. government, aided and private). The children who were randomly selected by the teacher came in groups of 3-4 to the desk where I was seated. This was to make it easy to facilitate children's familiarisation to the map exercise in small groups instead of a large group.

After orienting the children to the map and the areas near their school, the first child was asked the location of his house. Using an interactive process (discussing the home location and nearest landmark), the child and I together looked for the nearby landmarks, to help locate the house. The children were asked to trace their route from home to school, using the index finger. After checking the route using zooming options to magnify the map and see more geographic details, the path with the child's name was saved on the computer. The 'Play tour' mode was used, which is a virtual tour of the route with three dimensional images of the route from the origin to the destination chosen. It helped to confirm the route, and the child could see and confirm his path, as well as the distance travelled.

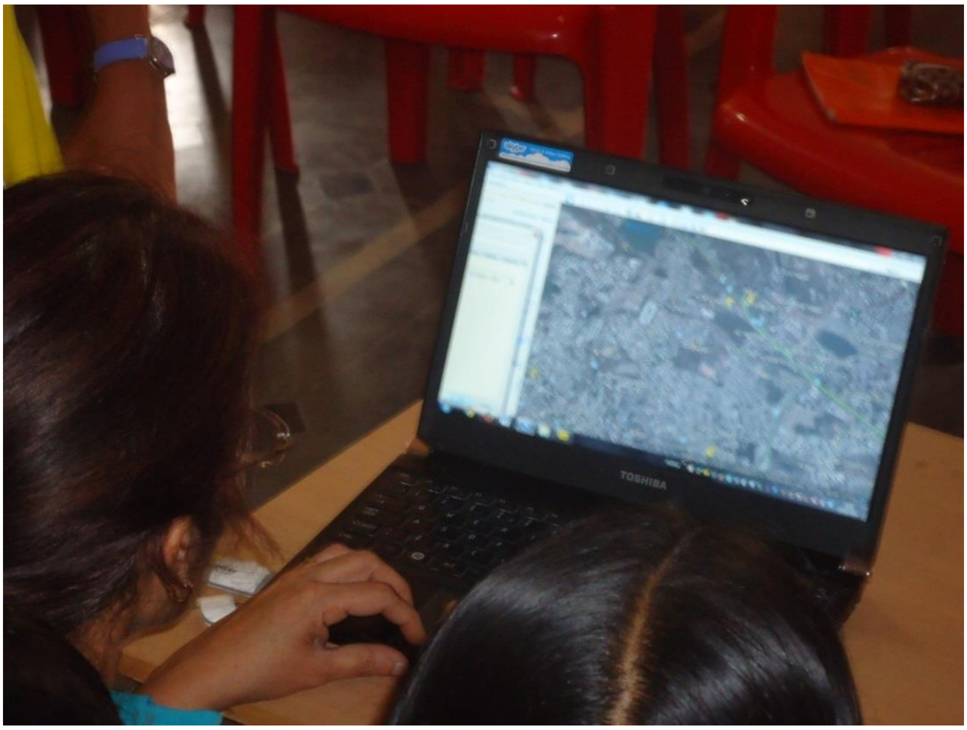
This procedure was repeated with each child selected in that school, and similarly in two other schools in that mandal. The time taken for the exercise was approximately 20 hours, for all the 50 children in the three schools. (Figure 3.2 and 3.3)

3.3.3.2 Nearest landmark method

The questionnaires from the main survey corresponding to the 50 children were extracted and the landmark details were entered into *Google maps* [163]. [14] The 'address and landmark' information was pasted in the '*from*' box and the school address/ location in the '*to*' box in *Google maps*. The '*give directions*' button gave the distance measure, according to the mode. *Google* gave a suggested route and the corresponding distance. This process was repeated for the all 50 children in the sample.

Figure 3.2 In-depth interview being carried out, as the class teacher looks on

Figure 3.3 In-depth interview method of estimating distance from a child's home to school



3.4 Measuring mode of travel to school (cross-sectional survey in schools)

3.4.1 Survey design

I conducted a cross-sectional survey using a two-stage stratified cluster sampling design. The geographical stratum comprised of mandals (i.e. boroughs) and the administrative stratum comprised of category of schools.

Geographical strata comprised 15 mandals from Hyderabad District, and one mandal from Rangareddy District. As described in Chapter 1, there are three main categories of schools in Hyderabad: government, government aided, and private schools. Government schools are run by the Central or State Government, government aided schools receive grant-in-aid from the government, and private schools are run by a Society or Trust without aid from any government sources. [164] I considered school management to be a marker of socio-economic status and parental influence: generally, government schools cater to lower income families, government aided schools cater to middle income families and children from higher income families attend private schools.

I obtained a list of all schools in each mandal in Hyderabad district with grades 6-9 from the District Education Office. I then separated the schools based on the three categories of schools. I selected one school from each mandal and from each category at random, using the software R. Next, the school principal randomly selected sections (i.e. classrooms which normally have 30-40 children) in grades 6-9. Assuming that the true prevalence of walking to school was 50%, [46] I estimated that a sample of 6,000 children would be required to be 95% confident that the sample estimate would be within 5% of the true prevalence. Stratification by mandal and by school type was used to ensure adequate representation from various socio- economic, demographic and geographic areas of the city, with varying transport links and facilities.

3.4.2 Data collection

3.4.2.1 Training of field workers

Five research assistants with survey and interview experience were recruited to assist in conducting the survey. They underwent a two day training session that covered all aspects of questionnaire administration, including on how to give clear instructions during the survey, how to clarify the items in the questionnaire, and how to answer children's questions. They also conducted mock surveys with each other to practise conducting the survey. The main survey was conducted in 45 schools (approximately 280 classrooms) over the next few weeks (November 25th 2013 through January 25th 2014), in the presence of the class teachers. (Figure 3.4 and 3.5)

All questionnaires were administered using pencil-and-paper methods. Depending on who was conducting the survey, the research assistants or I read out each question, allowing plenty of time for the children to mark the responses. After all the children in the class had answered one question, we went on to reading aloud the next question, and so on, repeating the process until all of the questions had been answered. This ensured that any questions or doubts that children had were attended to immediately, so that no child would feel left out. This approach helped to ensure that the response rate for each question would be high. I made periodic random monitoring visits to schools where research assistants were administering the survey to ensure they were adhering to the protocol (i.e., making sure that all questions were individually read out and explained in each classroom).

3.4.2.2 Instructions for completing the survey

Detailed instructions were given to children on every question. It was emphasised that there were no right or wrong answers, and that their answers would be kept confidential. Children were asked to think for themselves and provide their own answers, and not copy answers from the neighbouring children.

The demographic details consisted of the child's name, age, gender, and home address. In addition to the home address, children were asked to write down the nearest landmark to their home. I spent some time explaining about the nearest landmark, that it could be the name of a street, shop, pond, bus stop, temple/ mosque/ church, cinema, apartment complex, office building, car showroom, etc. There was no restriction on the number of words for describing the landmark.

For the question 'how did you travel to school today,' children were asked to write down all the modes they used to get to school, with the time taken, in parentheses. For example, 'walked from home to the bus stop' (x minutes), 'RTC bus from the bus stop near home to the bus stop near school' (y minutes), 'walk from the bus stop to school' (z minutes), etc. Nine options of modes were offered in a table (see Appendix vi for questionnaire), with the 10th option being 'other'. Travel to school during a usual week was explained as 'routine travel' to school, during any week, which is fairly similar on all days of the week.

Monsoon rains in India lead to heavy downpours during June-August, and the summers (March-May) are very harsh, with temperatures going up to 45 degrees centigrade. Questions on travel to school during the rains and during hot weather were meant to capture travel information during such weather.

Questions on independent travel were explained as parents allowing their children to cross and cycle on main roads, which were defined as important roads connecting city areas, and carrying a lot of traffic.

Perception of safety was explained as a feeling without any worry, or uneasiness about anyone, or about anything in particular.

For questions on physical activity, children were asked to tick the box with the number of days and hours per day that they exercise after school hours. Examples included fast walking, running, playing games, cycling, dancing, participating in sports and other activities like karate, etc., that made them sweat. They were instructed not to include their physical training (PT) activity or games period during school hours.

The question on road traffic injury was any non-fatal injury sustained in the previous 12 months, on the road while going to, or coming from school, due to a collision with another vehicle, or due to a fall or skid from a bicycle or two-wheeler, while standing or walking on the road. Various examples were given for children to help their understanding of the question. The number of injuries sustained was not required. The consequences of injuries were mentioned as those which led to the child missing at least one full day of their usual activities, or that which required treatment by a doctor or a nurse. This was a proxy for the severity of injuries.

3.4.2.3 Collection and storage of completed questionnaires

After administering the survey in a school and collecting the completed questionnaires from each class, the class teacher's signature was obtained to confirm his/her presence during the survey. A consecutive number was issued to each questionnaire. After checking for completeness, a summary sheet was prepared, with the following details: the number of completed forms in each classroom; the number of grades selected in each school; the total number of children enrolled in each class, and the number of children absent on the day of the survey. Questionnaires were stored in locked filing cabinets, and one file at a time was retrieved for data entry.

Figure 3.4 Cross sectional study being conducted in a private school

Figure 3.5 Research assistant conducting the study in a government school

3.5 Data management

3.5.1 Data entry

Password-protected computers were used for single data entry into a Microsoft Access database, which included a drop down menu of permissible response options for each questionnaire item, to reduce data entry errors. No names or personal identifiers were made available to the study team when data were transferred, or during data analysis. Data were stored as a single database, and regularly backed up on an external hard disk.

3.5.2 Data quality checks

Random checks were conducted for data accuracy, consistency and completeness. Every single folder containing the completed questionnaires and forms from one school were checked for inconsistencies. An example of an inconsistency was where a child's usual mode of travel was given as 'walk' and yet the time taken to get to school was recorded as '25 hours' (instead of '25 minutes'). Questionnaires were also checked for out-of-range answers, for example, if a child's age was recorded as one, two, or 20 years. Ten consecutive forms were checked and if all 10 forms were error-free, every fifth form was checked, followed by every tenth form, and so on, until that batch of forms was completely checked. If an error was spotted, this process was repeated.

There were approximately 30-35 errors in total, and these were mostly key stroke entry errors. For example, the hard copy had a particular option marked, but a different answer was entered into the database. Other errors included the time taken to get to school, which was entered as '1' or '1.5', which perhaps denotes the number of hours, without conversion into minutes. The errors were resolved in consultation with the data entry operators. I inspected the hard copy form for each error that was identified, and made the relevant corrections in the database as well as making a note in the paper copy.

3.6 Probability weights

For each stratum, I estimated the probability of each school being selected (first stage of sampling), followed by the probability of each section (class) being selected (second stage). The probability of selection at the first stage was the reciprocal of the number of schools in each stratum. The probability of selection at the second stage was the number of sections of each grade selected by principals, divided by the number of sections of each grade in each school (which was recorded when principals selected the sections). I checked the probability weights by comparing the population size estimated when applying the weights, with the numbers of children in grades 6-9 in each mandal recorded in the state education department [165, 166] reports.

3.7 Statistical analysis

3.7.1 Reliability studies

STATA 12 (Stata Corp, College Station, Texas) was used for all statistical analysis. For the reliability studies, agreement was assessed for each question using the kappa statistic. Standard categories were used for interpreting agreement (i.e. κ >0.81 'almost perfect' agreement; κ 0.61- 0.80 'substantial' agreement; κ 0.41- 0.60 'moderate' agreement; κ 0.21- 0.40 'fair' agreement; κ 0.01 - 0.20 'slight' agreement; κ 0.00 'less than chance' agreement). [167] The difference between the distances estimated by the two methods was plotted against the average of the two distances using a Tukey/Bland Altman plot. [168] Limits of agreement were calculated as the mean difference $\pm 1.96 \times SD$, within which 95% of the observed differences would be expected to lie. A paired sample *t*-test was used to assess whether the bias (mean difference) was statistically different from zero, where statistical significance was at the 5% level.

The age, sex and prevalence of walking was compared among the children present and those who were absent, and a chi-squared test of association was conducted between those present compared to the absentees.

3.7.2 Survey analysis of children's travel to school

For the analysis of the data on the cross-sectional survey of the travel to school, associations were examined between travel mode and distance to school, stratified by the school type. Logistic regression was used to estimate odds ratios with 95% confidence intervals for the association between walking and cycling and distance to school, adjusting for potential confounding factors (e.g. grade, gender, school type, independent mobility, physical activity). The 'survey' commands in Stata were used to account for stratification, clustering and unequal probability of selection, and the 'test' command was used to test the associations in the logistic regression models. Variables that remained statistically significant at the 5% level in the 'best fit' model were retained. Examples of the Stata code used are shown in Appendix vi.

3.7.3 Survey analysis of road traffic injuries on journeys to school

I estimated the prevalence of self-reported road traffic injury in the last 12 months during school journeys by mode of travel and distance to school. Logistic regression was used to estimate the relative risk (odds ratios with 95% confidence intervals) of road injury for each mode of travel, adjusting for potential confounding variables. As with the main survey analysis, the 'survey' commands in Stata were used to account for stratification, clustering and unequal probability of selection, and the 'test' command to test the associations in the logistic regression models. I retained variables that remained statistically significant at the 5% level in the 'best fit' model. A sensitivity analysis was conducted by fitting the model with distance as a categorical variable. Children who answered 'other' to the question on their usual mode of travel to school were excluded from the analysis.

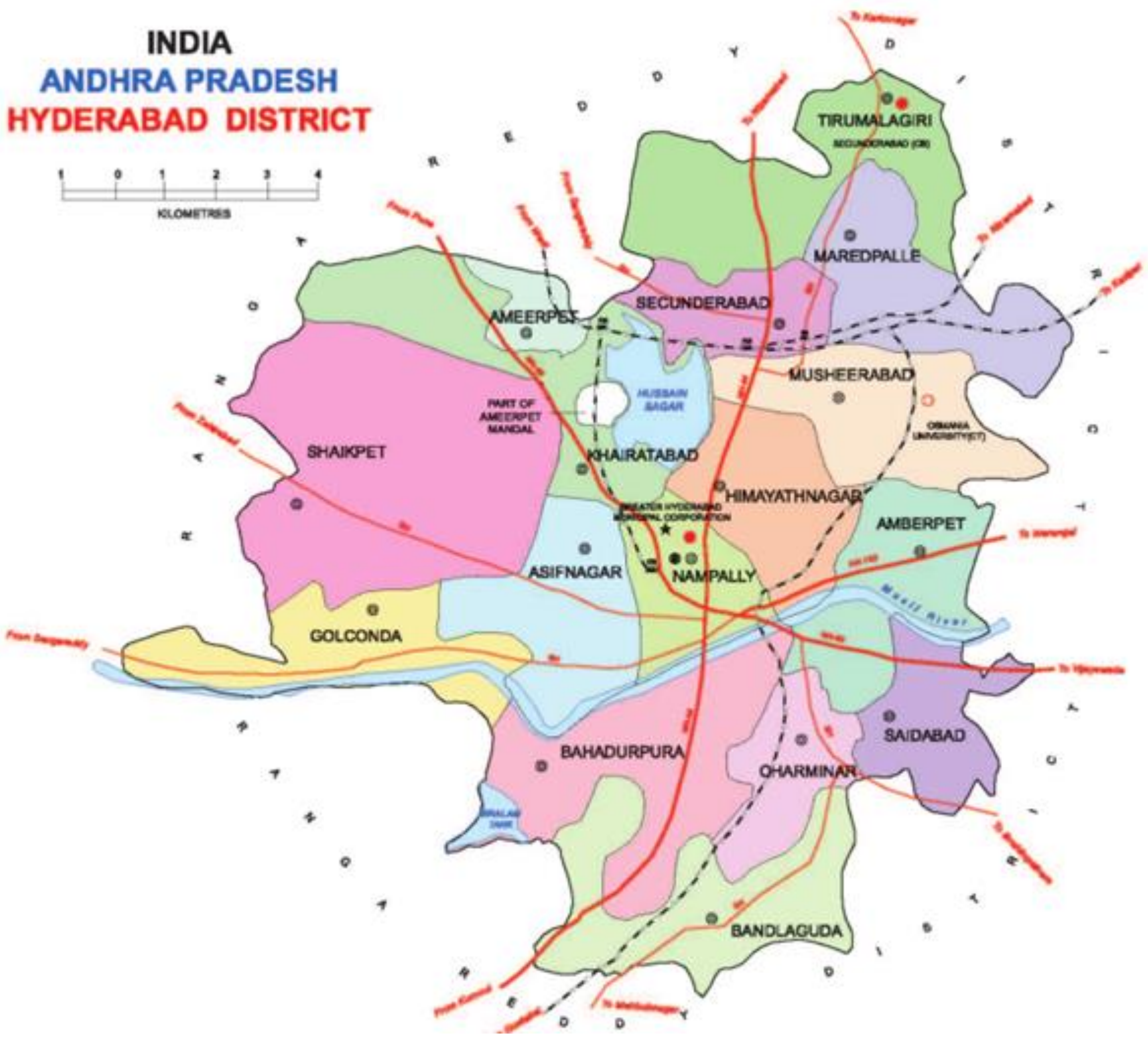
3.8 Ethics approval

Prior permissions were obtained from the Hyderabad District Education Office. The participating school principals gave verbal consent on behalf of the children. Informed consent was obtained from parents whose children participated in the focus groups. Ethical approvals were secured from the London School of Hygiene and Tropical Medicine, London, UK, and the Indian Institute of Public Health, Hyderabad, India.

3.9 Summary

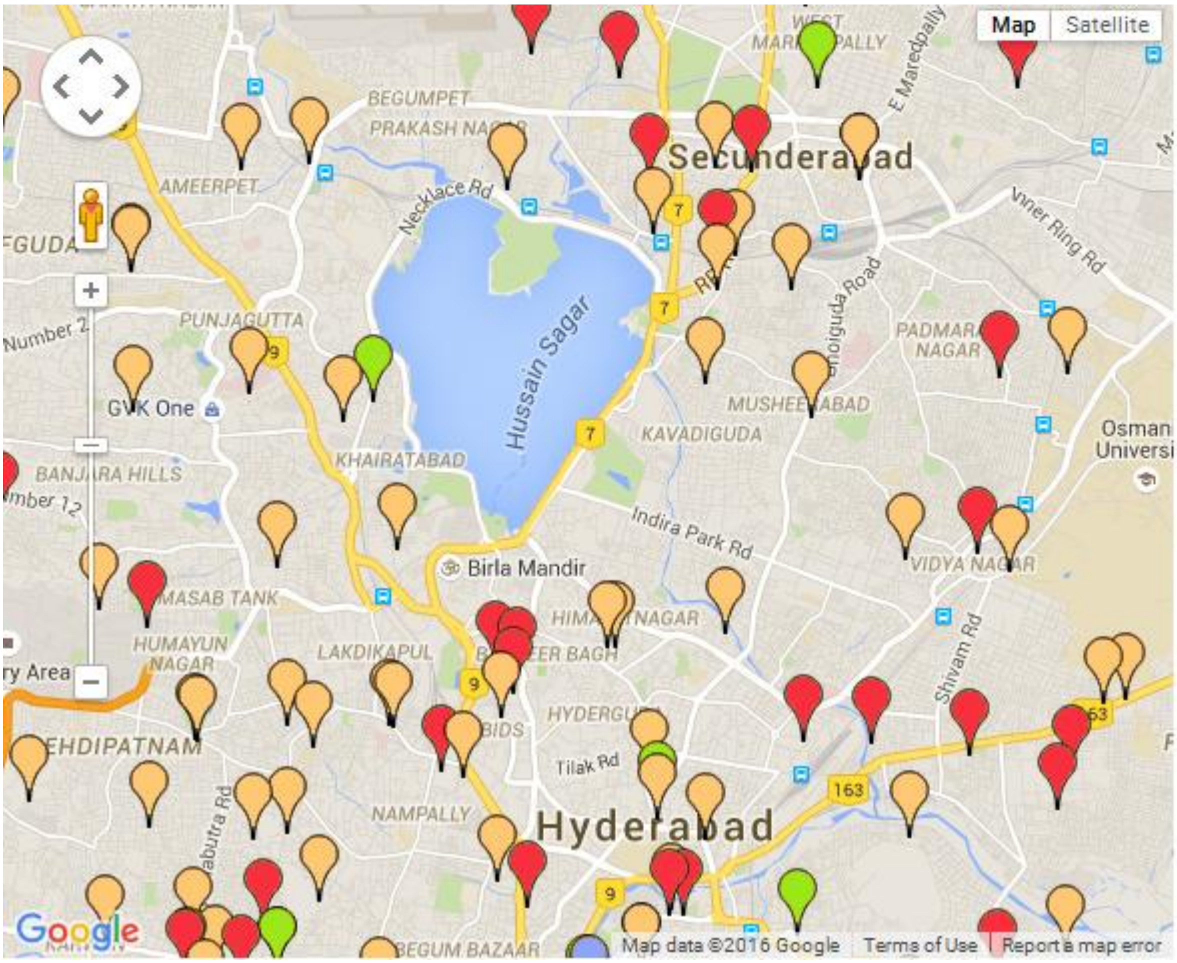
This chapter reiterated the importance of developing methods to measure children's travel to school for use in low-resource settings. It described how a questionnaire was developed and how the reliability and validity of the questionnaire was tested. Several alternative methods of estimating the distance from home to school were tried, including using the crow-fly and polyline distance and the map exercise for children in one class. This method was discontinued as the quality of data was unsatisfactory. But it gave rise to the idea that the information on the nearest landmark may be useful in estimating distance to school, which was used in the main survey, as will be described in Chapter 6.

Figure 3.6 Map of the mandals of Hyderabad district



Source: Maps of India: Telangana State

Figure 3.7 Map of government schools in Hyderabad district



Source: District education office, government of Telangana, Hyderabad

4 RESULTS 1: CAN WE MEASURE MODE OF TRAVEL TO SCHOOL RELIABLY?

4.1 Introduction

The previous chapter described the methods for the development and testing of the self-administered questionnaire in estimating the distance and mode of travel to school. This chapter presents the results of the questionnaire development and the results of the reliability studies.

After the first reliability study where the test and re-test was conducted among 61 children, I found that four questions out of 20 had poor reliability (i.e. kappa was between 0.2 and 0.54). These were *"How safe do you feel when you travel to and from school?" "Are you allowed by your parents to cross main roads alone?" "During the past week, on how many days did you have physical activity for at least 1 hour per day?"* and *"During the past week, how many PT periods did you attend?"* I presented these results on 25th September 2013 at a research seminar convened by the Transport & Health Group at the London School of Hygiene & Tropical Medicine. The questions from the audience and the discussion that followed focused on the possible reasons for the low reliability. Based on the discussion, I carried out cognitive interviews with seven children, with the objective of gaining feedback on the questionnaire items with poor reliability.

The purpose of the cognitive interviews was to assess the thinking processes underlying children's comprehension, and the generation of answers to the questionnaire items. I wanted to understand what the child thinks while choosing a response, and what specific words and phrases in the questionnaire would mean to the child. While answering the questionnaire, children thought about how they would answer each question, if they were a part of the survey in a school, specifically keeping in mind their own mode of travel. After revising the questionnaire, I conducted the second reliability study. For the analysis of the reliability studies, chi-squared tests of association were carried out between children who were present and the absentees, in addition to the kappa statistic.

This chapter is organised in two parts: Part 1 describes the results of the questionnaire development (focus groups, pre-pilot, and cognitive interviews); and Part 2 describes the results of the two reliability studies.

4.2 Results of the questionnaire development (part 1)

4.2.1 Focus groups

The participants felt that the overall instructions in the questionnaire were easy to understand. One child (boy) felt that the question on 'worry' was "silly" and another child (boy) felt that the option 'strangers' was "irrelevant". Two children (girls) felt that there were "too many parts" in the question on 'physical activity' and suggested some changes to be made to the questionnaire. The public health experts also gave several useful suggestions, as described in Table 4.1.

Table 4.1 Suggestions on the questionnaire from the focus groups

Suggestion	Quote	Suggested by (participant category)
Reword	*"Nobody says cycle- rickshaw these days. 'Rickshaw' is better"*	13 year old girl
	"Instead of 'this morning', say 'today'"	12 year old girl
Clarify	*"Clarify if physical activity is in school or during evenings, after school".*	Public health expert
	"The question 'How do you usually travel home during a usual week?' is not clear- if it is from school to home- or somewhere outside to home"	Public health expert
	"I don't know what is 'RTC'. Can you expand it?"	11 year old boy
Simplify	*"For the question on physical activity in a week, it is easier to think of one day, and calculate"*	14 year old girl
Revise order of the questions	*"The question on PT periods should come first. It introduces the questions on exercise, and is easy to count the number of periods. The question on physical activity can come next".*	Public health expert
General comments on the questionnaire	*"Children may ignore the instructions for 'next 2 questions'. Instead give simple instructions for each question".*	Public health expert
	"Make instructions boldface"	Public health expert
	"Keep the pattern of choices same for all questions, arranging the	Public health expert

	choices in two columns"	
	"Table may not be a good way to capture information on multiple modes of travel. A 6th grader may feel compelled to fill all blanks".	Public health expert
	"I feel comfortable with paper and pen. It will be good to have pictures for different modes of transport"	12 year old boy
Other suggestions	*"Give examples of physical activity in brackets, like 'brisk walking, running, exercising, playing' and so on"*	Public health expert
	"Write 'share-auto' separately as one of the travel options"*	Public health expert
	"Children may not understand 'PT period'. They will understand 'games period' …actually, you can give both options"	13 year old girl

* 'Share-auto' is an auto-rickshaw which is a popular and cheap mode of transport in Hyderabad. It seats five instead of three people, and the fare is shared by the passengers.

4.2.2 Pre-pilot

There were 12 children in the pre-pilot, with equal number of boys and girls. All 12 children responded. They needed clarification on the question about physical activity levels, and the question on who accompanies them on the trip to school and home. One child travelled in a chauffeured car, and was unsure about which box to tick. Based on this feedback, I created an option '*other adult*' for question no. 6. As the class size was too small to meaningfully record any variability, I decided to test the questionnaire in another school with a larger class size.

4.2.3 Cognitive interviews

Seven children participated in the cognitive interviews. All children said that they felt the instructions for completing the survey were simple. Two children said that they felt there were too many parts in the question on physical activity. Table 4.2 describes children's suggestions to reword some phrases in the questionnaire.

Table 4.2 Children's suggestions to reword some phrases in the questionnaire

Original word/ phrase	Suggested to be reworded/ rephrased as
'games period'	'PT period', or give both options
'cycle-rickshaw'	'rickshaw'
'how did you travel to school this morning'	'how did you travel to school today'
'involved in a road accident'	'injured in a road accident'
'on your own'	'alone'
'typical week'	'usual week'
'how would you like to be able to travel'	'how would you like to travel'

Table 4.3 Specific suggestions on certain questions in the questionnaire

Question	Specific suggestion
Mode of travel	"How do you usually travel home during a usual week- it is not clear from this question if it is about travel from school to home, or somewhere outside to home" "How do you usually travel home during a usual week- is it from school to home or somewhere" "How did you go to school this morning? Obviously we go to school in the morning….it is better to emphasise 'this' instead of 'morning'". "Replace with 'today' because there is a question, how do you travel home 'today'"
Physical activity	"The question on physical activity is confusing. instead of giving instructions for 'next 2 questions', which children may ignore, it is better to give examples in brackets, like brisk walking, running, exercising, playing etc." "The question on physical activity is not clear if it is about activity in school, or during evenings, at home, after school" "Instead of calculating physical activity for the past week, it is easier to think of one day, and calculate hour-wise. Otherwise, it is difficult to remember our activity and calculate for the whole week". "There are too many parts in the question on physical activity" "Physical activity… is it in school or in the evenings, after school?"

With whom did you come to school today?	"I have a driver who drives me to school, but there is no such option in the choice of answers" "It is better to write 'who did you travel to school with'?" "I travel by school bus – does it mean that I am accompanied, or travel alone?"
PT period	"Calculating PT periods per week is easy in my school, because we have 1 period every day, but for some schools it may not (be easy), and those children may have to think hard to answer this question".
Are you allowed by your parents to cycle on main roads alone? (Sometimes/ rarely/ never)	"I don't know how to cycle, but that option is not provided in the choice of answers"
What are you worried about when you travel alone to school?	"Change the question to 'what are you worried about during your school journey', and give an option of 'other' or give some space below the choices"
During the past 12 months, were you involved in a road accident?	"Change to during the past 12 months, were you 'injured' in a road accident?"

In response to the child's comment:

"I have a driver who drives me to school, but there is no such option in the choice of answers"

I added the choice 'other adult' to accommodate the possibility of being driven to school by a driver. The options in the revised questionnaire are: "Parent/ grandparent/ other children/ other adult/ alone"

Similarly, in response to a child's comment:

"I don't know how to cycle"

I added this option (*I don't know how to cycle*) to the range of choice of answers.

After the cognitive interviews, definitions were added for *exercise, main roads*, and *feeling safe*.

Table 4.4 describes the children's interpretations of certain phrases in the questions.

Table 4.4 Difficult words in the questionnaire and children's interpretation of the meaning

Domain	*Children's interpretation of the meaning*
Physical activity	*"Physical activity is playing at home, like outdoor play"*
	"It means not ill or sleepy…times when I am 'active' and not sleepy"
	"It is any activity that keeps me physically fit, not mentally fit. It activates all external organs….it is like jogging/ walking"
	"Physical activity is when people do things for fitness, like brisk walking, running, exercising, playing"
	"It is exercise, and staying physically fit"
	"It means playing at home, in the evenings, after school"
	"Physical activity means being active, full of strength and stamina"
	"Physical activity is playing at home. It is not PT period".
Main roads	*"It is any road where there are more vehicles"*
	"They are busy roads, with many vehicles traveling"
	"It is where fast vehicles go, since it connects other roads"
	"It is an important road, which connects parts of the city, it is big and has high speed vehicles"
	"Main road is where two roads meet in a junction. It is full of vehicles and traffic"
	"Main road means junction with fast moving vehicles"
	"It means traffic roads"

Feeling safe	*"Safe means not falling off (the auto-rickshaw) because I sit in the front and am worried about falling, especially during turns. I sometimes I feel I may fall down, especially during right turns because I sit on the right side"* *"Safe means not having motion sickness or not feeling uneasy"* *"Rash drivers make me feel unsafe, and my dad says not to sit too close to the car door. Every time I get into the car, I make sure the door is locked properly. Then I feel safe".* *"Feeling safe means not facing trouble, like kidnapping. I feel scared or have a subconscious worry that something bad might happen if my brother is not there. We travel together by private auto-rickshaw. Safe means trust".* *"Safe means nobody is harming me. When the auto driver talks on the phone, I don't feel safe"* *"I understand the question and can answer it in the questionnaire, but I don't know how to explain the meaning of 'feeling safe'"*
PT period	*"It means free- hand exercises, like 'drill'"* *"PT is when children do march past/ exercise/ yoga together"* *"PT means free- hand exercises… what you are saying is called 'games period' in our school"* *"PT means PE period. We don't have that period in my school. We do PT or drill or marching only during school ceremonies like investiture".* *"PT period is when we get to play games, mainly cricket"*

4.3 Results of the Reliability studies (part 2)

Table 4.5 shows the results of the reliability studies. There were 61 children in the first reliability study and 68 children in the second. Fifteen children absent during the re-tests were removed from analysis. There was perfect agreement (i.e. kappa 100) for age, sex and name. Almost all children (67 out of 68) wrote the same landmark in the test and re-test.

The results showed 'substantial' or 'moderate' agreement in 69% (11/16) questions; 'fair' agreement in 6% (1/16) questions and 'slight' agreement in 25% (4/16) questions. The question on the number of hours of physical activity per week (in addition to the number of days of physical activity per week) was added to the questionnaire after the first reliability study.

The results of the second reliability study (which was conducted after the questionnaire was revised following the cognitive interviews and focus groups) are also shown in Table 4.5. There was 'almost perfect' agreement in 11% (2/17) questions, 'substantial or moderate' agreement in 41% (7/17) questions, and 'fair' agreement in 23% (4/17) questions.

When I looked at the reliability based on the domains of the questions, I found that the questions on the usual mode of travel to school showed 'substantial' to 'almost perfect' agreement. The question on road injury showed 'substantial' agreement in both the reliability studies. Questions on parental permissions for independent travel, perception of safety, and physical activity after school were shown to be less reliable.

Table 4.5 Results of the two reliability studies

Questionnaire item	Questionnaire version 1 (First reliability study) kappa	Questionnaire version 2 (Second reliability study) Kappa
How did you travel to school today?	0.67	0.79
With whom did you come to school today?	0.53	0.31
How do you travel to school during a usual week?	0.73	0.75
How will you go from school to home today?	0.75	0.66
With whom will you go from school to home today?	0.58	0.58
How do you travel home during a usual week?	0.76	0.84
How would you like or wish to travel to and from school?	0.48	0.44
How do you travel to school during the rains?	0.56	0.64
How do you travel to school during hot weather?	0.66	0.88
Are you allowed by your parents to cross main roads alone?	0.18	0.24
Are you allowed by your parents to cycle on main roads alone?	0.30	0.20
How safe do you feel when you travel to and from school?	0.02	0.00
What are you worried about, during your journey to school?	0.54	0.31
During the past week, after school, on how many days did you exercise?	0.07	0.01
*During the past week, after school, how many hours did you exercise?	n/a	0.01
During the past week, how many Physical Training (PT) periods did you attend?	0.07	-0.01
During the past 12 months, were you injured in a road accident?	0.61	0.72
*Mention the nearest landmark to your home	n/a	n/a

*Question included only in the revised version

4.4 Strengths and limitations

For the reliability studies of the self-administered questionnaire in schools, the questionnaires were administered about one week apart. Some children's motivation and interest may have differed between occasions, altering the quality of their responses. There was a difference in the number of children who took the test and re-test, but it is not expected that the exclusion of the absentees would influence the results. Compared to those present, absentees had similar age (12.9 vs 13.1 years; p=0.09), and sex (44% vs 47% boys; p=0.55) distribution, and prevalence of walking (74% vs 69%; p=0.99).

The kappa score for the question on "mode of travel to school today" was lower than that observed by another study that also used the pen and paper method (i.e. 0.79 vs 0.98). [169] This was perhaps because it administered the questionnaire on the same day. The difference in kappa in my survey could also be due to the difference in the travel behaviour on the day of the survey, because my survey was administered one week apart.

Questions on the usual mode of travel and road injury were found to be more reliable than those on parental permissions, perception of safety, and physical activity, and this must be considered before using the questionnaire. The question on physical activity was adapted from the WHO Global School Health Survey. [46] It was found to be especially challenging and many children asked for clarification on this question.

The results of the questionnaire development show that children aged 11-14 can offer a unique insight into the comprehensibility of the questions during cognitive interviews. Children were able to recognise the different domains and the various options in each question. While a majority of the items were well understood, children seemed to readily identify vague concepts and difficult questions.

The cognitive interviews also had some limitations. The number of children who participated in the interviews was small (seven). Children belonged to a homogenous group who went to private schools, and were from well-to-do families. It is possible that their comprehension of the questionnaire could be better than children attending government schools. This was confirmed in the results of the reliability studies which were conducted in government schools.

4.5 Implications of the findings

The findings of the first reliability study confirmed that children found it particularly difficult to understand the four questions which showed poor reliability in the test re-test study (questions on physical activity, main roads, feeling safe and PT period). The meaning of "main roads" was more consistent across children, but "physical activity" "feeling safe" and "PT periods" meant different things to different children. These four items were revised and definitions for the terms were added (the rest of the questions on the travel to school seemed to have been understood by the children). The suggestions on rewording and rephrasing some questions led to a few changes in the questionnaire. The second reliability study showed that the kappa scores had improved in the main domains (mode of travel and road traffic injury). The version of the questionnaire used in the second reliability study was considered as the final version, to be used in the cross-sectional survey (described in Chapter 6).

The cognitive interviews confirmed that the questions with poor reliability in the test re-test study were perhaps due to poor comprehension of the words and concepts that were being discussed. All children who participated in the reliability studies belonged to the similar age group of 11-12 years. If they understood the questions, it is likely that older children may not have any difficulty understanding the questionnaire, since the main study will include children from 11 to 14 years.

4.6 Conclusions

This study developed a questionnaire on mode of travel to school and a method to estimate the distance that children travel to school in Hyderabad. It may be used to determine whether these are journeys that could be made by walking or cycling. In the absence of searchable databases to pinpoint the home location, Google Earth and Google Maps were used to estimate distance.

The questionnaire that was developed on children's travel to school in Hyderabad was found to be reliable, especially the main questions on the usual mode of travel, and road traffic injury.

I received valuable feedback on the meanings of difficult words in the questionnaire, as perceived by the children, especially for questions with poor reliability. The iterative process was valuable, which led to the development of the final questionnaire (which was used in the cross-sectional survey in the schools of Hyderabad, the results of which are described in Chapter 6). Whilst this chapter particularly focussed on the reliability and subsequent revision of the questionnaire in estimating the mode of travel to school, the next chapter looks more closely at the estimation of the distance from children's home to school.

5 RESULTS 2: CAN WE MEASURE DISTANCE TO SCHOOL RELIABLY?

5.1 Introduction

In Chapter 3, the methods for validating the questionnaire in estimating the distance to school were described. This chapter presents the results of the validation of the estimated distance from home to school. It reports on the accuracy of estimating commuting distance to school using the nearest reported landmark to home, compared to the distance measured by in-depth face-to-face interviews with school children.

This chapter is organised into two parts. As mentioned in Chapter 3, I tried other methods to estimate the commuting distance, like comparing the 'crow-fly' distance and the 'polyline' distance, and conducting the map exercise. Part one of this chapter describes these results. I then assessed the validity of the distance estimates based on the 'nearest landmark to home' method, by comparing with a 'gold standard' measure, based on in-depth, one-to-one interviews. Part two of this chapter describes these results.

5.2 Results

5.2.1 Initial methods to estimate commuting distance (part 1)

5.2.1.1 'Crow fly' distance and 'polyline' distance

As mentioned in the Methods section, the 'crow fly' distance and 'polyline' distance from home to school for 55 children were estimated, and the results are shown in Table 5.1. The average 'polyline distance' was 1.1km and the average 'crow-fly' distance was 0.94km. The 'polyline' distance was 19% greater, on average, than the 'crow-fly' distance.

Nevertheless, this method of estimating the distance from home to school was discontinued because it was based on the assumption that the child's house is in the centre of an area, and did not seem to be accurate.

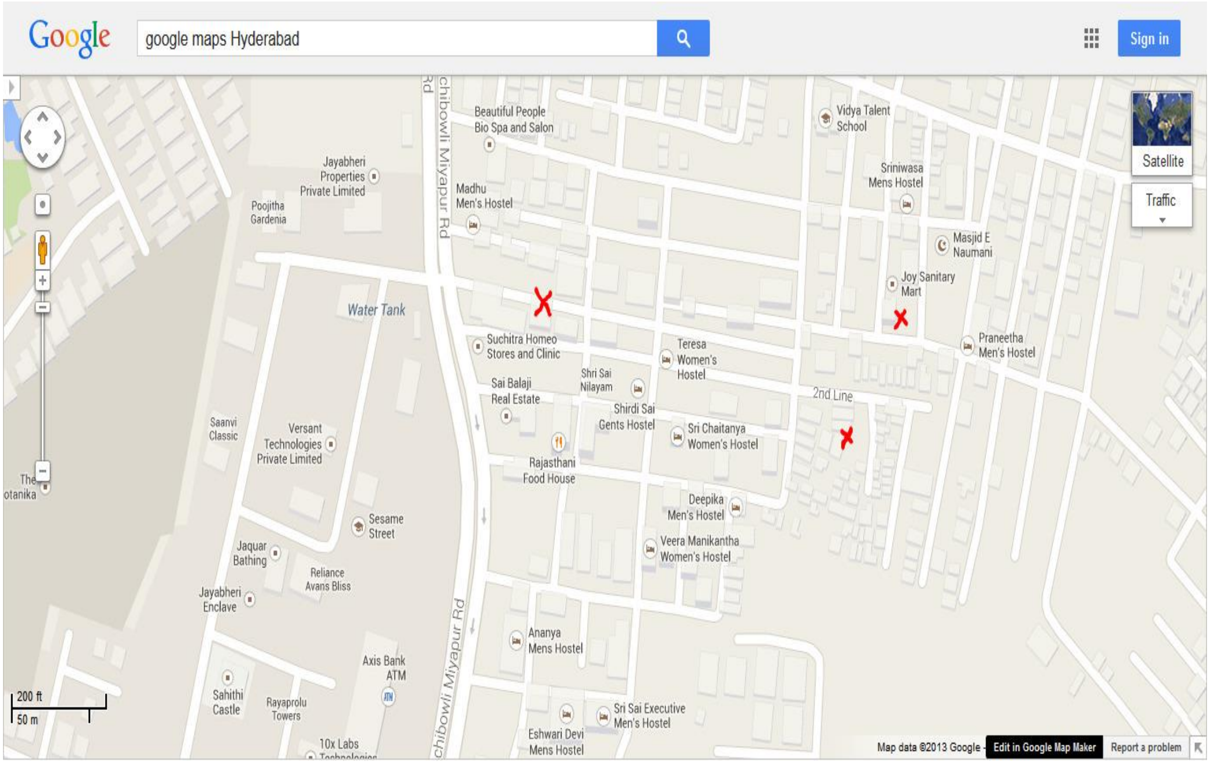
Table 5.1 Distance from home to school using the 'crow fly' distance and 'polyline' distance

n=55	Polyline distance (Km)	Crow fly distance (Km)	Difference	Ratio
Mean	1.10	0.94	0.16	1.19
Median	1.10	0.91	0.19	1.21
Standard deviation	1.02	0.91	0.14	0.12

5.2.1.2 Map exercise

The map exercise proved to be difficult because the detailed map showing the streets meant that only a short distance could be captured in the print-out. Only some of the children's homes and routes could be identified because of the scale involved. Figure 5.1 shows some children's' homes with a red cross. I considered printing a bigger map, positioning the school in the middle, but decided against it because of logistical reasons: approximately 70 children would have to identify their house and trace their route, one by one. As such the map exercise took about three hours to complete. This method of estimating the distance from home to school was therefore also discontinued.

Figure 5.1 Example of the 'map exercise'



The main outcome of the map exercise, however, was my realisation that all children were actively looking for a landmark near their home. This gave me the idea to find out about the nearest landmark to each child's home, in order to estimate the distance, by conducting an intense investigation using *Google Earth*. It would lead to the calibration of an alternate method for estimating children's distance to school. I designed a study to estimate the distance in a sample of children in each type of school (government, aided and private school). Based on this, the margin of error in estimating the distance from home to school could be measured.

5.2.2 Validity of distance using 'nearest landmark' and 'in-depth interview' (part 2)

Fifty children participated in the "in depth" method. There were 56% females (n=28) and 44% males (n=22). All three types of schools were represented. The distribution of school-type was Government (30%, n=15); Government aided (26%, n=13) and Private (44%, n=22).

Table 2 displays children's mode of travel from home to school, with many (40%, n=20) of them walking to school.

Table 5.2 Children's mode of travel from home to school

Mode	Frequency
Walk	20
Cycle	3
School bus	4
Car	3
2-wheeler	8
RTC bus	7
Auto-rickshaw	5
Total	50

5.2.2.1 Validation of estimated distance

Table 5.3 shows the average difference between the two methods of measurement for different modes of travel. It shows that none of the mean differences were statistically significant. Only one child reported coming by 'van' (private transport paid by parents) and was combined with 'school bus' (also private) for analysis. The 'nearest landmark' estimates were not significantly different from the 'in-depth interview' estimates. The distance estimated by the nearest landmark method was not significantly different compared to the in-depth method for walking , 52m [95% CI -32m to 135m], 10% of mean difference, and for walking and cycling combined, 65 m [95% CI -30m to 159m], 11% of mean difference. For children who travelled by school bus/ van, the 'nearest landmark' method under-estimated the distance by approximately 2.4 km (37% of the mean difference). For children who travelled by motorised transport excluding the school bus, the 'nearest landmark' method under-estimated distance by an average 325 metres [95% CI -664 m to 1314 m], 15% of the mean difference.

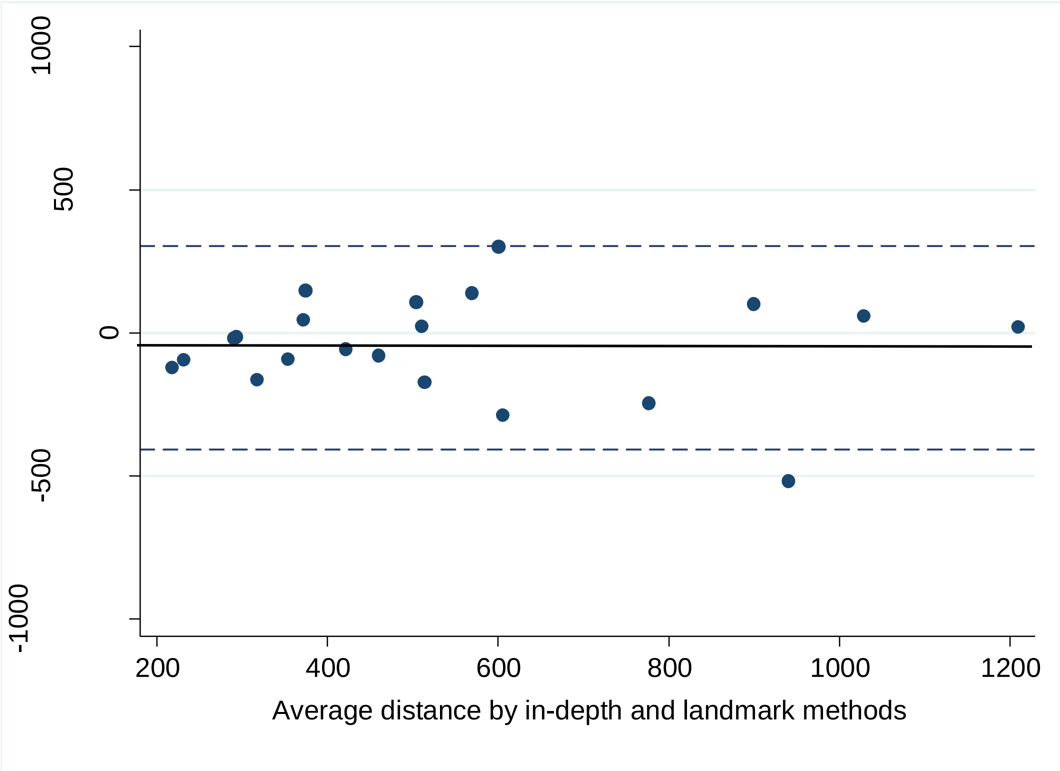
Table 5.3 Mean difference between the methods, by mode

Mode of travel*	n	Mean distance m (In-depth)	Mean difference m (In-depth-landmark)	95% CI	Difference as % of mean distance	P value
Walk	20	525	-52	(-135, 32)	-9.9	0.27
Walking or cycling	23	602	-65	(-159, 30)	-10.8	0.10
Auto rickshaw	5	2309	-391	(-918, 137)	-16.9	0.10
Motorbike	8	2403	91	(-190, 371)	3.8	0.53
Car	3	5356	523	(-1464, 2510)	9.8	0.37
RTC bus (Public)	7	3640	69	(-263, 402)	1.9	0.62
School bus/ Van	4	6436	2386	(-847, 5619)	37.1	0.10
Motorized travel (excluding school bus/van)	23	2202	325	(-664, 1314)	14.8	0.17

*Other response categories such as 'train' were not given by any child in this study

Figure 5.2 shows the mean difference plot for walking. The dotted lines show the limits of agreement, and the solid line shows the bias (-52m).

Figure 5.2 Differences between 'in-depth interview' and 'nearest landmark' (walking)



- - -Mean difference-1.96 SD= - 407m

- - -Mean difference+1.96 SD= 304m

Mean difference= - 52m

Figure 5.3 Mean difference plots for different modes **(dotted lines show limits of agreement)**

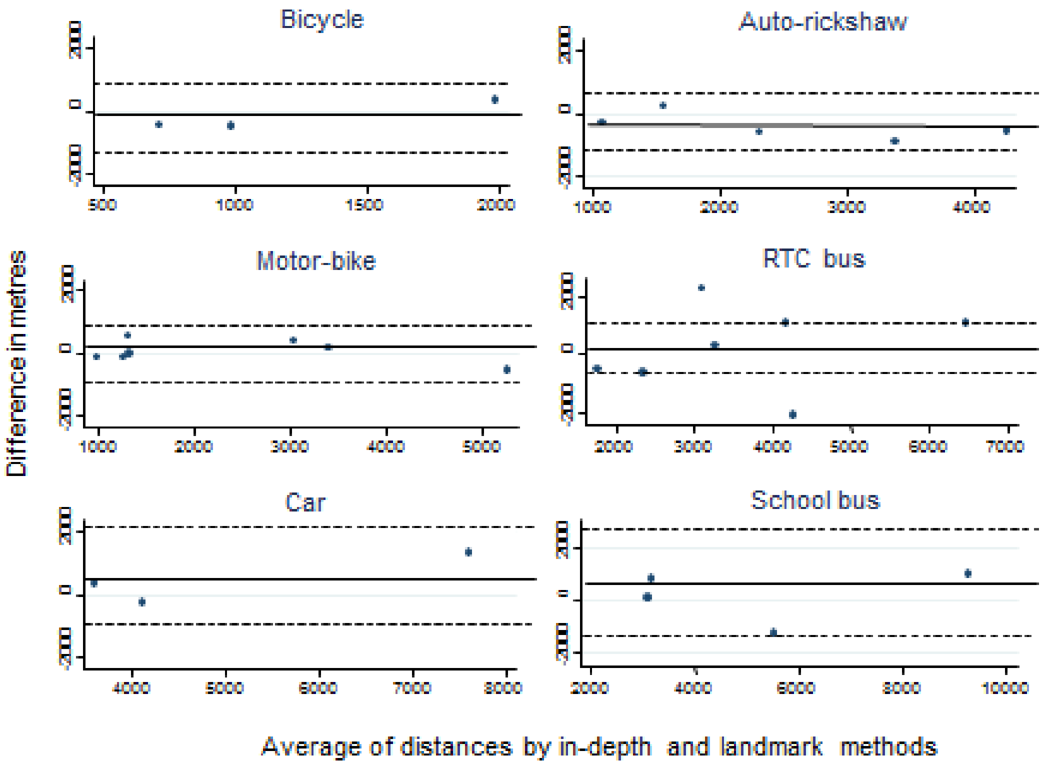


Table 5.4 displays the correlation coefficients for the difference in the averages, for different modes of travel. Although the p-values are large, the samples sizes are small, and do not enable bias, if any, to be detected. The 'van' was combined with the 'school bus' because both are similar in all respects, except that the van is smaller.

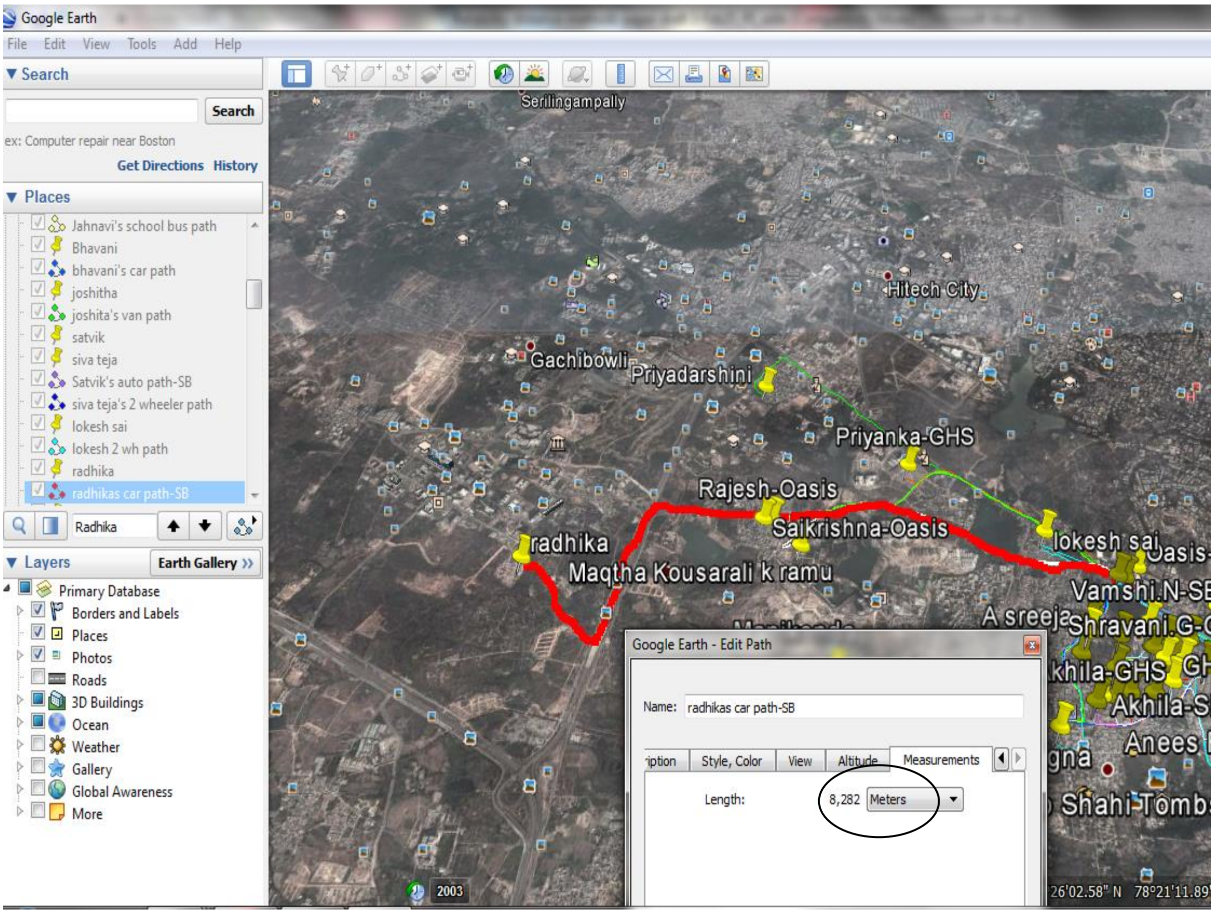
Table 5.4 Correlation coefficient for difference in averages, for different modes

Mode	n	Correlation coefficient	p-value	95% CI
Walk	20	-0.13	0.58	-0.54, 0.33
Cycle	3	0.96	0.17	Could not be estimated
2-wheeler	8	-0.38	0.36	-0.85, 0.44
Auto rickshaw	5	-0.62	0.26	-0.97, 0.57
RTC bus	7	0.21	0.64	-0.64, 0.83
Car	3	0.88	0.31	Could not be estimated
School bus	4	0.21	0.79	-0.94, 0.97

The screen shots of the two methods of estimating distance to school are shown below.

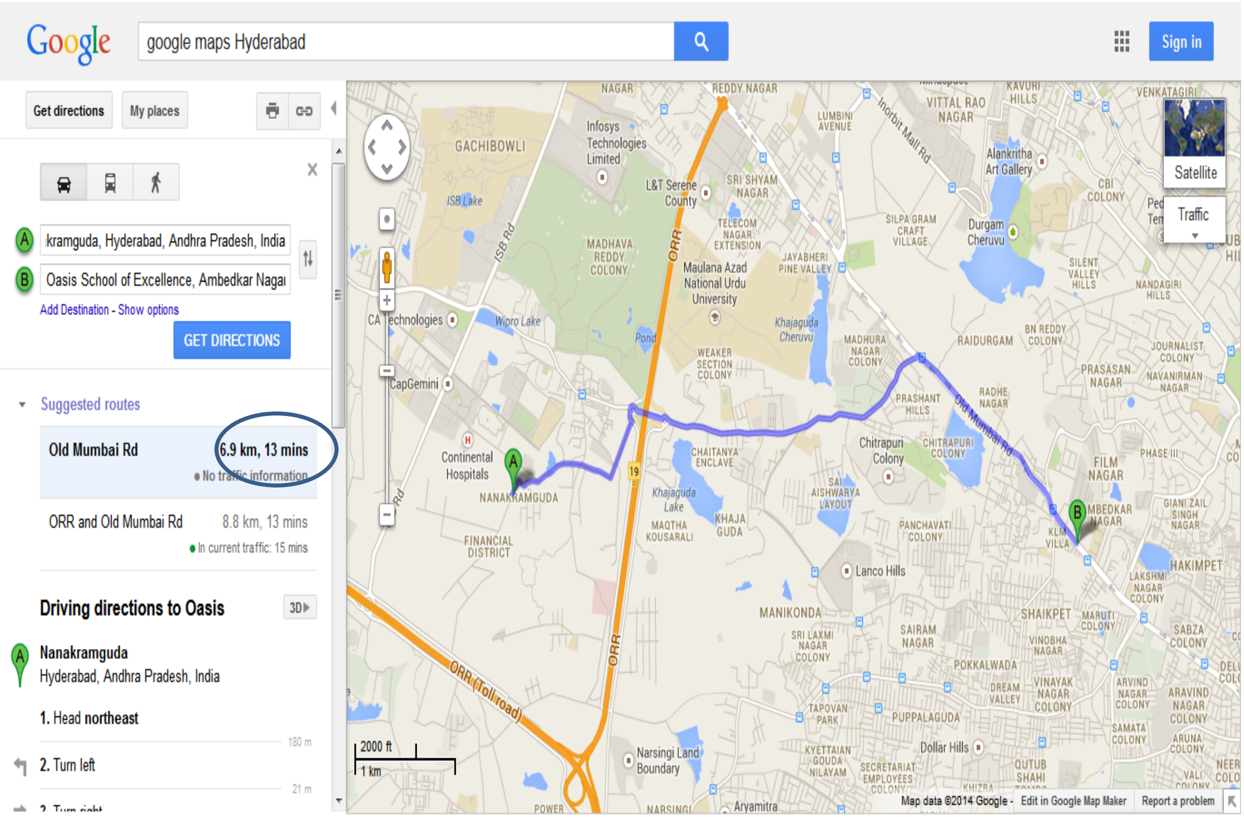
The 'In-depth interview' method for the route to school by a car shows an estimated distance of 8.2km (figure 5.4).

Figure 5.4 Example of the 'In-depth interview' method



The 'Nearest landmark' method for the same route to school by car shows an estimated distance of 6.9km (figure 5.5).

Figure 5.5 Example of the 'nearest landmark method'



5.3 Strengths and limitations

The 'in-depth' method of recording children's journeys enabled good quality data to be collected. The participating 50 school children in grades 7, 8 and 9 were randomly selected by the class teacher, and their detailed routes to school were estimated using maps of the neighbourhood, which was the strength of this study.

Other studies have relied on parent's reports, [170, 171] but I could not involve parents because of concerns about high levels of illiteracy among low-income parents in India.

No evidence of bias was found in the distance estimate when walking and cycling were combined. The nearest landmark distance was slightly greater for walking, and when walking and cycling were combined, and for auto-rickshaw. This was perhaps because children probably take short-cut routes which *Google* may not include in the maps. This was not the case with the school bus. Evidently the school bus does 'roundabout' and long-winding routes, since the service is paid for by the parents, and routes are designed for collecting and dropping off children from each household. It therefore does not usually reflect the distance from home to school that would be travelled using other modes. Children may even feel that they travel long distances because they spend a long time in the school bus. [172] For all types of motorised travel, the 'nearest landmark' distance was shorter than the 'in-depth interview' distance, with the exception of an auto rickshaw, perhaps due to its ability to take short-cut routes, possibly leading to traffic violations.

Due to limited resources, I could not use objective measures of distance such as GPS. Children's home address was not included because many urban areas in India including several localities in Hyderabad are growing rapidly. As a result, they do not have uniformly structured or geocoded searchable addresses on the web. [159] In the absence of searchable addresses, this questionnaire provides a cost-effective alternative. Reliability was assessed using written survey forms instead of 'hand-raising' protocols which were used in other studies. [173]

Google Earth is increasingly being used in Public Health. [174, 175] I used *Google Earth* and *Google Maps* as they are freely available and easy to use, and due to a lack of access to other GIS tools. It is suggested that *Google Earth* images should be checked for accuracy, [176] because they may not reflect recent changes in landscape like new urban development and recent disasters. [177] The distance from home to the nearest landmark was not accounted for in this analysis, and could therefore slightly alter the distance estimated. I do not know if the "landmark" method would have given more accurate estimates if I had searchable postcode information. For example, in the UK, objective assessment of distance between home and school in one study was based on Euclidean distance between postcodes. [178] Children's home addresses were converted into a map location using datasets that identify precise locations for all registered addresses in the UK. Distance from home to school was calculated as the Euclidean distance between home and school postcodes. Similarly, in a Canadian study, data were geocoded to the geographic centre of the home postal codes using GIS. [171]

Although the sample size was low, there was a 100% response rate. The in-depth method of sitting down with each child and tracing the routes of all children was the main strength of this study. I was able to identify the actual route that a child takes to school. Children's self-reported routes were meticulously arrived at and documented; instead of using parent's report, as was done in other studies. This presented an opportunity to capture children's exploration, especially those with independent travel, which is known to foster personal growth and development. [12, 179]

In the absence of searchable databases to pinpoint the home location, I used *Google Earth* and *Google Maps* to estimate distance. When the 'nearest landmark' was compared with 'in-depth' distance, they differed by 10% for walking and cycling. This margin of error was considered to be within acceptable limits of accuracy. For other modes like the school bus, the mean difference was higher, but this is because the school bus does not use a direct route. Future studies can therefore use the nearest landmark method to estimate the true distance that a child would walk or cycle to school. It confirms that the nearest landmark method is feasible, in the absence of GPS equipment and software, especially in low resource urban settings. This method should however be tested in rural areas, which have a different pattern of land-use.

This study used *Google Earth* and *Google Maps* for distance estimates in the absence of GIS software, and confirms that this is a reliable and alternate method, especially in resource constrained settings. These results will inform the next steps of the construction of a spreadsheet model to estimate the public health impacts of a policy restricting distance on the distribution of mode of travel to school.

5.4 Implications of the findings

The distance travelled by the children in this study ranged from 250 to 8414 meters, which was more than that found by a study in a Canadian neighbourhood (683 to 1355 meters). [157] The prevalence of walking and cycling was 46% in this study, which was higher than the active transport of 21% among 10-12 year old Australian children [180] A UK based study found walking to be 69% with insufficient number of cyclists (1%) for them to be treated as a separate group, similar to our study. [181] This study confirms that the self-administered questionnaire that I developed can be used to reliably estimate the distance travelled by children during school journeys. On average, the 'nearest landmark' method is as reliable as the 'in-depth interview' method and can be applied in similar low-resource settings, for a reasonably accurate estimate of the distance from children's home to school.

This chapter reiterates that the nearest landmark method is feasible, in the absence of GPS equipment and software, especially in low- resource urban settings.

5.5 Conclusions

This chapter has described the results of the iterative process of the methods attempted to estimate the distance from children's homes to school. This chapter contributes to understanding the reliability of estimating the commuting distance to school in Hyderabad using the nearest reported landmark to home. The results show that on average, the "landmark" method is as reliable as the "in-depth" method. Considering the non-availability of searchable address-based distances in Hyderabad, the "landmark" based method can be applied in similar low-resource settings, for a reasonably accurate estimate of the distance from children's home to school. The "landmark" method was used for the estimation of the distance from children's home to school, in the cross-sectional survey, which is described in the next chapter.

6 RESULTS 3: WHAT IS THE RELATIONSHIP BETWEEN DISTANCE AND MODE?

6.1 Introduction

In the previous chapter I presented the results of the reliability studies, and showed how the questionnaire was revised, in particular the question on distance (by introducing the question on nearest landmark to home). This chapter presents an analysis of the data from the cross-sectional survey to investigate the relationship between distance and children's mode of travel to school in Hyderabad. The results are presented according to domains, as described in Chapter 3: mode of travel to school, including travel during hot or cold weather; independent travel; perception of safety; and physical activity.

6.2 Results

6.2.1 Sample characteristics

Forty five of the 48 eligible schools that were selected agreed to participate, providing a total sample of 5,842 children. Three schools refused participation due to time constraints. Three percent of children in the participating schools were absent on the day of the survey (n=179). Compared to those present, absentees had similar age (12.9 vs 13.1 years), and sex (44% vs 47% boys), and prevalence of walking (74% vs 69%). Almost all children (99%) provided a valid home address, or nearest landmark, for the estimation of the distance to school. The mean age of the children in the sample was 13 years (SD 1.3 years). There was a higher proportion of girls (54%) in the sample (Table 6.1).

As mentioned in Chapter 3, 15 mandals from Hyderabad district and 1 mandal from Rangareddy district participated in the survey. Table 6.1 shows a higher proportion of children from private (unaided) schools, followed by government, and government aided schools. A higher proportions of girls than boys were present across all school types, especially in government schools (two government schools in the randomly selected list were for 'girls only').

Table 6.1 Descriptive findings of the sample of school children (n= 5,842)

	Government	Aided	Private	Total
Number of schools	16	15	14	45
n (%)	1,836 (31)	1,585 (27)	2,421 (41)	5,842 (100)
Boys n (%)	768 (42)	762 (48)	1,129 (47)	2,659 (46)
Girls n (%)	1,068 (58)	823 (52)	1,292 (53)	3,183 (54)
Age in years (mean, SD)	13 (2)	13 (2)	13 (1)	

6.2.2 Mode of travel to school

All the children surveyed were capable of walking or cycling to school. Table 6.2 shows children's usual mode of travel to school and back. Most children walked (57%) or cycled (6%) to school, but 36% used motorised transport (mostly bus). 64 children responded that they walked as well as travelled by RTC (public transport) bus and were assigned to the category 'RTC bus.' There was not much difference between the usual mode of travel from home to school, and from school to home, except that 9.3% of the children were escorted to school on a two-wheeler in the morning and 6.3% travelled home by a two-wheeler in the afternoon. It was noted that about 60% children walked or cycled during hot weather, and 53.9% walked or cycled during the rains.

Table 6.2 Children's usual mode of travel to school, and back home

Usual mode of travel	Home to school (%)	School to home (%)
Walk	56.8	58
Bicycle	5.8	6.1
School bus	8.1	8.4
Car	4.2	4.5
2-wheeler	9.3	6.8
RTC bus	5.2	5.2
Auto-rickshaw	9.6	10
Cycle-rickshaw	0.3	0.1
Train	0.0	0.1
Other	0.7	0.9
Total	100	100

6.2.3 Distance to school

The average distance travelled to school was 2.1 km (95% CI 1.2 to 3.0). Table 6.3 shows the proportion of children living at various distances from school. Most children (89.4%) lived within 5km of school, many (69.2%) lived within 2 km, and about a third (35.5%) lived within 1km from school.

Table 6.3 Proportion of children living at various distance categories from school

Distance from home to school	Children living in that distance (%)
<1km	35.5
1-2km	33.5
2-3km	12.4
3-5km	7.8
>5km	10.5
Total	100

The average time taken to travel to school per child was 15.8 minutes (SD 13.60). When I looked for the mandal-wise association with distance, mandal 9 (Khairatabad) and mandal

17 (Hayatnagar) seemed to have had the highest proportion of children who travel >5km. There seems to be a strong association between mandal and distance travelled to school ($p<0.0001$).

Table 6.4 shows the population estimates of children using various modes and the corresponding mean distance travelled per child for each mode. The average distance travelled for all modes was 2.1 km. The shortest distance travelled was by pedestrians (0.9 km; 95% CI 0.8 to 1.1) and the longest distance travelled was by children taking the school bus (5.5 km; 95% CI 3.6 to 7.4)

Table 6.4 Mean distance travelled, by mode

Mode	Population using this mode	Mean distance per child trip (km)	Lower 95% CI limit	Upper 95% CI limit
Walk	181,669	0.9	0.8	1.1
Bicycle	18,607	1.6	1.3	1.9
School bus	26,005	5.5	3.6	7.4
Car	13,388	4.9	3.0	6.7
2-wheeler	29,611	2.0	1.4	2.6
RTC bus	16,742	4.1	3.5	4.7
Auto-rickshaw	30,767	3.9	1.7	6.2
All modes	322,258	2.1	1.2	3.0

6.2.4 Distance and mode

Table 6.5 shows that a greater distance to school was associated with the use of motorised transport. About 87% of children living under 1 km walked or cycled to school, when compared to about 8% of children who lived 3-5 km from school.

Table 6.5 Usual mode of travel to school, by distance

Usual mode to school	Distance from home to school <1km	1-2km	2-3km	3-5km	>5km	Total
Walk	81.8	71.7	25.2	2.2	0.9	56.5
Bicycle	5.3	5.7	12.3	5.7	0.1	5.8
School bus	1.8	1.7	11.4	23.3	34.8	8.2
Car	1.1	1.6	5.2	13.2	15	4.2
2-wheeler	6.4	9.5	19.1	14	4.4	9.4
RTC bus	1	2.3	10.5	16.3	14.1	5.2
Auto-rickshaw	2.2	6.9	15.9	21.6	28	9.7
Cycle-rickshaw	0.1	0.3	0.4	0.9	0.5	0.3
Train	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.4	0.3	0.1	2.7	2.3	0.7
Total	100	100	100	100	100	100

Children studying in private schools travelled approximately 0.9 km more than those in aided schools. On an average, children attending government schools travelled 1.67 km, those attending aided schools travelled 1.42 km, and those attending private schools travelled 2.26 km (table 6.5).

Table 6.5 Mean distance travelled by children, by type of school

Travel to school	Government		Aided		Private		Overall	
Distance (km) to school (mean, SD)	1.7	(2.4)	1.4	(2.9)	2.3	(2.1)	2.0	(2.6)

6.2.5 Gender and mode

Table 6.6 shows the usual mode of travel to school by boys and girls. A higher proportion of boys walked or cycled to school (76.5%) when compared to girls (51.4%). The proportion of girls (17.8%) driven to school by private personal transport (car and two-wheeler) is twice that of the boys (8.1%). There seems to be an association between mode of travel to school and gender (p=0.0003).

Table 6.6 Usual mode of travel to school by boys and girls

Usual mode of travel	Boys (%)	Girls (%)
Walk	65.4	49.8
Bicycle	11.1	1.6
School bus	6.5	9.4
Car	1.2	6.6
2-wheeler	6.9	11.2
RTC bus	5.5	5
Auto-rickshaw	3.2	14.8
Cycle-rickshaw	0.1	0.5
Train	0.0	0.0
Other	0.1	1.2
Total	100	100.0

6.2.6 Grade and mode

Table 6.7 shows that usual mode of travel to school and grade are associated (p=0.03). A higher proportion of children in the 8^{th} grade cycled to school (7.6%) when compared to those in the 6^{th} grade (3.6%). A higher proportion of children in the 6^{th} grade travelled by auto-rickshaw (almost 13%) when compared to children in the higher grades (8-9%). In contrast, a higher proportion of children in the 8^{th} and 9^{th} grades travelled by 2-wheeler (10-11%) when compared to those studying in lower grades (6-8%). None of the children travelled by train.

Table 6.7 Usual mode of travel to school by grade

Usual mode of travel to school	Grade and %				
	6	7	8	9	Total
Walk	57.5	58.6	53.9	57.3	56.8
Bicycle	3.6	5.7	7.6	6.3	5.8
School bus	8.8	10.1	8.1	5.9	8.1
Car	3.2	5.9	4.8	3	4.2
2-wheeler	8.3	6.3	10.6	11.4	9.3
RTC bus	4.1	4.4	5.2	7	5.2
Auto-rickshaw	12.8	8.3	8.8	8.7	9.6
Cycle-rickshaw	0.5	0.3	0.3	0.2	0.3
Train	0	0	0	0	0
Other	1.3	0.5	0.7	0.4	0.7
Total	100	100	100	100	100

6.2.7 School type and mode

Table 6.8 shows that a higher proportion of children in government schools walked (69%) when compared with those in private schools (53%). Prevalence of cycling was similar (6%) across school types. The proportion using motorised transport was higher in children attending private schools (41%) than in those attending government schools (24%). RTC bus use was more common in children attending government schools than in private schools (19% versus 2%). Further, a higher proportion of children attending private schools travelled by school bus (11%) when compared to their counterparts attending aided schools (1%) (Table 6.8). (Figure 6.3 and 6.4 show how some children travelled to school).

Table 6.8 Distribution of usual mode of travel to school by type (adjusted for survey design)

Travel mode to school	Government		Aided		Private		Overall	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Walk	69.0	(58, 79)	68.0	(59, 76)	53.0	(34, 71)	57.0	(41, 71)
Bicycle	6.0	(4, 11)	6.0	(4, 9)	6.0	(3, 9)	6.0	(4, 8)
School bus	0.6	(0.2, 2)	1.0	(0.2, 8)	11.0	(5, 21)	8.0	(4, 17)
Car	0.5	(0.2, 1)	0.2	(0, 1)	5.0	(2, 16)	4.0	(1, 12)
2-wheeler	2.0	(1 , 3)	10.0	(6, 16)	11.0	(7, 16)	9.0	(6, 14)
RTC bus	19.0	(10, 34)	10.0	(4 , 25)	2.0	(1, 5)	5.0	(3, 10)
Auto-rickshaw	2.0	(1, 6)	4.0	(2, 7)	12.0	(5, 27)	10.0	(4, 21)
Cycle-rickshaw	1.0	(0, 1)	1.0	(0.2, 1)	0.3	(0.1, 1)	0.3	(0.1, 0.5)
Train	0.0	(0, 0)	0.0	(0, 0.3)	0.0	(0, 0)	0.0	(0, 0)
Other	0.1	(0, 1)	0.1	(0, 1)	1.0	(0.3, 3)	0.07	(0.3, 2)

Table 6.9 shows the mode of travel that children wished to use. A higher proportion of children wished to travel to school by bicycle (21% instead of the current 6%), and school bus (17% instead of the current 8%), and car (23% instead of the current 4%). In contrast, a lower proportion of children wished to walk to school (24% instead of the current 57%).

Table 6.9 Mode of travel that children wished to use

Mode	Children's current mode of travel to school (%)	Mode that children wished to use (%)
Walk	56.8	24.1
Bicycle	5.8	21.2
School bus	8.1	16.6
Car	4.2	22.9
2-wheeler	9.3	6.3
RTC bus	5.2	4.1
Auto-rickshaw	9.6	2.4
Cycle-rickshaw	0.3	0.1
Train	0.0	1.6
Other	0.7	0.6
Total	100	100

6.2.8 Perception of safety

Table 6.10 shows children's perception of safety, in terms of how safe they feel during the school journey. Out of the children who felt 'very safe', there was a slightly higher proportion of boys than girls.

Table 6.10 Perception of safety

Gender	How safe do children feel on the school journey?				
	Very safe	Fairly safe	Not very safe	Not at all safe	Total
Boy	73.4	17.2	7.4	2.0	100
Girl	66.7	22.7	8.1	2.5	100
Total	69.7	20.3	7.8	2.3	100

Overall, there was no particular association between gender and perception of safety ($p=0.21$). Furthermore, there was no evidence of an association between type of school and perception of safety ($p=0.10$).

As part of their perceptions of safety, I explored what children were worried about on their school journey. Table 6.11 shows that 45% of the children worried about being late, 32% did not worry about anything in particular on the way to school, and 15% worried about traffic. There appears to be an association between gender and what worries children ($p<0.001$). Girls worry about strangers, being late and being teased, while boys worry about traffic. Specifically, thrice the proportion of girls (6.4%) worry about strangers when compared to boys (2.6%) and a higher proportion of boys (18.2%) worry about traffic when compared to girls (12.9%) (table 6.11).

Table 6.11 What children are worried about on the school journey by gender

What worries children on	Gender		
the school journey?	Boys	Girls	Total
Traffic	18.2	12.9	15.3
Stranger	2.63	6.41	4.73
Being late	38.7	49.8	44.9
Getting lost	0.67	1.41	1.08
Being teased	1.50	2.02	1.79
Nothing	38.2	27.4	32.2
Total	100	100	100

I wanted to find out if child pedestrians worry more about traffic, and if children who travelled by motorised modes had any particular worries, for example, of being late. I found no such association between mode and worry in general ($p=0.21$). When analysed further, the worry about being late appeared to be associated with different modes of usual travel to school ($p=0.02$), but it was not associated with distance to school ($p=0.53$).

Table 6.12 shows the proportion of children who were worried about being late, by their mode of travel to school. A higher proportion of children who cycled (73%) or travelled by the school bus (68%) did not worry about being late, when compared to children using other modes.

Table 6.12 Worry about being late and mode of travel to school

Usual mode of travel to school	Worry about being late
Walk	45.3
Bicycle	27.7
School bus	32.4
Car	47.8
2-wheeler	50.7
RTC bus	45.4
Auto-rickshaw	48.3
Cycle-rickshaw	44.2
Train	40
Other	52.0
Total	44.1

6.2.9 Physical activity

I looked for an association between physical activity (measured as 'days exercised' and 'hours exercised') and other variables. There appeared to be no association between type of school and days exercised (p=0.43), and type of school and hours exercised (p=0.33). There appeared to be no association between mode of travel and days exercised (p=0.38) or hours exercised (p=0.12).

6.2.10 Independent travel

Independent travel was measured by asking whether the child travels to school alone, or is accompanied; or if the child is allowed to cross or cycle on main roads alone. Table 6.13 shows that a majority of children travelled to school alone (38%) or with other children (38.6%). About a quarter of the children (23.4%) were accompanied by an adult, mostly by a parent.

Table 6.13 Children travelling alone, or accompanied on the journey to school

With whom the child travels to school	Proportion (%)
Parent	16.8
Grandparent	1.42
Other children	38.6
Other adult	5.14
Alone	38.0
Total	100

When children were accompanied by a parent, the most common mode of travel was by 2 wheeler (78%), followed by walking (10 %) ($p<0.001$). No such association with mode was found when children were accompanied by a grandparent ($p=0.43$).

Table 6.14 shows the proportion of children who were allowed to cross main roads, or cycle on main roads alone. A majority (63%) of the children were never allowed to cross or cycle on main roads (29% for walking and 34% for cycling), while about 17% were always allowed to cross or cycle on main roads alone.

Table 6.14 Whether children are allowed to cross main roads or cycle on main roads

Parental permission	Allowed to cross main roads alone (%)	Allowed to cycle on main roads alone (%)
Always	17.9	17.7
Sometimes	45.3	26.5
Rarely	7.9	5.7
Never	28.8	34.1
Don't know how to cycle	n/a	15.8
Total	100	100

There appears to be an association between independent travel and gender. A higher proportion of boys (51%) were allowed to travel independently, as opposed to girls (27%) ($p<0.001$).

There appears to be an association between travelling alone and being allowed to cross main roads alone, because 71% of children who were accompanied on the trip to school were never allowed to cross main roads alone, when compared to 29% of children who travel to school un-accompanied (p=0.006).

Similarly, there appears to be an association between travelling alone and being allowed to cycle on main roads alone, because 68% of children who were accompanied on the trip to school were never allowed to cycle on main roads alone, compared to 32% of children who travelled to school un-accompanied (p= 0.001)

There appears to be an association between distance and independent travel, where independent travel decreases with increasing distance (p<0.001). Out of the children living under 1 km, 52% travel independently. Of the children living at a distance greater than 5km, only 12% travelled independently. However, I found no such association between type of school and independent travel.

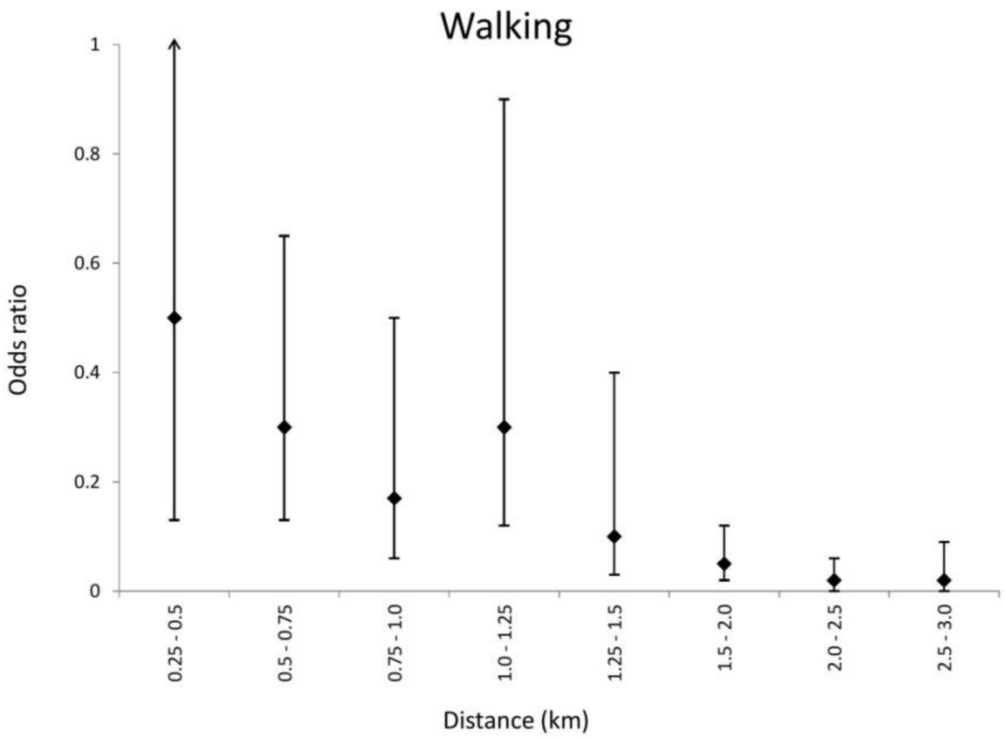
6.3 Other results: walking and cycling to school

6.3.1 Relationship between distance and walking or cycling

Logistic regression was used to estimate odds ratios with 95% confidence intervals for the association between walking and cycling and distance to school, whilst adjusting for potential confounding factors.

Figure 6.1 shows the relationship between distance and walking to school. It shows that walking to school was inversely associated with distance. Children living over 1.5 km from school were less likely to walk to school than those living within ½ km (Fig 6.1). The figure shows the adjusted model of the association between the different explanatory variables with the outcome variable of walking. It suggests that the odds of walking declines with increasing distance (except in the 1-1.25 km category). Compared to children living within 0.25 km of school (baseline group), children living 0.25–0.5 km from school were half as likely (OR=0.5) to walk to school, and children living 0.5–0.75 km from school were around 70% less likely (OR=0.3) to walk to school.

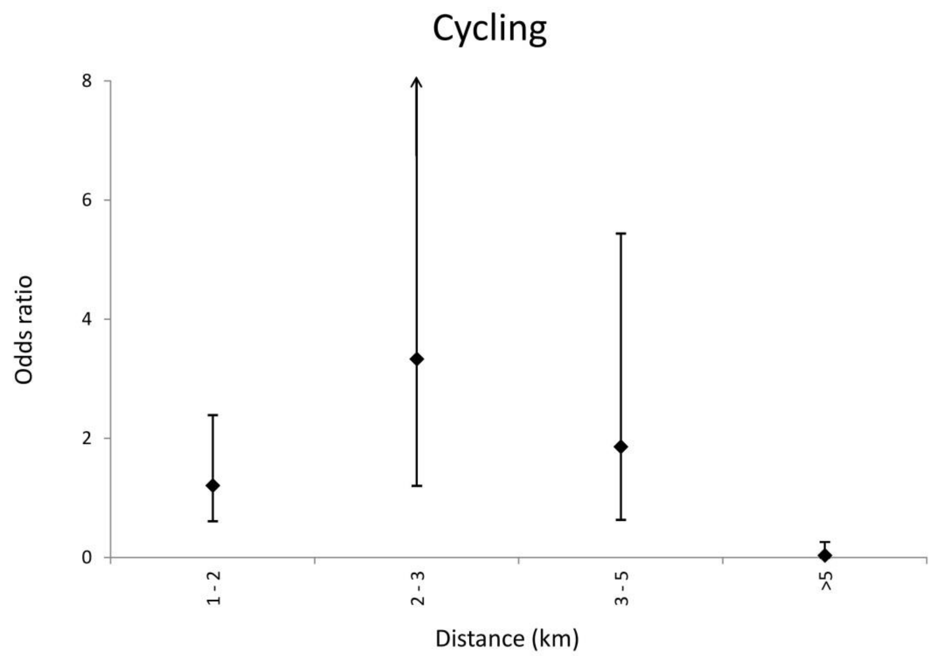
Figure 6.1 Relationship between distance and walking to school [1]



The opposite effect was seen with cycling. Figure 6.2 shows that children living 2-3 km from school were more likely to cycle to school than those living less than 1 km away. The odds of cycling seem to increase with distance, peaking at 2-3 km, and decrease beyond 5 km. Compared to children living within 1km of school (baseline group), children living 2-3km from school were over three times as likely to cycle to school (OR=3.3).

[1] Odds ratios adjusted for gender, grade, type of school, mode of travel, hours of exercise and travel alone

Figure 6.2 Relationship between distance and cycling to school [2]



6.3.2 Other factors associated with walking or cycling to school

Table 6.15 shows that children in the 8th grade were twice as likely to cycle as those in the 6th grade (OR 2.5; 95% confidence interval 1.4 to 4.2). Girls were less likely to cycle (OR 0.15: 95% CI 0.07 to 0.3) than boys. Children who travelled to school alone were approximately three times more likely to walk or cycle to school, compared to those who were accompanied (OR 3.3: 95% CI 2.3 to 4.6 for walk) Similarly, children who reported exercising after school were more likely to walk to school than those who did not exercise. Children who exercised for 7 hours a week were almost twice as likely to cycle to school as children who got no exercise (OR 1.9: 95% CI 0.92 to 4.1)

[2] Odds ratios adjusted for gender, grade, type of school, mode of travel, hours of exercise and travel alone.

Table 6.15 Factors associated with walking or cycling to school

Variable	Walking OR (95% CI)	Test for homogeneity	Cycling OR (95% CI)	Test for homogeneity
Grade		0.66		0.001
6 (reference category)				
7	0.9 (0.59, 1.2)		1.7 (0.71, 4.16)	
8	0.8 (0.55, 1.2)		2.5 (1.43, 4.25)	
9	0.8 (0.62, 1.1)		1.8 (0.73, 4.50)	
Type of school		0.08		0.96
Government (reference category)				
Semi-private	0.6 (0.22, 1.40)		1.1 (0.49, 2.53)	
Private	0.3 (0.13, 0.89)		1 (0.51, 2.1)	
Gender		0.47		<0.001
Male (reference category)				
Female	0.8 (0.50, 1.4)		0.15 (0.07, 0.29)	
Travel alone to school		<0.001		0.008
No (reference category)				
Yes	3.3 (2.3, 4.6)		2.8 (1.3, 5.8)	
Hours of exercise per week		0.331		0.532

None (reference category)		
0.5 hour	1.6 (0.99, 2.5)	1.2 (0.78, 2.02)
1 hour	1.7 (1.1, 2.8)	1.1 (0.66, 1.89)
2-3 hours	1.5 (0.73, 3.1)	1.2 (0.63, 2.5)
4-6 hours	1.8 (1.0, 3.2)	1.5 (0.75, 3.1)
7 hours	1.7 (.90, 3.4)	1.9 (0.92, 4.1)

Analysis adjusted for grade, type of school, gender, independent travel and hours of exercise the previous week.

6.4 Summary

The principal finding of this chapter, which describes the results of the cross-sectional study conducted in the 45 schools, was that most children in Hyderabad walked or cycled to school. Distance to school was strongly associated with the use of motorised transport. Children attending private schools travelled further and were more likely to travel by car. Children living 2-3 km from school were most likely to cycle to school.

6.5 Strengths and limitations

My estimates of children's usual mode of travel to school are based on self-reports, which are susceptible to information bias. Children who were absent on the day of the survey were not included in the survey. I used information based on children's home address and nearest landmark, to estimate the distance to school. The landmark based method showed minimal evidence of bias and gave reasonably accurate estimates of distance to school. Itwas found to be a feasible method, in the absence of GPS equipment and software, especially in low-resource urban settings. [182]

I was not able to select classrooms, which were selected by school principals, based on the availability of a free period for children to complete the survey. This could introduce bias if the principal selected the most literate or physically active children, but this is unlikely because classrooms are generally balanced for good, average, or moderate performers. Therefore the probability of any child being in the survey should be the same. Forty children did not provide their mode of travel, and 76 children did not give a valid address. These children were excluded from the analysis and this may have biased our results. I did not collect information on religion which is another potentially confounding variable.

Despite these limitations, this is the first study of children's commuting to school in India. I could achieve a 99% response rate from children attending private, aided and government schools. The large sample size and high response rate are important strengths.

I used a questionnaire that had been shown to be valid and reliable, and the question on usual mode of travel showed 'almost perfect' agreement using the kappa statistic during reliability testing. I estimated distance to school based on children's home address and landmark. Because my method was accurate to within 65m (-30m to 159m) of the true distance, [182] I am reasonably confident in the results of the relationship between distance and walking/cycling to school.

I estimate that the random sample of 5,842 children was representative of the target population of 322,258 children in Hyderabad. These results might therefore be generalised to children aged 11-14 in other urban areas in India, with similar population sizes and transport networks as Hyderabad.

I found that there was not much difference in the morning and afternoon commutes (children's mode of travel to school in the morning and back home in the afternoon). But this was not the case in other studies. A difference in travel mode during the morning and afternoon has been found, especially in studies reported from the US. A larger proportion of American children across all distance categories choose to walk and use the school bus in the afternoon, compared to using the car in the morning. Similar results were found in Oregon, US, where twice as many students walked back home from school (20%), compared to those who walked to school (10 %). [130] Merom and colleagues reported similar results from Australia, and found a difference in the prevalence of walking during the morning and afternoon trips. For example, the prevalence of walking on a Monday morning was 18%, compared to 24% on a Friday afternoon. [128]

Not much difference was found in my study, in children's mode of travel during hot and wet weather, when compared to their usual mode of travel. This finding reiterates that many families in India and their children do not have much choice regarding their mode of travel. [183] Other studies have shown that the prevalence of walking and cycling to school varies depending on the season, with active travel amounting to only 9% throughout the year. [135]

Increased distance to school was associated with the use of motorised transport, as seen in other studies. In Australia, the proportion of walkers reduced from 62% to 8% when distance increased from 1km to 3km. [132] Similarly, in California, the private vehicle was found to be the dominant mode of travel (50%), when distance was greater than 1 mile (1.6km). [127] The average distance to school in my study was 2.1 km. Most children (almost 90%) lived within 5km, many (70% lived within 2km, and 35% lived within 1km from school.

Children going to private schools travelled almost 1 km more than children in other types of schools. Another study also found that children going to public schools travelled further. [122]

There was a strong association between mandal and the distance travelled, but I was unable to find the possible reasons because of a lack of detailed information on the geographic characteristics of the mandals, for example, the length of roads, extent of pavements, volume of vehicles, etc.

I found in my study that more boys (77%) walked when compared to girls (51%), and more girls were driven (18%) than boys (8%). Similarly, my finding that a higher proportion of boys (11%) cycled, when compared to girls (1%) has also been identified in other studies that found that boys were more likely to cycle to school than girls (15% versus 1%), who were instead driven more often (27% versus 3%). [123, 140] Cultural differences seem to play a role in why more boys walk than girls. Girls in Indian families are generally more protected than boys. This means that girls are restricted in terms of their mobility, and are escorted more often, while boys are allowed to walk (and cycle) to school. Another study based on data from India has found a higher level of sedentary behaviour among girls when compared to boys. [46] A study on road use pattern among children in Hyderabad found that the average number of trips on road per day was significantly higher for boys (mean 11.5, median 10) than for girls (mean 9.6, median 8). [32] Another study that compared the levels of physical activity and sedentary behaviour in schoolchildren from 34 countries across 5 WHO Regions, including schools in India, [46] shows that a higher proportion of boys (61%) use active transport (walking/ cycling) than girls (51%) in India.

Similarly, higher rates of cycling to school among boys may reflect cultural factors and conservative social tendencies like parental shielding of girls and stricter monitoring of their independent mobility. Findings on the influence of gender on walking and cycling were, however, not always consistent, since no such association was found by another study conducted in Washington State, USA. [126]

I did not find much difference in the mode of travel to school by grade, except that children in the 8th grade were more likely to cycle. This is perhaps a marker for age, and 8th graders are possibly perceived to be old enough to manoeuvre the traffic conditions in India when compared to 6th graders, while 9th graders could be enrolled in after-school activities requiring long distance travel by other modes. This is unlike other studies which have shown that students' travel to school was associated with age. For example, walking and cycling to school in the US increased from 16% in kindergarten to 24% in the 5th grade, and reduced to 18% in the 8th grade. [18] Similarly, older children were more likely to walk or cycle to school, and seemed to peak at the 6th grade. [133] In Switzerland, older children were found to travel longer distances. [117]

I found that a higher proportion of children studying in government schools walked and used public transport buses, while more children in private schools used private motorised transport. The Indian government provides free education but it does not pay for transportation. Children in lower income families walk if they cannot afford bicycles. Children in higher income families have greater access to motor vehicles and I found that a greater proportion of children at private schools travel by motorised transport. As mentioned before, the type of school in India is an indicator of socio-economic status. A similar result was found in another study from the UK. [12]

I explored accompaniment to school, in the form of questions on independent travel, which was measured by asking whether the child travels to school alone, or whether the child is accompanied; or if the child is allowed to cross or cycle on main roads alone (Table 6.13). I found that almost 40% of the children travelled to school alone or with other children (39%). About a quarter of the children were accompanied by an adult, mostly by a parent (17%). Studies have shown age to be significantly associated with children's independent mobility to and from school and that older children are less likely to be escorted to and from school by their parents. This is perhaps linked to parents' perception that their child has the cognitive capacity to navigate his/her way to school safely at a certain age. [184]

When asked about how they wished to travel, fewer children reported that they wished to walk, while more children wished to use the car, school bus, and bicycle, to go to school. Children, especially two-thirds of the girls felt 'not at all safe' during school journeys, and this is a cause for concern. Another study from South India reported that school girls felt unsafe and vulnerable to sexual harassment, especially while traveling by public transport. [185]

The worry about being late was associated with mode, but not with distance. Almost half (45%) of the children worried about being late, and this is perhaps because of traffic congestion. Three-quarters of the children travelling by bicycle were not worried about being late, compared to other modes, and this maybe because the time taken to cycle is more predictable than for other modes of travel. Similarly, children travelling by the school bus were not worried about being late, presumably for a different reason. If the school bus arrives late, the school does not penalise the children, since the school management runs the buses. But, if a child who travels by any other mode is late, schools give several forms of punishment. These range from having to run a few rounds in the playground, or facing detention outside the principal's room for one class period (equivalent to 45 minutes), or being sent home, [186] or three late arrivals being counted as one day of being absent. [187]

6.6 Conclusions

This cross-sectional study has given the first estimates of how and how far children travel to school in Hyderabad. The relationship between distance and mode presented in this study is new information, especially among children in urban India. Most children in Hyderabad walk or cycle to school. If these levels are to be maintained, there is an urgent need to ensure that walking and cycling are safe and pleasant.

Children's daily travel to school is not yet a focus of attention of policy makers in India, although it is likely to be on every parent's mind. More work is needed to improve pedestrian safety—constructing pavements, in the least-- to support the high prevalence of walking reported in this study. Devising appropriate strategies to ensure children's safety on the roads is challenging, but essential. The reasons for mode choice including barriers to walking and cycling, and the extent of parental influence will be useful to explore through future research.

Figure 6.3 A typical school day in urban India, with children using various modes of travel

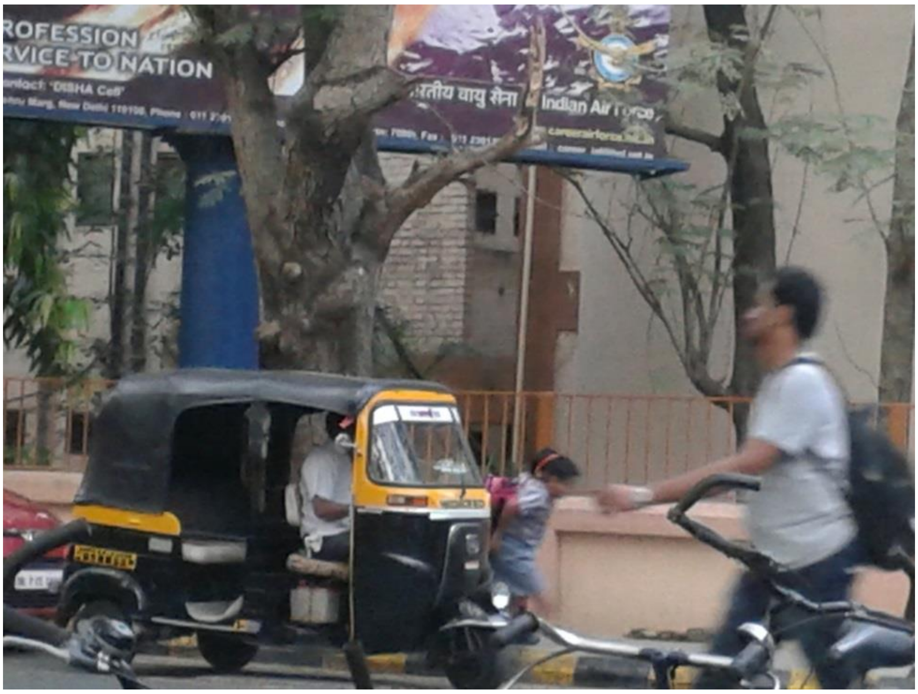


Figure 6.4 Some parents escort their children to school

7 RESULTS 4: WHAT IS THE RISK OF ROAD TRAFFIC INJURY ON THE SCHOOL JOURNEY?

7.1 Introduction

The previous chapter described the results of the distance and children's mode of travel to school in Hyderabad. The principal finding was that most children in Hyderabad walk or cycle to school, and distance to school was strongly associated with the use of motorised transport. This chapter presents the results of children's self-reported road traffic injuries on journeys to school. The information on road injuries was collected using the self-administered questionnaire during the cross-sectional survey, as described in Chapter 3.

As mentioned in Chapter 1, a third of a billion children travel to school every day in India. Children's travel to school is a routine and necessary activity. But we do not know the numbers of children injured on the route to school; whether children in certain age groups are particularly susceptible to road injuries, and whether travel mode choice is associated with injury risk. It is important to identify these risk factors because the school trip is a part of children's daily activity, and is amenable to interventions. [188] Children are vulnerable to road injury because they are small and may not be able to judge speed very well. [102] Literature from other countries shows that age, sex, socio-economic status and distance travelled are some of the factors associated with child pedestrian injuries. [189] [190] [191]

Research from several countries shows that school travel itself could be a risk factor for road injuries. [189] According to a study conducted in the UK, pedestrian injuries are a leading cause of death and serious injury among school aged children, and a large proportion of these injuries occur while children are either walking to, or from school. [192] Previous studies have documented up to 25–50% of child pedestrian injuries to occur during school related travel. [193] [194] In the UK it was reported that children from lower socio-economic backgrounds may be up to five times as likely to be injured as pedestrians than children from higher socio-economic status backgrounds. [195]

Inequalities were greatest for deaths of children as pedestrians. The higher risk of being killed as a pedestrian, compared with as a car occupant suggests greater exposure to risk of road injury. [196]

A study examined trends in road death rates for child pedestrians, cyclists and car occupants in England and Wales between 1985 and 2003. Taking into account distance travelled, the study found that there are about 50 times more child cyclist deaths (0.55 deaths/10 million passenger miles; 0.32 to 0.89) and nearly 30 times more child pedestrian deaths (0.27 deaths; 0.20 to 0.35) than there are deaths to child car occupants (0.01 deaths; 0.007 to 0.014) in England and Wales. [197] We do not have similar information on road injuries during school related travel in India. This chapter presents the results of children's self-reported road traffic injury during school journeys in Hyderabad.

As described in Chapter 3, detailed instructions were given to children on every question. The question on road traffic injury was: "During the past 12 months, were you injured in a road accident?" Road 'accident' was defined as 'any non-fatal injury sustained by the child in the previous 12 months, on the road while going to, or coming home from school, due to a collision with another vehicle, or due to a fall or skid from a bicycle or two-wheeler, while standing or walking on the road'. The number of injuries sustained was not required. Children were asked to only report injuries which led to the child missing at least one full day of their usual activities, or which required treatment by a doctor or a nurse. This was included to focus only on the more severe injuries.

Different injury data sources and methods can yield substantially different injury rates. Self-reported injuries are also known to have their limitations. Underestimation can possibly occur from recall bias, which has been demonstrated to decrease injury-rate detection by up to 76% when a 1-year versus 1-month recall period is used. It has therefore been recommended that the most recent month of recall time be used, to estimate annual minor injury rates, and the 1-year recall time to estimate annual major/fatal injury rates. [198]

Another study from Kampala sought to measure and compare pedestrian injury rates in primary school-attending children aged 4–12 captured via hospital records, police records, community surveys, and teacher reports. Injury reporting by volunteer teachers was found to be feasible and possibly cost-effective method that was tested in that study. [198]

Similarly, frequent data collection in large cohorts with short recall intervals (in some studies 1 week) is thought to be well suited to obtain valid information on injury incidence and prevalence rates. It is also deemed better to use parents as the informants than children, as self-report questionnaire data from young children may be inaccurate. [199]

In a study from Denmark that studied musculoskeletal injuries among school children, injuries were reported by parents answering automated mobile phone text questions on a weekly basis and diagnosed by clinicians. Objective examinations were conducted by clinicians, and only children with a diagnosed injury were included in the data analysis. The study mentions that frequent, prospective and sensitive monitoring led to a better capturing of injuries. [200]

7.2 Results

7.2.1 Participants

As mentioned in Chapter 6, 45 schools out of the 48 eligible schools that were selected agreed to participate. Three schools refused participation, due to time constraints. Approximately 3% of the eligible children in the participating schools were absent on the day of the survey. The total sample was 5842 children, of whom 5789 (99.1%) children answered the question on road injury.

7.2.2 Descriptive data

The average age of children in the sample was 13 years (SD ±1.3 years), with a higher proportion of girls (54%) participating in the survey. Of the children who completed the questionnaires, 40 (0.7%) did not provide information on their mode of travel to school. Almost all children (98.7%) provided a valid home address, or nearest landmark, for the estimation of distance to school.

7.2.3 Main results: prevalence

The overall prevalence of self-reported road traffic injury in the last 12 months during school journeys in Hyderabad was 17% (95% CI 12.9 to 22.8) (table 7.1).

Gender-More than twice the proportion of boys (25%; 95% CI 19.5 to 30.5) reported road injury when compared to girls (11%; 95% CI 6.8 to 17.6). Type of school-The prevalence of road injury did not appear to differ much by the type of school. School grade- There was not much difference in the prevalence of road injury by grade. Children in the 6th grade seemed to have a slightly higher prevalence of road injury when compared to children in the other grades.

Table 7.1 Prevalence of road injuries during school journeys in Hyderabad

	Design adjusted prevalence of road injury %	95% CI	P value
Overall	17.33	12.91, 22.85	0.0005
Gender			0.0005
Boy	24.63	19.54, 30.55	
Girl	11.07	6.75, 17.64	
School type			0.6821
Government	14.77	11.2, 19.23	
Aided	17.96	13.71, 23.18	
Private	17.48	11.92, 24.9	
Grade			0.3782
6	19.54	13.99, 26.62	
7	15.62	10.42, 22.75	
8	17.49	12.52, 23.9	
9	16.03	11.92, 21.22	

7.2.3.4 Mode of travel

As shown in table 7.2, the prevalence of road injury varied with mode of travel and distance to school. Cyclists reported the highest prevalence of road injury (33%), followed by children who travelled by motorised 2-wheelers (20%) and children who walked to school (17%). The lowest prevalence was reported by children who travelled by school bus (8%). The prevalence of injuries among children who travelled by car (16%) was not much different from among those who travelled by RTC bus (15%) or auto-rickshaw (13%).

7.2.3.5 Distance to school

The prevalence of road traffic injury was highest (25%) among children who travelled 2-3 km to school and lowest (9%) among children who travelled over 5 km. The prevalence of road injury to children who walked or cycled increased with distance.

Table 7.2 Prevalence of self-reported road traffic injury by mode and distance to school

Mode	Prevalence (%)	Distance to school					
	Children in sample (n)	<1km	1-2km	2-3km	3-5km	>5km	Total
Walk	%	13	19	30	26	42	17
	N	*1,859*	*1,330*	*224*	*24*	*8*	*3,445*
Bicycle	%	33	30	33	49	0	33
	N	*103*	*108*	*80*	*32*	*1*	*324*
School bus	%	39	4	4	12	4	8
	N	*13*	*31*	*64*	*92*	*207*	*407*
Car	%	54	16	25	4	10	16
	N	*16*	*24*	*22*	*40*	*58*	*160*
2-wheeler	%	14	17	34	21	4	20
	N	*111*	*146*	*117*	*55*	*25*	*454*
RTC bus	%	4	6	10	22	19	15
	N	*37*	*73*	*132*	*140*	*139*	*521*
Auto-rickshaw	%	17	7	26	9	11	13
	N	*33*	*93*	*73*	*67*	*104*	*370*
Other modes*	%	62	4	0	16	0	16
	N	*9*	*11*	*4*	*12*	*9*	*45*
All modes	%	16	18	25	16	9	17
	N	*2,181*	*1,816*	*716*	*462*	*551*	*5,726*

* *Cycle rickshaw, Train, Other*

7.2.3.5 Relative risk by mode

Table 7.3 shows the odds ratios and 95% confidence intervals associated with each travel mode compared with children who walked to school. Children who travelled by bicycle were more likely to report an injury compared to children who walked (OR 1.5, 95% CI 1.2 to 2.0). Children who used the school bus were less likely to report an injury than those who walked (OR 0.5; 95% CI 0.3 to 0.9). This was after controlling for gender, school type, grade and mandal. I found that the results of the sensitivity analyses did not differ when categories of distance were used.

Table 7.3 Association between road traffic injury and travel mode (walking as reference mode)

Mode		Odds Ratio (95% CI)	
	Children in sample	Model fitted with distance as linear term	Model fitted with categories of distance
Walk (reference category)	3,494	1.0	1.0
Bicycle	329	1.5 (1.2, 2.0)	1.4 (1.1, 1.9)
School bus	410	0.5 (0.3, 0.9)	0.5 (0.2, 0.9)
Car	161	1.3 (0.7, 2.4)	1.2 (0.7, 2.3)
2-wheeler	458	1.3 (0.8, 1.9)	1.2 (0.9, 1.7)
RTC bus	531	0.8 (0.6, 1.2)	0.8 (0.6, 1.1)
Auto-rickshaw	374	1.0 (0.5, 1.8)	0.9 (0.5, 1.7)
Total	5757		
Test for homogeneity		P<0.001	P<0.001

Logistic regression model including terms for gender, school type, grade, mandal

7.2.3.6 Relative risk by other variables

Table 7.4 shows the association between road injury and distance, grade, gender, type of school, mandal, independent mobility (including traveling alone and being allowed to cross and cycle on main roads alone), and physical activity.

7.2.3.1 Distance

I found no evidence for associations between road traffic injury and distance. (p=0.5661)

7.2.4.2 Grade

I found no evidence for associations between road traffic injury and grade (p=0.285)

7.2.4.3 Gender

Girls were one third as likely to report an injury as boys (OR 0.3; 95% CI 0.2 to 0.5). (p=<0.001)

7.2.4.4 School type

I found no evidence for associations between road traffic injury and type of school (p=0.963)

7.2.4.5 Location (Mandal)

Compared to children who lived in Asifnagar (mandal 1) children who lived in other mandals were less likely to report a road injury. Children who lived in mandal 3 (Ameerpet) and mandal 17 (Hayatnagar) seemed especially less likely to report a road injury (p<0.001).

7.2.4.6 Independent travel

Children who were allowed to cross main roads only ‘sometimes’ were 30% less likely to report a road injury when compared to those who were allowed ‘always’ (p=0.03).

Children who were ‘never’ allowed to cycle on main roads were half as likely to report a road injury when compared to those who were ‘always’ allowed (p=0.0007).

7.2.4.7 Physical activity

Children who got 4-6 hours of physical activity per week were twice as likely to report a road injury than those who got zero hours of physical activity per week (p=0.01). [Table 7.4]

Table 7.4 Association between road injury and important variables

Road injury	Odds Ratio (95% CI)	Wald test
Distance		0.5661
0-1 km (reference category)	1.0	
1-2km	0.8 (0.5, 1.1)	
2-3km	1.0 (0.7, 1.4)	
3-5km	0.9 (0.5, 1.7)	
>5km	0.8 (0.5, 1.2)	
Grade		0.285
6 (reference category)	1.0	
7	0.7 (0.5, 1.2)	
8	0.8 (0.5, 1.1)	
9	0.7 (0.5, 1.0)	
Gender		<0.001
Male (reference category)	1.0	
Female	0.3 (0.2, 0.5)	
Type of school		0.963
Government (reference category)	1.0	
Semi-private	1.1 (0.6, 2.0)	
Private	1.0 (0.7, 1.5)	
Mandal		0.0001
1 Asifnagar (reference category)	1.0	
2 Amberpet	0.1 (0.1, 0.3)	
3 Ameerpet	0.0 (0.0, 0.2)	
4 Bahadurpura	0.2 (0.0, 1.2)	
6 Charminar	0.4 (0.1, 1.1)	
7 Golconda	0.2 (0.1, 0.4)	
8 Himayatnagar	0.2 (0.1, 0.4)	

9 Khairatabad	0.3 (0.1, 0.7)	
10 Maredpally	0.3 (0.1, 0.6)	
11 Musheerabad	0.3 (0.1, 0.5)	
12 Nampally	0.5 (0.2, 0.9)	
13 Saidabad	0.5 (0.2, 1.0)	
14 Secunderabad	0.3 (0.2, 0.6)	
15 Shaikpet	0.2 (0.1, 0.5)	
16 Tirumalagiri	0.1 (0.1, 0.2)	
17 Hayatnagar	0.1 (0.0, 0.2)	
Usual mode of travel		0.0009
Walk (reference category)	1.0	
Bicycle	1.3 (1.0, 1.8)	
School bus	0.5 (0.3, 1.0)	
Car	1.2 (0.7, 2.2)	
2-wheeler	1.3 (0.9, 1.9)	
RTC bus	0.8 (0.6, 1.1)	
Auto-rickshaw	1.0 (0.5, 2.0)	
Cycle-rickshaw	0.6 (0.2, 2.6)	
Train	0.7 (0.0, 16)	
Other	1.4 (0.4, 5.4)	
Independent travel		0.893
Accompanied (reference category)	1.0	
Travel alone	1.0 (0.7, 1.4)	
Allowed to cross main roads alone		0.0397
Always (reference category)	1.0	
Sometimes	0.7 (0.5, 0.9)	
Rarely	0.8 (0.5, 1.2)	
Never	0.8 (0.5, 1.2)	

Allowed to cycle on main roads alone		0.0007
Always (reference category)	1.0	
Sometimes	0.9 (0.6, 1.4)	
Rarely	0.9 (0.5, 1.8)	
Never	0.5 (0.4, 0.8)	
Don't know how to cycle	0.6 (0.4, 0.9)	
Physical activity		0.0178
0 hours/ week (reference category)	1.0	
Half an hour/ week	1.0 (0.7, 1.6)	
1 hour/ week	1.3 (0.6, 2.6)	
2-3 hours/ week	1.3 (0.7, 2.5)	
4-6 hours/ week	2.0 (1.1, 3.6)	
7 hours/ week	1.0 (0.7, 1.6)	

7.3 Discussion

7.3.1 Principal findings

The overall prevalence of self-reported road injury in the last 12 months during school journeys in Hyderabad was 17%. A higher proportion of boys (25%) reported a road injury than girls (11%). There was a strong association between road injury, travel mode and distance to school. Children who cycled to school were more likely to be injured, compared to children who walked, and travel by school bus was found to be safer than walking.

7.3.2 Strengths and limitations

These estimates of the prevalence of road injury to children during their school journeys in the last 12 months are based on self-reports, which are susceptible to recall bias. Children may have reported injuries that occurred outside of the 12 month period, or did not occur on the school journey, or they may not have reported some injuries at all. The relatively long recall period of 12 months may have led to under-reporting, especially if they were minor injuries. [201] Recall bias might have also occurred if children using some modes (e.g. bicycle) were more likely to remember an injury than children using other modes (e.g. school bus). This may have led to differential misclassification of the outcome by mode of travel. But there is no reason to suggest that children's ability to recall might differ by distance to school.

The mode of travel in which the child was injured was not asked directly, and it was assumed based on their usual mode of travel. It is possible that the injury occurred because a different (and not usual) mode of travel or route was taken, which is a major limitation of this study. Mode of travel was asked as the primary question. ("How did you come to school today?") and various options were given, as mentioned in the questionnaire. Distance to school was not asked because children may not estimate the distance they travel correctly. Distance was however estimated for each child, using the nearest landmark to home, as reported by that child.

My definition of injury was one which resulted in at least a day of school missed, or required treatment by a doctor or nurse. Some parents may have taken their child with a minor injury to see a doctor or nurse, while other parents may not have. Also, this study did not record the number of injuries, severity of injury, or location of injury, which limits interpretation.

The severity of injury is unlikely to be the same for different travel modes. Specifically, among bicycle injuries, which were most common, it is likely that the majority did not involve collision with a motor vehicle (which usually causes greater severity of injury and disability). Similarly, the striking vehicle for pedestrian injury in the mixed traffic environment in Hyderabad may have been a bicycle, a motorised 2-wheeler, or an auto-rickshaw. [32] The mechanism of injury, however, was not recorded in any detail.

Children who were absent on the day of the survey were not included in the study. It is possible that they are different from those who were present, or that they were absent because of a road injury. However there were very few absent (<3%). This is similar to other estimates of absenteeism (1%) from south Indian schools. [202] Children are absent usually due to legitimate reasons, including sickness. [203] Forty children did not provide their mode of travel, 76 children did not give a valid address, and 53 children did not complete the question on road injury. These children were excluded from analysis and this may have biased my results.

Due to the cross-sectional nature of the study, I was not able to investigate causal relationships. For example, it is possible that children changed their travel mode following a road injury. Children who were injured when cycling may have changed to a safer mode of travel, such as the RTC bus. This is perhaps less likely in India, where children who walk or cycle do so because they do not have a choice. [204] The question on road injury did not include the number of injuries, and only obtained information if any injury was sustained in the past 12 months. I may therefore have missed information if a child sustained more than one injury.

The results may have been confounded by other factors. For example, I do not know if recall of road injuries is associated with age, sex, mode, or other factors. I was also unable to account for the extent to which characteristics of the road environment, such as vehicle speeds and volumes differ between the mandals where children commute to school. The survey was conducted in the dry season when injuries may differ compared with other seasons. However, I asked about all road injuries in the last 12 months, which should cover all seasons.

Despite these limitations, there was a good response rate (99%). The sample size of 5,842 children in this study was higher than those in previous studies (1820 and 2809) on injuries in Hyderabad. [32] [205] I used a questionnaire that had been shown to be valid and reliable. It showed ‘substantial agreement’ using the kappa statistic for the question on road injury during reliability testing. [182] Whilst test re-test is a good measure of reliability, I was unable to validate self-reports against medical reports of the actual injuries due to financial and time constraints. I estimated distance to school based on children’s home address and nearest landmark. Because this method was accurate to within 65m (-30m to 159m) of the true distance, [182] I am reasonably confident in the results of the relationship between distance and prevalence of injury. To my knowledge, this study was the first to examine road traffic injuries among children during school journeys in Hyderabad, which is a vital first step for informing policy.

7.4 Comparison with other studies

I found an overall prevalence of road traffic injury during school journeys to be 17%. It is much more than that found by a New Zealand study where travel related injuries were 1.6% of all injuries. [206, 207] My estimates of road injury, however, are similar to that reported by another Indian study, 19% (n=42), that used a three year recall period in urban areas of Andhra Pradesh (the capital of which is Hyderabad). [205] Road injury estimates are inconsistent across studies and may reflect differences in the operational definition of road injury, or origin- destination of trips (any travel, and not necessarily school journeys). We do not have a gold standard by which to compare the prevalence of road injury during school trips across studies.

There were no studies in Hyderabad that particularly reported road injury by mode and distance during school journeys. Studies on injuries in Andhra Pradesh included road injury estimates by location/activity/reason for being on the road, etc. For example, one study reported that of all road injuries, most (84%, n=42/50) occurred when children were travelling, including trips to/ from school. [205] Another study from Hyderabad reported the reason for being on the road as '*going/ coming from school/ work'* for 19 % (n=45) of all road injuries. [32]

Cycling was the most risky travel mode, followed by riding 2-wheelers, and cycling. My estimate of road injury as a cycle user (33%) and as a pedestrian (17%) was higher than a Palestinian study (11% for cycling and 8% for walking), [208] which used the Health Behaviour in School-aged Children (HBSC) survey. [46] This is perhaps because my definition of road injury was specific to travel to school when compared to the HBSC survey which included the activity context (biking/ sport/walking/ fighting, etc.). [209] My estimates were lower than those reported by another Indian study on the road use patterns of children (46% for cycling and 42% for walking respectively). [32] This could be because their estimates were from a household survey of all road injury among children aged 5-14 years, irrespective of destination. Another study from Andhra Pradesh used a 3 year recall period for severe, non-fatal injuries, and found that of all the children injured in road injuries, 52% (26/50) were cyclists, and 20% (10/50) were pedestrians. [205]

There was no evidence of association of road injury with other factors like parental permissions, perception of safety, grade, school type or physical activity levels on which the questionnaire collected information. I conducted a sensitivity analysis with various distance categories, but found that the risk of road injury did not alter much with respect to the distance category used. I reported road injury by mode, mainly. I also wanted to estimate road injury by distance. This was to find out if road injuries are being reported at shorter distances (which are completed using non-motorised transport), versus longer distances, which are usually undertaken by motorised transport.

The overall prevalence of road injury among boys was higher than among girls, which is consistent with results from other Indian studies. [32] Previous studies also show that boys have a higher exposure to bicycle riding compared with girls. Many of the differences in hospital emergency attendance are thought to stem from different exposure rates. [210] I was unable to estimate the risk of road injury for girls who cycled because the number of girls who cycled were quite small (n=5), when compared to boys, n=319)

The results showed that travel by school bus was protective, but the school bus is a private form of transport, paid for by wealthy parents to collect children at the door step. Not all parents can afford to send their children by school bus. Even then, the prevalence of road injury by school bus for distance <1km was probably high because it represents the van (we combined the analysis for *School bus* and *Van).* The van is like a smaller school bus used for shorter distances, and seems less safe. These results show that the RTC bus (public transport), with approximately 15 million passengers per day and used by 72% of the population in Hyderabad as the primary mode of transport, is slightly safer than the car. With a high prevalence of road injury (20% for 2-wheeler and 16% for car), private motorised vehicles represented similar or higher risk of road injury than walking, and seemed to be less safe than public transport modes, as found previously. [206]

7.5 Implications of the findings

The results of this study highlight the lack of safety associated with children's journeys to school in urban India, and that mode choice alters injury risk. Children's journey to school is a daily activity. It is necessary for children to make these journeys to school. The majority of children in Hyderabad walked or cycled to school, and many children in this study reported injuries within 1 km from school. The mode of travel during injury was not asked. This is a limitation of the study. Care must be taken to ensure that the mode of travel used at the time of injury has to be noted when this questionnaire is used in future studies.

These results emphasise that road injuries are a huge problem in Hyderabad. This is reflected in four important points: children's self- reported road injury prevalence of 17% (chapter 7); children's response that 15% were worried about traffic on the journey to school and 45% were worried about being late due to traffic congestion (chapter 6); 65% of parents reporting (during the pilot) that the most serious concern they have regarding their child's school journey is the 'traffic condition', and 66% of parents in India believe that their child will be seriously hurt on the road in the next year. Traffic condition is the traffic situation in India, which is considered chaotic by anyone who has used the roads in India. The perception that Indian roads are unsafe is adequately backed by newspaper reports, and reinforced by frequent occurrence of road injuries that parents are so accustomed to seeing, on a daily basis.

The volume of traffic and parental concerns for road injury may discourage healthier forms of travel such as walking and cycling. There is also a need for future studies to evaluate detailed exposure data on the number, severity and location of road injury near school zones. Measures like the introduction of affordable school buses will be useful to explore, to inform policy. As the prevalence of road injury was high among children who walked or cycled to school, interventions should particularly focus on making active travel for children safer. This can only be done by improving the overall road safety in Hyderabad, with a strong emphasis on the construction of pavements and bicycle lanes.

7.6 Conclusions

Children's journeys to school are a daily activity that ought to be pleasant and safe. Almost a fifth of the children reported a road traffic injury in the past 12 months during school journeys in Hyderabad. Considering that a third of a billion children travel to school in India, and a majority of them walk or cycle to school, this is a public health problem of enormous proportions. To prevent these injuries, interventions should particularly focus on making walking and cycling for children safer.

These estimates of children's road traffic injuries were used in a spread sheet model of the impact of alternative scenarios on road traffic injury risk, as described in the following chapter.

8 MODELLING PUBLIC HEATH IMPACTS OF SCHOOL TRAVEL: ROAD TRAFFIC INJURIES

8.1 INTRODUCTION

In Chapter 1, I introduced the main topic of my thesis, the third of a billion journeys that are made every day in India, as children travel to school. Some travel by foot or bicycle. Others use the school bus, the public bus, an auto-rickshaw, a cycle-rickshaw, a private motor car, or perhaps one of the fastest-growing modes of transport – the motorised 2-wheeler.

In Chapter 4 and Chapter 5, described the development of a questionnaire to measure mode of travel and distance to school and assessed its reliability and validity in estimating distance and mode of travel to school in a low-resource urban setting like Hyderabad.

In chapter 6, I showed that in one of the fastest growing cities in India, Hyderabad, most children aged 11-14 years walk or cycle to school, while significant proportions travel by motorised 2-wheelers, auto-rickshaw, school bus, or RTC bus. A minority travel by motor car, and these children are likely to be attending the wealthier, unaided private schools. I found that the use of different modes of travel varies according to the distance from home to school.

In chapter 7, I showed that road traffic injury is an important public health problem in India. I found that self-reported road traffic injury during the journey to school in the previous 12 months was highest among children who usually cycled to school, and also high among children who either walked to school, or rode as passengers on motorised 2-wheelers.

In this final chapter, I shall examine the risks of road injury on the way to school in further detail, and I shall consider other as yet unexplored public health impacts.

This chapter has two main aims:

1. To estimate the risk of road traffic injury by mode per child kilometre travelled

For this, the risk of non-fatal road injury was estimated by mode and distance to school in Hyderabad, using daily child passenger kilometres travelled by mode as the measure of exposure;

And:

2. To use the estimates of road traffic injury risk to model possible impacts on road injury of future transport scenarios for urban planners to consider implementing in Hyderabad.

This is a modelling exercise undertaken to estimate the impacts of alternative transport scenarios on the risk of road traffic injury in Hyderabad.

8.1.1 Models and methods to estimate road injury risk

Several approaches have been described in the published literature to estimate the risk of mortality and morbidity due to road traffic crashes. Here I will give a brief overview to set the context for my modelling.

Bhalla et al. (2007) described a risk-based analysis framework for estimating traffic fatalities. They developed a model that explored road traffic fatalities under hypothetical transport growth scenarios related to a developing country. Using their model they found that traffic fatalities are lowest in a transport scenario dominated by bus use. In the presence of vulnerable modes of motorised transport, such as scooters (motorised 2-wheelers) and motorcycles, traffic fatalities continue to increase with increased motorisation. The authors, however, did not discuss non-fatal road traffic injuries. [211]

Woodcock et al. (2009) constructed a road traffic injury 'matrix' based on road traffic injury risk per unit of travel. In this model, the notation *P[pedestrian risk (car)]* is the probability of a pedestrian being injured by being struck by a car, per kilometre walked. This is estimated as the total number of pedestrians who are injured by cars, divided by the total distance walked times the total distance driven by cars. In this model, the distance travelled by all cars is used to estimate the road traffic injury risk per kilometre travelled for different scenarios of increased active travel in the population. [212]

As summarised by Beck [213] various measures have been used to assess exposure to traffic hazards in the road environment. These measures include distance travelled, number of trips undertaken; number of streets crossed by pedestrians, and amount of time spent traveling. Most studies have focused on a single category of road user, for example, motorcycles. [214] Others, including Pucher and Dijkstra [207] have compared road traffic injury rates among pedestrians and cyclists in the United States, Germany, and the Netherlands. The work by Elvik and Vaa [215] compared road traffic injury risks by mode of travel in six European countries. They calculated injury rates per kilometre travelled and found that, relative to car occupants, pedestrians, bicyclists, and motorcyclists were at increased risk of road injury, whereas bus occupants were at decreased risk.

Harrison and Christie [216] investigated the exposure and crash patterns among motorcycle riders in an Australian study. A sample was selected, and used to estimate the riding exposure (distance ridden) in one year. Two self-declared readings were obtained from motorcycle odometers and the annual exposure estimates were calculated. The study found an overall crash rate of 0.96 crashes/100,000 km across the whole sample. Crash rates were estimated for different subgroups of riders (e.g. by age, residence, motorcycle make, engine size, type of road and by weather, and riding on weekdays or weekends).[216]

Beck (2007) used the National Household Travel Survey to estimate traffic exposure (i.e., person-trips) in the United States. Fatal and non-fatal traffic injury rates per 100 million person-trips were calculated by mode of travel, sex, and age group. The non-fatal traffic injury rate was found to be 7.5 per 100 million person-trips. The highest non-fatal injury rate was for motorcyclists (103 per million person-trips), while the lowest rates were for bus occupants (1.6 per million person-trips) and pedestrians (2.1 per million person-trips). [213]

In India, government reports do not include estimates of road injury per million person-trips made, or per 100,000 km travelled. Their estimates are based on road length (e.g. injuries per 10,000 km of paved roads), population (e.g. injuries per 100,000 people), or numbers of vehicles (injuries per 10,000 registered vehicles). These three methods have always been reported, and continue to be reported by all the states of India. [93] However, the official estimates do not report injuries for non-motorised travel.

To the best of my knowledge, this is the first study to quantify the risk of non-fatal road traffic injury for school journeys, by various modes and distances travelled in Hyderabad. The results will hopefully contribute to a better understanding of how to model a safer journey to school, keeping in mind children’s exposure to road traffic injuries and air pollution, and the needs to secure sustainable modes of transport in Hyderabad for the coming generations.

8.2 METHODS

8.2.1 Data sources

The primary data from the cross-sectional survey was used for the construction of the model. As explained in Chapter 7, the prevalence of road injury among children was estimated using self-reported information which was collected using validated questionnaires in 45 schools. As explained in Chapter 6, information on mode and distance to school was collected using the same questionnaire. A summary of the relevant items taken from the questionnaire is presented in Table 8.1 below.

Table 8.1 Items from the questionnaire

Data item	Description
Mode	The questionnaire collected information on the usual mode of travel to school. Modes of travel were categorised as *walking, cycling, auto-rickshaw* and *cycle rickshaw* (commercial three-wheeled passenger vehicles)*, school bus* (private)*, RTC bus* (public road transport corporation bus)*, motorised 2-wheeler*, *car* and *train*.
Distance	Distance from home to school was estimated using Google Earth™ based on the school location and children's' self-reported nearest landmark to home.
Road traffic injury	Children self-reported whether they had suffered a road traffic injury on the questionnaire. All injuries, regardless of severity, in the past 12 months were recorded. Self-reported road injury was recorded in a single question. The information on mode of travel was recorded separately to this (as per the 'Mode' at the top of this table).

8.2.2 Specifying future transport scenarios

The following paragraphs give a brief overview to set the context for my scenarios. The Indian government plans to identify and develop 100 'smart cities' with a funding of

US$15 billion. In addition to improving the supply of water and electricity, and tackling solid waste management, the smart city mission aims to provide efficient urban mobility and public transport, especially creating walkable localities, reducing congestion and air pollution, and promoting transit oriented public transport with last mile connectivity. [104]

Some cities have already made progressive plans and are implementing them. Visakhapatnam city in Andhra Pradesh (population 1.7 million) is one such example. [217] Since 2012, successive municipal commissioners in Visakhapatnam seemed to have made it their task to beautify the beach road, with varying degrees of success. It is a long stretch of 10 km, and an important road in the city, running parallel to the ocean. One particularly progressive civic chief freed the beach road from traffic since 2013. 'No vehicle' zones were introduced during his tenure across 20 km of the city roads. All motor vehicles were restricted every morning (5 am to 7.30 am) to encourage walking and cycling. Especially popular among the public is the beach road, with walkers, joggers and cyclists enjoying the uninterrupted space every morning (figure 8.4). [218]

But the intervention was not without problems- walkers complained that vehicles would stray into the zone, and people would protest. When no substantive action was taken by the authorities, citizens reportedly got together, and, using the strength of their sheer numbers, started restricting the vehicles themselves, through collective action and community policing. [218] Eventually, city traffic police were appointed by the municipality, to control the erring vehicles. The initiative is still in force, and is getting stronger, judging by the number of people who throng there every morning (estimated to be up to 2,000). [219] Visakhapatnam is one of the four cities where the International Council for Local Environmental Initiatives has been working out strategies for climate change adaptation. Recently, the civic authorities have proposed to develop a cycling track and walker's path in the city as part of the non-motorised transport project of the smart city initiative.

In other Indian cities, vehicle restrictions were triggered by dangerously high levels of air pollution. For example, the Delhi government ordered all private cars older than 10 years to be taken off the roads, and has mandated vehicles with odd and even numbers to be allowed to run only on alternate days to curb pollution. [220] Experts feel the implementation could prove to be a major challenge, as over two million vehicles would have to be kept off the roads every day. [100]

Similar initiatives followed in other Indian cities, including Hyderabad. 'Rahgiri' is one such initiative where long stretches of the main roads near the 'information technology corridor' in Hyderabad are closed to vehicular traffic every Sunday, from 7 am to 10 am. [221] [222] Such interventions have had an overwhelmingly positive response from communities. They show that restricting long stretches of main roads, including the important ones, to vehicular traffic, for one or two hours during the day, may not be an impossible proposition after all.

Against this background, I undertook a modelling exercise to estimate the impacts of alternative future transport scenarios on the risk of road traffic injury to children in Hyderabad. The aim of this modelling exercise was to identify those scenarios that would lead to the greatest reduction in road traffic injuries in future. The alternative future transport scenarios are inspired by my 'thought experiment' which involves hypothetical scenarios, which are, however, based on real situations. The scenarios were encouraged by the initiatives described above, and relate to the restriction of certain types of vehicles in the vicinity around schools. The model predicts the potential impact of the hypothetical scenarios on the risk of road injury. The scenarios have to be viewed both within the local context of Hyderabad's urban setting, with the ever increasing population and vehicles, and the recent efforts to restrict motor vehicles in urban areas. The scenarios are based on the policy vision of the state government, and may well be plausible scenarios in the future.

Three scenarios were considered:

Scenario 1 was the present situation of 'business as usual', with the current mode and distance to school;

Scenario 2 was where children would not be required to travel further than 2 km to school each day;

Scenario 3 was where the restriction of children travelling no more than 2 km to school is combined with the restriction of motor vehicles within the 2 km area of each school. Vehicular restriction would be during the start and end of each school day (8-9 am) and (3-4 pm) respectively.

Assumptions:

- The distance of 2 km was considered walkable and cyclable for children (8). It is therefore reasonable to expect most children within 2 km of school to be able to walk or cycle to school especially when motor vehicles are restricted;
- By restricting motor vehicles during the start and end of each school day and within 2 km school zones, the probability of a child being struck by any of these motorised vehicles would be greatly reduced. This would essentially provide protection from the potential striking vehicles around school zones;
- The restricted motor vehicles would have to use alternate routes to take people to work, etc., as would be suggested and planned by the relevant authorities (traffic police and city Municipal Corporation).

8.2.3 Estimation and analysis

The road injury risk under the different scenarios was estimated using a Microsoft Excel spreadsheet.

8.2.3.1 Road injury risk under Scenario 1 (business as usual)

The cross-sectional survey of children was conducted in schools in 2014, and the information collected on self-reported road injury was from the previous 12 months. Therefore, the estimates that are presented here are those of the risk of road injury to children aged 11 to 14 years for the year 2013.

The exposure measure is distance travelled by mode (d_m), and the outcome measure is road injury by mode (I_m). The risk of road injury for a child travelling by each mode on the journey to school is summarised below:

$r_m = K \times d_m \times L$

where:

r_m = risk of road injury for mode 'm';

d_m = distance travelled by the child using mode 'm' from home to school (average kilometres per trip)

m = usual mode of child's travel from home to school, where 'mode' = [walk, cycle, school-bus, car, motorised 2-wheeler, RTC bus, auto-rickshaw, cycle-rickshaw, train]

L = 'locality' or traffic type encountered by the child during the school trip (LVT, HVT light-vehicular-traffic and heavy-vehicular-traffic)

K = a constant.

The notation and source of the parameters used to estimate the road injury risk is presented in Table 8.2

Table 8.2 Estimation of road traffic injury risk for mode 'm'

Parameter	Symbol	Source
Sample size	n_m	Cross-sectional survey
Population size	N_m	Computed using Stata 13 using 'survey' commands
Mean trip distance to school (km)	d_m	Cross-sectional survey
Mean annual distance (Mean trip distance for 200 school days' return journeys) (km per year)	$\mu_m = 200 \times 2 \times d_m$	Cross-sectional survey
Total distance travelled to and from school by all children in the population (km per year)	$D_m = N_m \times 200 \times 2 \times d_m$	Computed using Excel
Total number of road traffic injuries estimated in the population in one year	I_m	Computed using Stata 13 using 'survey' commands, based on children's self-reported road injuries
Risk of road traffic injury per 100,000 child-km	$r_m = (I_m / D_m) \times 100{,}000$	Computed using Excel

Notes:

Mode (m) - Although information was collected on travel by other modes (i.e. cycle-rickshaw, train and others), these modes represent a small percentage (0.8%) of the travel by children in the population, and they were excluded from this analysis (partly due to concerns about the precision of any estimates based on such small numbers, and partly for reasons of presentation).

Distance (d) - A 'trip' was defined as a one-way journey between home and school. The events reported by children in the questionnaire (i.e., trips, injuries) were assumed to have occurred during the nominal school year (June through March) and on weekdays (Monday through Fridays). For each school trip, the mean trip distance travelled per mode (d_m) was obtained from the cross-sectional survey. Approximately 200 school days were assumed to fall within the nominal school year. The mean annual distance μ was obtained by multiplying the mean trip distance by 200×2 (i.e. to account for the return trip). The total annual distance travelled by all children was calculated by multiplying the mean annual distance travelled per child, by the total number of children in the population. These total annual distances travelled were used to estimate the annual exposure for all children using each mode of travel to school, and were the denominators for the estimates of the annual injury rates. The total annual distances travelled for each mode are presented as millions of kilometres travelled. (Table 8.3)

Road traffic injury (I_m) – The total number of road traffic injuries estimated in the population in one year was estimated by accounting for the survey design in Stata.

Risk of road traffic injury per 100,000 child-km per year – This was calculated for each travel mode by dividing the total number of children estimated to have been injured by their usual mode of travel (I_m), by the estimated total annual kilometres travelled by all children using that mode (D_m). (Table 8.3)

As explained above, the injury risk per 100,000 child kilometres were calculated for each travel mode and for all travel modes combined. These risk estimates were therefore distance-adjusted measures of risk, since I allowed for distance in the calculations. Risks were calculated in Microsoft Excel and confidence intervals were calculated using STATA.

8.2.3.2 Road injury risk under Scenario 2 and Scenario 3

To estimate the road injury risk for the alternative transport scenarios, the steps outlined below were followed:

Scenario 2:

1. Distance travelled by children during school journeys was restricted to 2 km or less.

For this, all children were re-assigned to 0-2 km distance. Children, who, under scenario 1, travel over 2 km, were now assumed to travel 2 km or less to school.

2. This gave me the new numbers of children travelling under scenario 2 (and 3).
3. The mean distance was re-calculated, which was 1 km (average of 0 km and 2 km).
4. The new mean distance travelled (1km), was multiplied by the new number of children who travel between 0- 2 km to school, to obtain the new total number of kilometres travelled annually.
5. Applying the risk of injury (as presented in table 8.3), I estimated the new risk of road injury for scenario 2.

Scenario 3:

For scenario 3, steps 1 to 4 are similar to that of scenario 2. In addition, data were obtained from a previous study in Hyderabad, on the vehicles involved in road traffic collisions with pedestrians and cyclists. [32] For pedestrian injuries, the study found that over 67.3% of the vehicles striking pedestrians were motorised (approximately 51% were 2-wheelers and 16% were auto-rickshaws) and about 30% were bicycles. Similarly, for bicycle injuries, 22% of the striking vehicles were found to be 2-wheelers and auto-rickshaws. Using these proportions for scenario 3, the potential numbers of injuries that could be prevented were estimated both for pedestrians and cyclists. For pedestrian injuries, the number of children walking (316,785) was multiplied with the proportion of pedestrian injuries resulting from auto-rickshaws and 2-wheelers combined (67.3%). The number of injuries that would be averted under scenario 3 was estimated by subtracting this number from the number of injuries already estimated under scenario 2. Similarly, estimates for bicycle injuries were made.

8.3 RESULTS

8.3.1 Distance

Table 8.3 shows that children aged 11-14 years travelled an estimated total of 260 million km during school journeys in Hyderabad in the 2013 school year. The seven primary modes of transport varied considerably in terms of the number of kilometres travelled by children each year. The two modes that accounted for most of these kilometres were *walking* (66.8 million km) and *school bus* (60.2 million km), while cycling accounted for the lowest number of kilometres (11.6 million) travelled.

The average distance travelled per school trip was approximately 2.1 km (95% CI 1.2 to 3.0).

The shortest distance travelled was by pedestrians (0.9 km; 95% CI 0.8 to 1.1), followed by cyclists (1.6 km; 95% CI 1.3 to 1.9). The longest distance travelled was by children taking the school bus (5.5 km; 95% CI 3.6 to 7.4) (Table 8.3).

8.3.2 Road injury risks

The injury risk estimates are presented in Table 8.3 with findings for each mode of travel, by distance travelled, for all school types combined. The overall risk of road injury per 100,000 km was 20.4 (95% CI 10.3 to 30.5). Cyclists had the highest risk of injury (53.3; 95% CI 13.2 to 93.5), followed by pedestrians (47.5; 95% CI 25.1 to 69.9). Children travelling by school bus had the lowest risk of injury (4.3; 95% CI -0.5 to 9.0).

Walking contributed to 26% of the total distance travelled by children to and from school, but 57% of the road injuries were reported by pedestrians. Cycling contributed to 4% of the total distance travelled, but 12% of the injuries were reported by cyclists. Likewise, 2-wheelers constituted 9% of the total kilometres travelled, but 11% of the injuries were reported by passengers of 2-wheelers. Approximately a quarter of all kilometres were travelled by school bus, but only 4% of injuries were reported by passengers of school bus (Table 8.3).

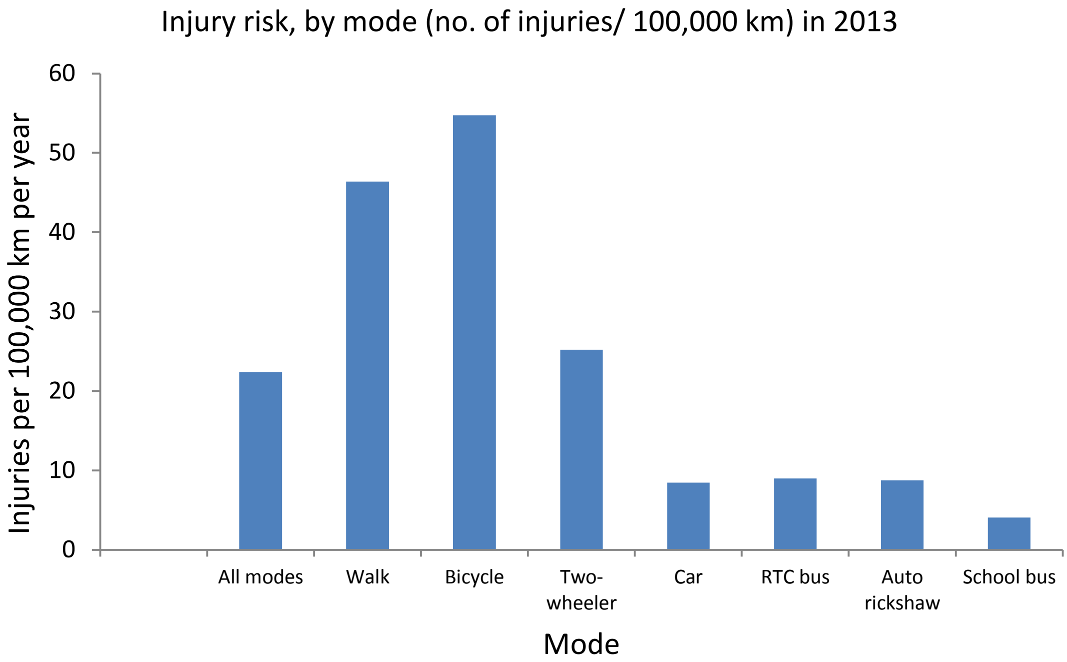
Table 8.3 Road injury risk estimates (by mode) for school journeys

Mode	Children (11-14 years) using this mode	Mean distance per child trip (km), 95% CI			Total exposure (km/year)* 95% CI			Number injured in RTI, 95% CI			Risk per 100,000 child km/year, *95% CI (a)* 95% *CI (b)*				
												(a)		(b)	
Walk	181,669	0.9	(0.8,	1.1)	65,400,840	(58,134,080	79,934,360)	31076	(16,436	45,715)	47.5	(25.1,	69.9)	(20.6,	78.6)
Bicycle	18,607	1.6	(1.3	1.9)	11,908,480	(9,675,640	14,141,320)	6353	(1,573	11,134)	53.3	(13.2	93.5)	(11.1	115.1)
School bus	26,005	5.5	(3.6	7.4)	57,211,000	(37,447,200	76,974,800)	2438	(-294	5,170)	4.3	(-0.5	9.0)	(-0.4	13.8)
Car	13,388	4.9	(3.0	6.7)	26,125,879	(16,313,883	35,937,874)	2083	(-36	4,203)	8.0	(-0.1	16.1)	(-0.1	25.8)
2-wheeler	29,611	2.0	(1.4	2.6)	23,752,227	(16,839,278	30,665,163)	5974	(956	10,992)	25.2	(4.0	46.3)	(3.1	65.3)
RTC bus	16,742	4.1	(3.5	4.7)	27,463,871	(23,588,962	31,338,774)	2446	(996	3,897)	8.9	(3.6	14.2)	(3.2	16.5)
Auto rickshaw	30,767	3.9	(1.7	6.2)	48,533,860	(20,441,410	76,626,296)	4046	(512	7,580)	8.3	(1.1	15.6)	(0.7	37.1)
All modes	322,258	2.1	(1.2	3.0)	270,696,720	(154,683,840	386,709,600)	55262	(27,923	82,601)	20.4	(10.3	30.5)	(7.2	53.4)

*2013 population estimates for 200 school day return journeys
(a) Using CI for RTIs only
(b) Using CI for RTIs and exposure

Figure 8.1 shows the overall risk of road injury per 100,000 km, by mode. The risk of injury was highest for the vulnerable road users (pedestrians, cyclists and passengers of motorised 2-wheelers). Passengers of heavier vehicles had lower risk (auto-rickshaw, car, RTC bus, school bus). Passengers of school bus had the lowest risk of injury among all modes of travel to school.

Figure 8.1 Road injury risk, by mode, on children's journeys to school in Hyderabad



8.3.3 Modelling the impact of the scenarios on road injuries

Tables 8.4 to 8.6 show the results of the spreadsheet model of the impact of the scenarios on road injuries.

Under scenario 1, (business as usual) about 69% of the children live with 2 km of school. Out of these, about 167,000 children walk to school. Table 8.4 shows the distance-wise percentage and numbers of children, as well as numbers of road traffic injuries on the journeys to school. The total number of road injuries is estimated to be 48,341. (Table 8.4)

Table 8.4 Impact of scenarios on road injury during journeys to school: Scenario 1

Scenario 1 (Business as usual)						Distance to school (km)						Total	%
	<0.25	0.25 to 0.5	0.5 to 0.75	0.75 to 1	1 to 1.25	1.25 to 1.5	1.5 to 2	2 to 2.5	2.5 to 3	3 to 5	>5		
	5.1%	3.6%	18.4%	8.5%	20.9%	5.5%	7.3%	8.6%	3.9%	7.9%	10.6%		100%
Child population (11-14 years)	16061	11531	58130	26832	66113	17296	22999	27085	12196	24963	33579	316,785	316,785
% by usual mode													
Walk	4.71	3.28	15.08	5.92	17.28	3.31	3.51	2.24	0.88	0.18	0.10		
Bicycle	0.04	0.06	0.66	1.12	0.61	0.42	0.90	1.05	0.47	0.45	0.01		
School bus	0.00	0.04	0.17	0.41	0.14	0.18	0.26	0.87	0.54	1.85	3.71		
Car	0.05	0.00	0.07	0.29	0.26	0.06	0.21	0.36	0.29	1.04	1.59		
Two- wheeler	0.17	0.10	1.39	0.59	1.16	0.81	1.22	1.72	0.64	1.11	0.47		
RTC bus	0.01	0.08	0.24	0.04	0.36	0.18	0.24	0.84	0.45	1.29	1.50		*% of*
Auto rickshaw	0.02	0.06	0.57	0.11	0.90	0.53	0.88	1.38	0.59	1.71	2.98		*trips 99*
Numbers by usual mode													
Walk	14908	10391	47771	18766	54740	10482	11110	7102	2780	558	305	178,914	
Bicycle	138	176	2086	3561	1929	1337	2851	3336	1504	1431	32	18,379	
School bus	0	140	527	1303	446	558	827	2767	1715	5845	11737	25,866	
Car	146	8	208	916	839	193	650	1152	903	3301	5046	13,363	
Two- wheeler	534	327	4413	1884	3668	2567	3865	5452	2030	3516	1478	29,734	

RTC bus	26	250	754	126	1129	559	762	2675	1425	4096	4745	16,548	
Auto rickshaw	67	181	1804	364	2836	1680	2777	4359	1867	5423	9437	30,796	
RTIs by usual mode													
Walk	354	494	4540	2675	10404	2490	3167	2700	1321	424	290	28,860	*16%*
Bicycle	4	9	223	570	412	357	912	1424	802	1222	34	5,967	*32%*
School bus	0	1	4	17	8	12	21	94	73	399	1000	1,629	*6%*
Car	1	0	3	22	27	8	31	73	72	419	801	1,456	*11%*
Two- wheeler	7	8	223	143	370	324	585	1100	512	1419	746	5,435	*18%*
RTC bus	0	2	13	3	40	25	41	191	127	584	845	1,872	*11%*
Auto rickshaw	0	2	30	9	96	71	140	294	157	731	1591	3,122	*10%*
Average distance per day (both ways)	0.25	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	8.00	10.00		
Average distance per year (km)	50	100	200	300	400	500	600	800	1000	1600	2000		
Total RTIs												48,341	*15%*

Under scenario 2, all children (100%) would live within 2 km from school. Children were re-distributed to the distance categories up to 2 km. The total number of road traffic injuries is estimated to be 41,049, a reduction from the 48,341 estimated under Scenario 1. (Table 8.5)

Table 8.5 Scenario 2

Scenario 2 (Restricting journeys to 2 km max)	Distance to school (km)											
	<0.25	0.25 to 0.5	0.5 to 0.75	0.75 to 1	1 to 1.25	1.25 to 1.5	1.5 to 2	2 to 2.5	2.5 to 3	3 to 5	>5		
	5.0%	5.0%	20.0%	20.0%	20.0%	20.0%	10.0%	0.0%	0.0%	0.0%	0.0%		100%
	15839	15839	63357	63357	63357	63357	31679	0	0	0	0	316785	
Percentage by usual mode													
Walk	6.69	4.66	21.42	8.42	24.55	4.70	4.98	0	0	0	0		
Bicycle	0.06	0.08	0.94	1.60	0.86	0.60	1.28	0	0	0	0		
School bus	0.00	0.06	0.24	0.58	0.20	0.25	0.37	0	0	0	0		
Car	0.07	0.00	0.09	0.41	0.38	0.09	0.29	0	0	0	0		
Two- wheeler	0.24	0.15	1.98	0.84	1.65	1.15	1.73	0	0	0	0	*30.31*	*% of trips redistributed*
RTC bus	0.01	0.11	0.34	0.06	0.51	0.25	0.34	0	0	0	0	*69.69*	*% of trips (new denominator)*
Auto rickshaw	0.03	0.08	0.81	0.16	1.27	0.75	1.25	0	0	0	0	*98*	*% of trips*
Numbers by usual mode													
Walk	21178	14761	67863	26659	77763	14891	15782	0	0	0	0	238,897	
Bicycle	196	250	2964	5058	2740	1899	4050	0	0	0	0	17,156	
School bus	0	199	749	1851	634	793	1175	0	0	0	0	5,402	
Car	208	11	295	1301	1192	275	923	0	0	0	0	4,205	

Two- wheeler	759	465	6269	2677	5211	3646	5490	0	0	0	0	24,517	
RTC bus	37	355	1071	179	1604	794	1082	0	0	0	0	5,123	
Auto rickshaw	96	257	2562	517	4029	2386	3945	0	0	0	0	13,793	
RTIs by usual mode													
Walk	503	701	6449	3800	14780	3538	4499	0	0	0	0	34,271	*14%*
Bicycle	5	13	316	810	585	506	1296	0	0	0	0	3,532	*21%*
School bus	0	1	6	24	11	17	30	0	0	0	0	89	*2%*
Car	1	0	5	31	38	11	44	0	0	0	0	129	*3%*
Two- wheeler	10	12	316	203	526	460	831	0	0	0	0	2,356	*10%*
RTC bus	0	3	19	5	57	35	58	0	0	0	0	178	*3%*
Auto rickshaw	0	2	43	13	136	101	200	0	0	0	0	495	*4%*
Total RTIs												41,049	*13%*

Under scenario 3, children's journeys remain within 2 km of school, with the additional restriction of motorised traffic during school times, such that the potential hazard from striking vehicles is reduced. As mentioned in the methods, 67.3% of road injuries to pedestrians were found to be from 2-wheelers and auto-rickshaws. By restricting these vehicles during school times, 67.3% of the injuries estimated under scenario 2 are estimated to be prevented during school journeys (i.e., 67.3% out of 58,795 injuries, = 39,569 injuries are prevented).

The total injuries estimated for pedestrians under scenario 3 with 100% walk journeys is therefore 19,226 (58,795 – 39,569= 19226) (Table 8.6)

Similarly, the total injuries estimated under scenario 3 with 70% walk journeys and 30% cycle journeys is 29,386 (13,582 injuries to pedestrians and 15,804 injuries to cyclists).

Assumption: All children are assumed to walk to school under scenario 3 (it can be changed to 70% walking and 30% cycling, as shown in table 8.6, or 50% walking and 50% cycling, etc., to get different numbers of injuries prevented for pedestrians and cyclists)

Table 8.6 Scenario 3

Scenario 3 (Restricting children's journeys to 2km, with restriction of vehicles during school start and end time)				
Children and distance to school	N	%	>2km	
Scenario 3 with 100% walk journeys	316,785	100	0	
RTIs (67.3% reduction in pedestrian RTI after restricting vehicles)				19226
Scenario 3 with 70% walk journeys	221749	70	0	
and 30% cycle journeys	95035	30	0	
RTIs (67.3% reduction in pedestrian RTI after restricting vehicles)				13582
and 22% reduction in RTI to cyclists after restricting vehicles)				15804
Total RTIs				29,386

8.4 DISCUSSION

8.4.1 Principal findings

This study quantifies the road traffic injury risk to school children by mode of travel in Hyderabad. Vulnerable road users who face the highest risks of road injury were identified. Relative to school bus occupants, cyclists, pedestrians and motorcycle passengers were 13, 12 and 6 times, respectively, more likely to be injured, for the same distance travelled. School bus travel was found to be the safest travel mode. Risk of injury by the private passenger car was similar to that of travel by RTC bus and auto-rickshaw, both public modes of transport.

Alternative transport scenarios were envisioned, based on the local context and policy aspirations of the government, and road injury risk was estimated for various modes of children's travel to school and compared. RTIs under scenario 1 (business as usual) were estimated to be the highest at 48,341, while RTIs under scenario 2 (restricting school journeys to 2 km) were estimated to be 41,049. RTIs under scenario 3 (restricting journeys to 2 km along with restricting vehicles during school start and end time) were estimated to be the lowest, at 29,386.

8.4.2 Strengths and limitations

As mentioned in Chapter 7, there are several limitations associated with the measure of road injury used in this study. For example, the link between road injury and mode is made by the assumption that 'usual mode' is the mode the child was using when he/she was injured. I do not know if road injury actually happened when the child was using that mode. It is also possible that children changed their travel mode and adopted safer modes following a road injury. Other limitations include the cross-sectional nature of the study, which does not lend itself to causal inference, and the use of self-reported injury, which is susceptible to recall bias. The relatively long recall period of 12 months may have led to under-reporting of injury, [201] and the lack of information on the severity of injury, are other limitations.

Detailed and finer level sub-group analysis was not supported by the data. For example, it would have been useful to calculate bicycle injury risk for female cyclists in private schools, and compare the results with the risk in government schools.

It was not possible to compare the injury risk reported in this study with the official injury data from India, which is under-reported, and especially unreliable for less severe injuries. [38] Official reports estimate that children's road traffic deaths account for approximately 6% of the total road injury deaths in India. [33]

Unfortunately, I had very little information on children's socio-economic status or social class differences. This is a limitation of my thesis. The only information I had was the type of school the child was in, which was a proxy for the socio-economic status. I considered school management to be a marker of socio-economic status and parental influence, because generally, government schools cater to lower income families, government aided schools cater to middle income families and children from higher income families attend private schools. Another study from Hyderabad found significant differences in the road use pattern for the children based on the per-capita monthly household income. For instance, all trips by foot and the time spent on road per day decreased with increasing per-capita household income quartile. On the other hand, the proportion of trips by cycle or motorised two-wheeled vehicle increased with increasing per-capita monthly household income quartile. [32]

Road injury is a function of many factors, [20] and we can make better estimates of the risk of injury when other factors are also considered. In this study, however, I did not have information about the traffic environment- volume of traffic or travel speed- but we can assume that road danger is more or less high on most main roads because only 7.8% of roads in Hyderabad were found to have pavements. [26] Moreover there was no information regarding the use of safety equipment which might have protected the road user, for example, helmets. But cyclists- both adults and children- do not wear bicycle helmets in Hyderabad, [32] [223] and the use of motorcycle helmets is also low. [224] The probability of fatalities is known to vary with the type of road user, as well as the hazard, or the striking vehicle. [211] I did not have any information on the striking vehicle, which could have served as a proxy for the severity of injury, and is a limitation of this study.

While these limitations are acknowledged, this thesis is the first to explore the impacts on road injury risk of children's travel to school in Hyderabad. The scenarios chosen were based on the local context and the recent traffic restrictions in many urban areas, and seem to be within the realm of reason. For example, after re-assigning the children to a distance of 2 km from the schools, they were all expected to walk or cycle. This does not seem un-reasonable, since 2 km is considered a distance that can be covered by non-motorised transport, even for children. [8] The scenarios also considered the current examples of vehicular restriction in Indian cities, making the scenarios plausible in future. For example, trucks and heavy vehicles are already restricted in residential areas. [225] Restriction of all motorised traffic on several stretches in Visakhapatnam every morning, throughout the year, is another such example, as discussed in section 8.2.2.

As described in Chapter 1, several transport networks are currently available in Hyderabad, and the Metro rail is expected to be a major transport development, with an estimated ridership of 60,000 people per hour. But the Metro may be unlikely to impact many children's journeys to school, at least in the beginning, given the corridor length of 72 km and that too, only along the main roads of the city.

Previous literature on road safety in India reinforces the findings of this study that pedestrians, cyclists and users of motorised 2-wheelers are vulnerable road users. The school travel data for this study has been drawn from the cross-sectional survey (chapter 6), which is the only reliable information available on children' school travel in Hyderabad. The questionnaire was shown to be reliable for the usual mode of travel to school, for distance travelled, and for self-reported road traffic injury (as described in Chapters 4 and 5). Using exposure data (number of annual child km travelled) to assess injury risk was the strength of this study. Such exposure based rates can be compared across different parameters, as was done in this study, for different modes. They can be compared over time, and using other background information to explain any trends, can help assess road safety interventions.

An important outcome of this study was the identification of the high-risk road users among children travelling to school. These findings are similar to those reported by studies conducted in high income countries, except that the risk in my study was higher. Past studies have presented road injury risk for a single mode, [216] but this study presents road injury risks for various modes, and all road users on the journey to school in Hyderabad.

In a way, travel by bus is a proxy for social class differences. For example, wealthier children travel by school bus, and are picked up and dropped off almost from their door step. But children from lower socio- economic status travel by public (RTC) bus, which costs much less than a school bus, and involves a walk of an average of 1km, to get from home to the bus stop, and another 1km from the other bus stop to school.

The lack of safety around buses has been documented in India. A study conducted by D. Mohan in 2000-2001 reports that buses operated by the Delhi Transport Corporation were involved in 928 crashes of which 152 were fatal. The study also mentions that a comparison of bus crash statistics of four major cities in India (Chennai, Delhi, Kolkata and Mumbai) show that fatalities per 100 million passenger km range between 0.40 and 1.04. These rates are higher when compared to an average rate of 0.33 for the USA. [226]

School bus travel is perhaps safest because it is a private service, paid for by parents, and it picks up and drops off children close to their homes. The higher injury rate observed for RTC bus travel may reflect injuries sustained during the trip to and from the bus stop (although I do not have this information from my study). Bangalore city has wisely used the relatively safer mode- the bus- in its plans to provide safe routes to school. For example, it commissioned 210 RTC buses to ferry school children who do not have, or cannot afford, a private school bus service. The main objective behind the initiative was to decongest school zones. Since a bus can accommodate about 75 children, approximately 15,750 (i.e. 210 × 75) private vehicles could potentially remain off the roads. However, the problem of last mile connectivity remains, and the initiative is still struggling to become viable. [227]

As my study was to explore road traffic injuries during school journeys only, I did not collect information on children's activities after school. Therefore, my questionnaire on road injury was specific to injuries on the way to, and from, school.

8.4.3 Implications of the findings

The primary contribution of this research is that it provides a comparison of the road injury risk by mode, and identifies potentially safer modes of travel to school. This is relevant to understanding the inherent risks of children's trip to school, which are in turn strongly connected to the urban built environment planning. The spread sheet model hypothesised different scenarios that potentially influence travel behaviour and the associated road safety risks. The results show that alternate transport scenarios which restrict the distance travelled, and restrict motor vehicles near schools, can potentially reduce road traffic injuries to children during school journeys.

This study collected information from school children in Hyderabad to investigate their annual travel exposure on the journey to school, in order to estimate their injury risk per kilometre travelled by mode. Similar to the findings of the chapter on road injury (chapter 7) the results of this chapter re-iterate that travel to school in Hyderabad by walking and cycling is most risky, and travel to school by the school bus is safest.

These results can be appropriately generalised to other urban school children aged 11-14 years with similar travel behaviour in other Indian cities. These scenarios are based on the local context and the urban setting of Hyderabad, taking into consideration the recent promotion of 'no-vehicle zones', and may not be politically too difficult to implement.

Safety in numbers

It has been estimated that there may be fewer road traffic injuries by transferring a substantial part of trips made by motor vehicles to walking or cycling. As the number of pedestrians or cyclists increases, the risk faced by them goes down. This is explained by the 'non-linearity of risk' and 'safety in numbers' which means that the more numbers of people walk or cycle, the safer walking and cycling becomes. [228]

We saw that road injuries under scenario 2 decrease, when compared to that under scenario 1. It is a considerable decrease (48,341 to 41,049 injuries). But the hazard from motorised vehicles is still there under scenario 2. Only with the restriction of vehicles under scenario 3, such that striking vehicles responsible for most injuries are removed during certain times, do injuries reduce substantially (48,341 to 29,386). This reiterates that merely promoting walking and cycling to school (keeping everything else constant) is unlikely to reduce injuries substantially, unless combined with strict interventions like vehicular restriction near schools.

These findings emphasise that children will continue to be at high risk of road injury because not all parents in Hyderabad can afford to send their children to school by the school bus. Parents who have a choice are likely to support the use of 2-wheelers and private cars, ignoring the physical activity benefits of walking and cycling to school, and the risk of exposure to air pollution. This shows that while the societal implications may be important, they may be out-weighed by the family decision and parents' perception of the safe mode of travel to school. This is due to the imminent danger of road injury, even if parents know that motorised modes of travel are not sustainable in the long run.

Therefore, a major factor that is important to consider in understanding choice of mode of travel to school is parental concern about lack of road safety in India. A study on parents' perceptions on their children's road safety reports that of the 6,000 parents surveyed in six countries, 66% of parents in India believe that their child will be seriously hurt on the road in the next year. Moreover, 90% of parents in India expressed concern about their child's safety when walking to school. [146] The situation may not change unless serious efforts are made to ensure that walking and cycling are safe, using a host of proven road safety interventions, including building pavements and cycle lanes.

The vulnerable road users in low and middle-income countries have been repeatedly found to be pedestrians, cyclists and 2-wheeler users. This study mirrors these findings for children's trips to school in Hyderabad. Literature on effective counter- measures for road injuries are now widely available: side-walks, bicycle lanes, bicycle helmets, signalised crossing, reduction in vehicle speeds, engineering measures such as raised medians and refuge islands on high traffic volume roads. [20] But none of these measures are in place near school zones in Hyderabad, and should be urgently implemented to protect these vulnerable children.

Designing safe spaces for children, particularly from home to school can only be accomplished when integrated with the larger road safety interventions mentioned above. This may have the added advantage of increasing walking and cycling to school among children and their escorting parents.

A natural extension of this work would include the addition of more variables like the density of traffic and road network near schools, and severity of road injury. This would account for the interaction between the environments in which the child makes the journey, which may be useful to consider.

8.5 Conclusions

This chapter provides exposure-based road traffic injury risk for all major modes of travel to school in Hyderabad, motorised and non-motorised. Importantly, this chapter attempts to inform the emerging road safety literature of the role of distance and mode in influencing the risk of road injury, in the bigger context of children's school travel behaviour, an issue that has not received adequate attention in the wider context of road safety in India.

The findings suggest that travel by non-motorised modes carries a disproportionately higher risk of road injury. Although there is strong evidence of the benefits of physical activity through active travel, it may be difficult to advocate for it against the heightened injury risks found in this study. Unless walking and cycling are made safer in the entire city of Hyderabad, there will continue to be large numbers of children injured on the daily journeys to school.

Figure 8.2 Police barricade motor vehicles at the 'no vehicle zone' in Visakhapatnam

Figure 8.3 Parked vehicles while people walk and cycle on the beach road in Visakhapatnam

Figure 8.4 People walk and cycle on the beach road in Visakhapatnam

Figure 8.5 'No car day' in Delhi, October 22nd, 2015

Figure 8.6 Rahgiri in Hyderabad (Vehicle free road from 7 am to 10 am, every Sunday)

Figure 8.7 People enjoying a walk on Rahgiri day in Hyderabad

Source: Internet, gallery.oneindia.com

9 DISCUSSION AND CONCLUSIONS

9.1 Introduction

In this final chapter I draw together the conclusions of my research and locate them within the local context of Hyderabad. In Section 9.2 I outline my main findings against the key research questions; I discuss the implications of the results, and compare the results with previously published studies. In Section 9.3 I outline the directions for my future research plans, and finally in section 9.4, I conclude by providing some recommendations for policy and practice.

9.2 Main findings and their implications

9.2.1 How does distance influence mode of travel to school- A systematic review

In India over 300 million children are making journeys to and from school each day, and yet little is known about the distances travelled and the modes used. Information on distance and mode of travel in Hyderabad is necessary, to plan how transport choices are made, and to draft effective strategies to promote safe paths to school, including children's walking and cycling to school. Without this information those who plan new housing developments, those who plan and build new schools, and those who maintain roads and plan transport infrastructure, may neglect the opportunities to ensure that communities remain safe and sustainable. In Chapter 2, we saw that all studies appraised in the systematic review reported an inverse relationship between distance and walking or cycling to school, and a direct relationship between distance and use of motorised transport to school. The systematic review (conducted in 2012) could not identify studies from low and middle-income countries.

The review noted that children are strongly influenced by their parents' attitudes and practices. We saw that parental and family attributes and circumstances influenced children's commuting to school. In the studies reviewed, children were more likely to walk or cycle when their parents themselves valued physical activity. Considering the evidence that everyday travel by walking and cycling is associated with positive health benefits for children, [3] [114] it became evident that there is a definite need for research on children's travel to school in Hyderabad. I therefore decided to design a questionnaire on children's travel to school, and to test its reliability and validity in estimating distance and the mode of travel to school. I undertook a cross-sectional survey to record the mode of travel and the distance travelled by children to school in Hyderabad.

9.2.2 Can we measure distance and mode of travel to school reliably?

In this thesis I have developed methods to estimate the distances that children travel to school and the modes of travel they use, in settings where there is either limited access to GPS, or limited indexing of household addresses in online mapping systems such as Google Earth. As the world's population grows there will continue to be places which are rapidly growing, where we are unable to locate every household address on an electronic map to estimate distances to schools, or places of work. The instrument I developed for estimating distance uses the nearest landmark to the homes of children, and I found this to be a reasonable proxy. I have developed a short questionnaire on children's travel to school in Hyderabad and have shown that questions on usual mode of travel, and road injury were reliable as demonstrated by a high kappa statistic for agreement.

The estimates of distance to school based on information about the nearest landmark to a child's home was also found to be a valid measure of distance when compared to a method based on in-depth interviews with children. When I compared the 'nearest landmark' versus 'in-depth' distance, they differed by 10% for walking and cycling, and this margin of error was considered to be within acceptable limits of accuracy. For other modes like the school bus, the mean difference was higher, but this is because the school bus does not use a direct route. It is possible that asking children to draw their routes to school on image maps will have excluded smaller and unofficial routes, and biased the results to have the effect of overestimating their exposure to main routes. This is a limitation of the study.

Future studies can therefore use the nearest landmark method to estimate the true distance that a child would walk or cycle to school. It confirms that the nearest landmark method is feasible, in the absence of GPS equipment and software, especially in low-resource urban settings. This method should be tested in rural areas, which have a different pattern of land-use. Further development of this approach, for example using factor analysis to refine the items, may also improve the questionnaire.

9.2.3 What is the relationship between distance and mode?

The principal finding of the cross-sectional study that I conducted in 45 schools was that most children in Hyderabad walked or cycled to school. As found in the systematic review, the results of my cross-sectional survey confirmed that distance to school was strongly associated with the use of motorised transport. Children attending private schools travelled longer distances and were more likely to travel by car. Children living 2-3 km from school were most likely to cycle to school. A higher proportion of boys walked or cycled to school when compared to girls, while the proportion of girls who were driven to school by private personal transport was twice that of the boys. We also saw an evidence of an association of the usual mode of travel to school, by grade. A higher proportion of children in the 8th grade seem to cycle to school when compared to those in the 6th grade.

Distance to school has a strong effect on mode choice. [94] [210] A majority of the children in my study lived within 1.6 km (one mile) from school, and overall, most (63%) walked or cycled. In comparison, a fifth of the children lived within one mile from school in the USA and overall, 12% walked or cycled. [206] As shown in high income settings, boys were more likely to cycle to school than girls, and older children were more likely to cycle than younger children. [229] These findings may reflect cross-cultural social norms related to children's independent travel.

Walking was more common in government and aided schools than in private schools. As I have explained in Chapter 1, the type of school in India is an indicator of the socio-economic status of families, with children from wealthier families studying in private schools and tending to use private motorised transport. Similarly, a British study found attendance at an independent school to be a strong predictor of car travel. [12] I also found that children who reported exercising after school were more likely to walk to school than those who did not exercise. Children who exercised for 7 hours a week were almost twice as likely to cycle to school as children who got no exercise. I estimated that among children aged 11 to 14 years in Hyderabad 63% commute to school by walking or cycling. This prevalence is higher than in countries which have pavements and cycle lanes. [8, 138, 230, 231] Compared to children in the UK and USA, most children in India walk or cycle to school. This is in spite of few pavements and cycle lanes. [102] The reasons for mode choice including barriers to walking and cycling, and the extent of parental influence will be useful to explore through future research. Although commuting by car is currently available to only 4% of children in Hyderabad, it is likely to increase, given the 12% annual growth of motor vehicles in India. [4] Infrastructure such as pavements for walking and safe space for cycling need to be urgently improved, to preserve independent travel and increase children's physical activity.

9.2.4 What is the risk of road traffic injury on the school journey?

I estimated that among children aged 11 to 14 years in Hyderabad the overall prevalence of road traffic injuries during journeys to school in the previous 12 months was 17%. My results suggest that cycling to school may be more hazardous than walking, while travelling by the school bus is safest. Almost twice the proportion of boys reported road injury when compared to girls. The prevalence of road injury, however, did not seem to differ much by the type of school or by grade.

Good quality data on road injuries are essential to formulate, to implement, and to evaluate road safety policies and interventions. There is no centrally coordinated and publicly available road injury surveillance data in India. [38] The burden and impact of road injuries in India is estimated to be much higher than those reported by official sources. It is estimated that official records underreported road deaths by 10 - 30% and serious injuries by more than 50%. [38] Police records and data sources especially lack information on modifiable risk factors (i.e., helmets, seat belts, drunk driving, speeding, road factors, etc.)

Furthermore, there are no routine measures of road injury in Hyderabad, stratified by age. While there is some data from published studies in Hyderabad on the incidence, prevalence and risk factors of road traffic injury in adults, there are fewer data on children's injuries. It is important to study the risk factors for children's injuries because road injuries are preventable, and children who sustain road injuries frequently require long-term care, depriving them of education and social development opportunities.

Estimates of the incidence of road traffic injury are inconsistent across studies which may reflect differences in the operational definitions of road traffic injury, or in the origin-destination of trips. Studies may have included 'any travel' as the purpose of the trip, and not necessarily ‘school journeys’. Since there is no gold standard by which to compare the prevalence of road traffic injuries in different settings, robust study designs that can answer similar questions more reliably need to be used. [232]

I estimated the overall prevalence of road injury among children aged 11 to 14 years during school journeys to be 17%. There have been no previous studies in Hyderabad that have reported on road traffic injury during school journeys by mode and distance to school. One study in India reported the reason for being on the road as ‘*going/ coming from school/ work’* for 19% of all road injuries. [32] This estimate of 19% is not very different from my estimate of 17%.

Children who usually cycled were more likely to report having suffered a road traffic injury during their school journeys. Reports of road traffic injuries were also high for children travelling to school by 2-wheeler, or by walking. My estimates of road traffic injury for children as a cyclist (33%) or as a pedestrian (17%) were higher than those reported by a Palestinian study (11% for cycling and 8% for walking). [208] This difference is perhaps because the Palestinian study included the activity context (e.g. sport) whereas my definition of road traffic injury was specific to school travel. [209] My estimates, however, were lower than those reported by another Indian study on road use by children (46% for cycling and 42% for walking). [32] This difference could be because the estimates were from a household survey of all road injury among children aged 5-14 years, irrespective of the destination. Another study from Andhra Pradesh used a 3 year recall period for severe non-fatal injuries, and found that of all injured children, 52% were cyclists, and 20% were pedestrians.[205]

The overall prevalence of road injury among boys was higher than among girls, which is consistent with results from other Indian studies. [32] Boys have a higher exposure to bicycle riding compared with girls and many of the differences in hospital emergency attendance are thought to stem from different exposure rates. [210] I could not estimate the risk of bicycle injury for girls because the number of girls (n=5) who cycled was quite small, compared to boys (n=319).

Travel by school bus was safer than walking, but the school bus is a private form of transport, paid for by wealthy parents to collect children at the door step. Not all parents can afford to send their children by school bus. The RTC bus (public transport) has approximately 15 million passengers per day and is used by 72% of the population as the primary mode of transport in Hyderabad. [85] My results show that the public bus is as safe as the car. Private motorised vehicles were associated with a higher prevalence of road injury (20% for 2-wheeler and 16% for car), than the public transport modes. A similar finding has been found in New Zealand. [206]

The main limitation of my research is that I did not ask about the mode of travel in which the children were injured. This was to keep the questionnaire short. I have assumed that the mode was their usual mode of travel. I acknowledge the limitations of the cross-sectional design and am cautious about interpreting the estimates of the prevalence of road injury by mode, for these reasons. But the kappa statistic for the question on self-report of road injury on the way to school was high, and this is one of the strengths of the study.

One of the potential solutions to avoid self-report error is to cross-check with the health facility or hospital records. Although it was not possible to do that in this study due to time and financial resource constraints, it is however likely that some parents may have taken their child with a minor injury to see a doctor or nurse, while other parents may not have.

This study presents children's road traffic injury data in all the mandals of Hyderabad, thereby giving a city-wide estimate, and satisfying external validity. The 5,842 children in the sample are estimated to represent a population of 322,258 children and I believe that these results might be generalisable to children aged 11-14 years in other urban school populations in India with comparable road infrastructure and travel behaviour.

My results highlight the potential safety issues that are associated with children's journeys to school in urban India. The results suggest that choice of mode of travel may alter injury risk. There is a need for future research to evaluate detailed exposure data on the number, severity and location of road injury near school zones. Measures such as the introduction of affordable school buses will also be useful to explore. Children's journeys to school are a daily activity that ought to be pleasant and safe. This can only be achieved by improving the overall road safety in Hyderabad, with a strong emphasis on the construction of pavements and cycle lanes.

9.2.5 Modelling public health impacts of travel to school: Road traffic injuries

In Chapter 8, I estimated the road traffic injury risk in children during their daily journeys to school. This is a new, albeit modest, application to the method of injury risk matrix [211] in the context of urban Indian children's journeys to school. I discussed the risk of injury on school journeys in the current (business as usual scenario 1) situation, and during alternate transport scenarios: re-assigning children to 2 km distance (scenario 2), and re-assigning children to 2 km distance combined with restriction of motor vehicles (scenario 3), leading to a protection from the striking vehicles around school zones. I thus estimated the annual road injury risk per child kilometre, therefore accounting for the average distance travelled to school per year.

My analysis showed that if all children lived within 2 km from school this would reduce the total distance travelled and the number of road injuries. Motor vehicle restrictions within 2 km of school during the morning and afternoon commutes would also be needed to reduce road traffic injuries. The results of this chapter re-iterate that travel to school by walking and cycling is most risky, and travel to school by the school bus is the safest.

These results emphasise that road injuries are a huge problem in Hyderabad. This is reflected in four important points: children’s self- reported road injury prevalence of 17% (chapter 7); children’s response that 15% were worried about traffic on the journey to school and 45% were worried about being late due to traffic congestion (chapter 6); 65% of parents reporting (during the pilot) that the most serious concern they have regarding their child’s school journey is the traffic condition, and 66% of parents in India believe that their child will be seriously hurt on the road in the next year. [146] The perception that Indian roads are unsafe is adequately backed by newspaper reports, and reinforced by frequent occurrence of road injuries that parents are so accustomed to seeing, on a daily basis.

The ‘car culture’ that is ubiquitous in high income countries may be a distant possibility in India, but everybody aspires to own a car because it is perceived as a safer mode of transport and a status symbol. This was reflected in the response from the survey, of how children wished to travel in future. Currently, 57% of children walk to school, but less than half (24%) wished to do so. Similarly, 4% of children currently travel to school by car, but 23% of all children said they instead wished to travel by car. Twice the proportion of children (17%) expressed their wish to travel by school bus than the current 8%. In chapter 2, we saw that the decision on school travel is often made by parents, and is supposedly in the best interest of their child. The lack of road safety is therefore a huge influencing factor on the choice of mode.

In chapter 8 I also discussed what transport networks are currently available in Hyderabad, and how the transport options might change in future, with the arrival of the Metro rail. We saw how things would be different, if children need not travel beyond 2km to school, and what we think must be a plausible scenario a few years into the future. Strong political will and support are necessary to make this happen, with the municipality, traffic police, and the community as lead agencies that need to be involved to make changes to the traffic flow and management.

I would like to emphasise here that I chose Hyderabad to conduct this research on children's travel to school because of reasons of practicality and feasibility, as my job and work is based in Hyderabad. Although Hyderabad is only slightly behind other large cities in India in terms of size, economy, and poverty levels, it follows that those differences may manifest themselves in transport usage. For example, Delhi has far more number of private cars which may be used by families to escort children to school, and Mumbai is known to have a better public transport system. It might mean that my study results may not be entirely transferable to other major cities in India.

The school system in India is also similar in other Indian states and cities: government, semi-private aided, and private unaided schools. Therefore it seems I might get similar findings if I repeated the study in other major Indian cities, in the sense that children from lower socio economic classes would walk or use public buses when compared to children from higher socio economic classes. But the proportion of various modes of travel to school may differ across cities in India according to transport networks and usage.

9.3 Future research

The findings from my research suggest a number of implications for policy formulation and directions for future research. I believe I have gained several important insights: I have collected and analysed data on children's independent mobility, the distances travelled to school, and modes used, the variations in modal choice by gender, the inequalities in car use by school type, and the road injury risk during school commutes. I would like to build on the results presented in this thesis, to other important public health impacts of the journey to school. I would specifically like to expand the work in the direction of air pollution, and to repeat my survey in different settings.

9.3.1 Children's exposure to air pollution

In 2015, 195 countries met during the Conference of Parties in Paris, to discuss their concerns about air pollution and its impact on climate change, and agreed to reduce emissions. Being one of the highly populated countries, India is expected to be a key player in implementing specific plans to reduce emissions in the next few years. With this background, epidemiological evidence of children's exposure to air pollution will be useful, to inform policy and control measures. In chapter 1, I discussed that in addition to road injury as a public health impact of children's journeys to school, children's exposure to air pollution in Hyderabad is another important public health impact of the journey to school. In chapter 8, I estimated the distances that children travel to school by each mode of travel. The amount of air pollution to which children are exposed during these distance is not currently known. Further research is needed to measure air pollution exposure per kilometre travelled, using different modes.

A large proportion of the increase in air pollution is attributed to the growing vehicle population in Hyderabad. [58] To the best of my knowledge, there are no published studies that estimate the emission impact of children's school journeys in Hyderabad. Previous studies in Hyderabad have painstakingly developed emission inventories for total PM (PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), and carbon dioxide (CO_2). But these are disaggregated by source of emissions: transport, industrial, brick kilns etc., and not by commuting trip purpose: for work, school, etc. So, while there is some information on the total emissions in Hyderabad, [58] we do not know how much of the total can be attributed to children's school commute.

We know from the results of the systematic review (chapter 2) that longer commuting distances have an impact on mode choice. It has also been shown to have obvious impacts on emission levels. [233-235] Using my data on distance and children's mode of travel in

Hyderabad, along with the available emission factors, I plan to estimate the average black carbon emissions attributable to the school journey.

I have started discussions with an air pollution expert who is planning to estimate the air pollution levels in peri-urban areas of Hyderabad. I would like to estimate children's exposure to air pollution in the journey to school, for different modes of travel, as well as for different routes taken to school. My aim is to measure carbon levels using personal air monitors that will be worn by children. I would get estimates of traffic related air pollution, disaggregated by distance and mode, giving us estimates of air pollution by child kilometres travelled. These wearable gadgets will enable objectively assessed estimates of pollutants during active (walking/ cycling) and sedentary time (sitting/ standing in bus, car, etc.) among children traveling to school. Depending on the equipment, I may be able to get information on PM_{5} and $PM_{2.5}$ as well as other pollutants like NoX, oxides of Sulphur, CO_2, etc.

9.3.2 Mode and distance to school in rural areas

In addition, in future research I plan to repeat the school survey in rural areas of the state, to see how children in the rural areas travel to school, and how far they travel. This might be done in the rural districts of Telangana, or the neighbouring state of Andhra Pradesh. According to the recent census data, vehicle ownership is higher in the urban areas. A third of the households in urban India own 2-wheelers, compared to 14% in rural areas. Similarly, 10% of households in urban areas own a car, compared to 2% in the rural areas. [236] Considering a higher growth predicted for 2-wheelers in the rural areas, a repeat survey is likely to give different results from what I have found in the highly urbanised Hyderabad. Although the mortality due to road traffic injuries is higher in the urban than rural areas, [237] we do not have information on non-fatal injury in urban versus rural areas. It will be interesting to see where the differences may be.

When I started this research in 2011, the mobile phone penetration in India was about 800 million. Now (2016), it is estimated to be 1.04 billion, but these are just users of mobile phones, and not smart phones, which have the capacity to measure distance. Therefore, although the mobile penetration in India in 2016 is estimated to be around 81%, the number of smart phone connections per 100 population is still low, at approximately 17%. The number of smart phone users in 2011 was estimated to be around 33 million. [72] In contrast, the number of smart phone users in India is now estimated to have grown to 239 million by the end of 2015. [72]

So, although now there is a definite possibility of using mobile phone technology for estimating distance to school, it was much more difficult and prohibitively expensive to use a smart phone to estimate distance in 2011 when this research was started.

I wanted to consider the stages of a journey by mode rather than the mode alone. That is the reason for the elaborate question on ‘how did you travel to school today’, where space was provided in the questionnaire for various stages of the journey (for example, home to bus stop, bus journey, bus stop to school, etc.). But when the survey was conducted and children returned the questionnaires, I noticed that a few children did not fill the details about the various stages of their journey. I therefore analysed the data with the assumption that the mode of travel mentioned is the primary mode used by the child to get to school. Care should be taken in the future development of the Questionnaire to capture the information on the stages of a journey by mode.

9.3.3 Trends in modal choice

I would also like to explore the possibility of repeating the survey in Hyderabad itself, after a year or so after the Metro rail service becomes operational. I am curious to see the impact of the metro rail service on children’s daily commuting to school. The Hyderabad Metro rail will be operational in two years, and presents a new option for travel to school. It envisages a ridership of approximately 1.7 million people every day. [86] It will remain to be seen if children travelling to school and back will contribute to the overall ridership in the Hyderabad Metro, and by how much.

9.3.4 Physical activity in children

Another important public health impact of the journey to school is the opportunity for physical activity of children. We have seen in chapter 4 that the question on physical activity was not found to be as reliable as the question on usual mode of travel to school and the one on road injury. I want to improve my questionnaire in this regard, perhaps by asking children the various activities they participate in, and calculating the average duration in minutes of each activity. Metabolic equivalent tasks (MET) could then be estimated.

Previous studies have shown that wealthier children living in urban areas of India tend to be less physically active, or do not meet the WHO recommended physical activity guidelines. For example, a study was conducted among school children in grades 9-12 in Delhi, on the risk factors for non-communicable diseases.[238] It found that about 55% of boys and 70% of the girls reported not being engaged in sports at school or at home. I would like to understand the various reasons for the decreasing physical activity levels among children in urban areas of India. There could be cultural and other reasons which need to be explored. Studies have shown that parental attitudes and perceptions on physical activity have an influence on children's physical activity levels. [134] I would like to explore Indian parents' perceptions of the importance of physical activity among children and how they view their role as a parent to encourage physical activity among their children. There are no such studies in India, and would be worth exploring.

9.3.5 Parental influences and attitudes

The decisions as to how to travel to school are largely made within the home and family at the individual level. The school journey is not only constructed as a form of travel, but also as an indicator of children's independent mobility. [239] It has been shown that parental influence plays a significant role in influencing children's choice of travel mode. We saw in the chapter on the systematic review (Chapter 2) that parental attitude is an important independent predictor of children's mode of travel. Parents' walking and cycling was associated with their children regularly walking to school. [131] Distance was cited as the main reason for not allowing children to walk or bicycle to or from school (Chapter 2) Parental concern about safety, worry about traffic and personal safety, including fear of abduction, were frequently documented. [12, 117, 132] We saw that parents' own history of transport to school, perception of the importance of physical activity, and weather also seemed to influence their decision regarding their children's mode of travel to school. [132] Gender and maternal travel mode were associated with children's active commute, as were parental perceptions of accessibility to walk. [134] A Swiss study reported that parents preferred to drive their children to school due to 'distance', 'having the same way to go', 'bad weather' and 'child being late'. [117]

While we know that parental influence and permissions are an important determinant for children's mode choice, we do not have published research studies on this in India. The available information is usually in the local newspapers. [240] I wanted to involve parents of the children in my original study plan. In order to obtain information on the determinants of mode of travel, I designed a questionnaire for the parents. This was to be distributed to children, to take home for completion by their parents, and brought back to school the next day. The Ethics Committee had raised concerns about the level of illiteracy among parents and the subsequent response rate, especially in parents with low income. These concerns were justified, as I later learned, going by the results of the pilot study. The response rate for the parent questionnaire was 70% after the third reminder visit in a private school and 60% in a government school.

The principals of two government schools to whom I spoke, confirmed that most parents of the children enrolled there are illiterate. Although I tested a method by which the children read out the questions to their parents and filled in their answers, the response rate was not satisfactory. I therefore decided not to use the parent questionnaire in the survey, for the reasons discussed.

More input from schools' parents would have greatly benefited this research. The informal conversations that I had with many parents during the course of my research, however, confirmed that parents regard their child's travel to school as an important daily activity. They had a lot of interest in this area, which I hope to be able to explore through future research, especially on the barriers and enablers of using a particular mode to school, and of active travel in general.

My research did not engage with parents as I had originally intended. I would therefore like to involve parents through a future research study, to find out about parent's concerns, and their perceived barriers and facilitators of mode choice. Given the government's policy aspirations of increased public transport use, it will be useful to explore how parents make decisions regarding their child's transport and what the key drivers are, behind the decisions, in order to understand their influence on children's travel behaviours. I shall use alternate methods to get information, for example, by purposefully selecting some parents such that they reflect the range of mode of travel, and perhaps use in-depth interviews and focus groups.

9.4 Conclusions and recommendations

During my research I have developed methods to measure distance to school, transport modes used, and the risk of road traffic injury, among children aged 11 to 14 years on their journeys to and from school in Hyderabad. The relationship between distance and mode presented in this study is new information, especially among children in urban India. This thesis has established that a self-administered questionnaire on children's travel to school can reliably estimate distance and mode of travel to school in a low-resource setting where there is limited access to GPS. This thesis shows that children's daily travel to school in Hyderabad has huge public health implications, especially road traffic injuries. These results have significant implications and may be of importance to those who plan new housing developments, those who plan and build new schools, and those who maintain roads and plan transport infrastructure.

India is undergoing a social and economic transition. This is leading to increased motor vehicle ownership and use, leading to population-wide adoption of passive commuting behaviours. Walking and cycling is a good thing, but it is under threat from cars and motorised 2-wheelers in India. The automobile manufacturing industry in India will continue to promote their products aggressively. Because of the auto- industry's increasing share in contributing to the country's economy, it may be a challenge for the government to constrain its growth. The overall increase in travel demand by the year 2041 in Hyderabad is estimated to be about 170% higher than in 2011. This would translate to 13.1 million trips (about 2.5 times higher) during 8 am-12 noon, when compared to 5.3 million trips in 2011. The non-motorised mode share of 35% in 2011 is expected to reduce to 29%, due to increase in vehicle ownership and trip length. [241]

There are some recent and encouraging changes in Indian cities though, which may set the stage for a change in India's future mobility. This was not so in October 2011, when this research was started. Advocacy from civil society, concern from non-governmental organisations and international pressure has forced the inception of new policies and events highlighting the importance of walking and cycling in Indian cities. For example, earlier in 2015, Delhi ordered all private cars older than 10 years to be taken off the roads, to reduce emissions. Another new development is that the government of Delhi has mandated vehicles with odd and even numbers to be allowed to run only on alternate days to curb pollution, for two weeks from 1st January 2016. Although criticised for various reasons, the initiative is nevertheless encouraging, for forcing the government to take some action to address the harmful levels of air pollution.

As another example, the government of Orissa (Eastern India) gave away free bicycles to girls of grades 8-12 in government and aided schools, which became a popular programme. Although the scheme was initiated to encourage girls' education and reduce school drop-out rate, it was extended to include boys from low income families, and is likely to have other public health benefits in the long run. [242]

In chapter 8, I described various instances of long stretches of roads with vehicular restriction, to encourage walking and cycling. The other initiatives are examples of 'car-free days' in several cities of India, and a progressive transport policy of Chennai and Visakhapatnam, with an emphasis on non-motorised transport. [243, 244] The policy should of course, actively try to match people's aspirations of how they want to make choices regarding their mobility.

To sustain these policy initiatives, strong political commitment, combined with strict enforcement, and adequate funding is needed, with good policing and infrastructure facilities. Community support for vehicular restriction is increasing, and people's participation in such activities, going by newspaper reports, is huge. These are the people who will also benefit from reduced injury risk during daily journeys, as a result of a reduction in motorised vehicles. These people would be the critical mass or the 'numbers' in the 'safety in numbers' concept [245] which says that, in theory, the total number of road traffic injuries could go down if a substantial share of trips by motorised transport is transferred to walking or cycling. [228]

School journeys provide the opportunity to walk and cycle on a daily basis, with the associated public health benefits of these journeys. Ensuring that walking and cycling are safe, enjoyable and convenient modes of urban transport for short journeys, is critical for improving health and ensuring ecological sustainability. More work is needed (e.g. constructing pavements) to support the high prevalence of walking reported in this study. India has a long way to go in constructing dedicated cycle lanes: Netherlands has 35,000 km of cycle paths, compared to 100 km in Delhi and under 10 km in Hyderabad [246]

The government commissioned transportation survey in Hyderabad recommends the provision of protected raised footpath facilities on either side of major road corridors and grade separated crossings for pedestrian traffic. These should be combined with hard measures such as dedicated lanes for pedestrians and cyclists, and median barriers to separate oncoming vehicle traffic. In addition, introducing school safety zones which include a host of speed reduction measures, car-free zones, safe drop-off and pick-up points, etc., are necessary, to bring about a long-term change to mobility patterns.

The journey to school in the western countries has evolved over the past decade due to “a wide range of interrelated policies, strategies and schemes developed in transport, education, social inclusion, health, urban design and road safety.” [239] In the UK, many nationwide policies and strategies specifically targeted towards the journey to school have been funded. There is even the evaluation of the *Travelling to School Initiative.* [247] Many measures have been introduced for getting children to travel safely to school, and are worth trying in Hyderabad, after adapting them to suit the local context.

These measures include ‘walking school buses’ where adult volunteers accompany groups of children to school. [248] These conspicuous groups teach children how to walk safely, and raise awareness about the health benefits of walking, and reducing congestion and pollution, especially near schools. Some high-income countries have ‘travel coordinators’ who advise parents and children on the safest routes to school. Some other countries like Thailand have improved the safety near school zones. Bangalore, India, has tried to ban the parking of vehicles within 200m from some schools; improved pedestrian crossings near selected schools; introduced dedicated public buses to be used by schools; and staggered the school timings. [22]

Despite its importance, the journey to school in India is seldom included in any public and policy discourses- either within the agenda of road safety, or sustainable transportation. This is the first epidemiological research that examines school transportation mode choice, distance travelled, and road injury risk, among school-going children in urban India. This thesis contributes to understanding children’s travel patterns in Hyderabad, which is a crucial first step for demanding much deserved attention to an area which cannot be neglected any more. I hope the evidence from this study garners strong support for action in the immediate future.

Appendix (i)

Eligibility screening questions

1.	Are there data on children's mode of transport to school?	Yes Unsure No (Exclude)
2.	Are all participants aged 5–18years/ grade 1-12, or their parents, or related to their school (teachers/ governors/ administrators?	Yes Unsure No (Exclude)
3.	Does the study explore distance as a determinant of travel to school, as mentioned in the factor of interest?	Yes Unsure No (Exclude)

Appendix (ii)

Summary of included studies

Study	Population				Commute to school		
Author/ Year/ Ref no.	Sample size	Participants/ age/ Grade	Sex	Country	Mode share reported	Data source	Main outcome measures
Fed highway admin/ 2008/ [137]	Not mentioned	All members of selected household	M, F	USA	In '69, 15% used pvt vehicle, In '01, 50% used pvt vehicle.	Secondary data (NHTS) List-assisted random digit dialling computer-assisted telephonic interview survey	Prevalence of various modes, distance wise
Natl Cent SRTS/ 2010/ [249]	130,000 parents, 2.4 million student trips	Children, parents	M, F	USA	Walking, cycling increased from 16% in K to 24% in 5th, fell to 18% in 8th grade.	Parent questionnaire, student tally- children's show of hands in school	Prevalence of various modes, reasons parents disallow ACS
Babey/ 2009/ [250]	3,451	12-17 Yr olds	M, F	USA	50% walked or cycled.	Parents, adolescents 2005 California health interview survey	No. of days ACS previous week, objectively measured urbanicity, Euclidean distance with GIS
Bringolf-Isler/ 2008/ [251]	1345	Parents	M, F	Switzerland	78% walked/ cycled, 12% regularly driven once/week.	Parents, of children visiting SCARPOL centres	Frequency of regular car trips to school, prevalence of various modes, distance by GIS,
Dalton/ 2011/ [252]	1552	Parents, adolescents	M, F	USA	53% ACS, 68% walked 7% cycled. Only 9% had year wide ACS, majority	Parents, children computer assisted telephonic survey tool,	Prevalence, frequency of ACS, Built environmental characteristics

					of whom lived<1mi	observation	influencing ACS, varying by distance in miles
D'Haese/ 2011/	696	Parents of children	M, F	Belgium	59.3% ACS (38% cycled, 21% walked)	Parent proxy report. Parent version of Neighbourhood Environment Walkability Survey (NEWS-Y)	Prevalence of ACS in objectively measured criterion distance
He/2011/ [253]	n/a	Children 5-18 yrs	M, F	USA	60% car, 25% ACS, 12% bus	Secondary data (Regional Transportation Survey, Personal travel diary, Academic performance index)	Frequency, prevalence of ACS, distance from home to nearest school
Landsberg/ 2007/ [124]	2232	8th grade	M, F	Germany	62% ACS (9% walked, 50% cycled, 4% did both), 31% bus, 4% car,	Children-Supervised questionnaire at school. KOPS study tool	4 fold skin thickness, pubertal development stage, prevalence ACS
McDonald/ 2007/ [254]	several thousands	Children 5-14 Yrs	M, F	USA	12.7% ACS in 2009 vs. 48% in 1969	Secondary data NHTS 2009 special school travel records, travel diary, information on trip distance, duration, adult accompaniment	Odds Ratios & marginal effect of each factor on probability of walking/cycling
McDonald/ 2008/ [255]	14,553	Children 5-18 Yrs	M, F	USA	ACS among Hispanics 28%, Blacks 16%, Asian 13%, Whites 9%.	Secondary data NHTS	ACS, based on Socio-economic status, access to vehicles, racial and minority wise, prevalence

							ratios used instead of odds Ratios
McDonald/ 2011/ [256]	19,671	Children 5-15 Yrs	M, F	USA	41% ACS in 1969 vs. 13% in 200. Steep rise in car use, 17% in 1969 to 55% in 2001	Secondary data National personal transportation survey	Usual mode of transport, adjusted odds Ratios
Merom/ 2006/[128]	812	Parent/ caregiver	M, F	Australia	ACS <50%, difference in prevalence of walking was more AM-PM than day-to-day. Monday AM18%, Friday PM 24%	Parent/ caregiver proxy report computer assisted telephonic interview	Frequency and prevalence of mode of travel
Moudon / 2011/[126]	749	Children 5 -18 Yrs	M, F	USA	Inverse association between network distance and ACS, even for children living<1mi away	Secondary data 2006 PSRC and HATS- Household activity& travel survey	mode of commuting to school, distance, socio-demographic, environmental variables, geocoded travel activities
NCSRTS/ 2010/ [249]	130,000 parents, 2.4 million student trips	Children 5-18 Yrs	M, F	USA	ACS reduced from 45% in 1995 to 41% in 2009 for<1mi, and 12 to 7% for 1-2 mi category. Car use increased from 45-51%, walking fell from 12-10% from 1995-2009	Parents, children. Parent questionnaire, student tally- show of hands in school	Mode share, frequencies, proportions, distance
Nelson/ 2010/ [257]	2159	16 Yr olds living within 2.5 mi	M, F	Ireland	61.3% walked, 8.7% cycled. Boys cycled more than girls (15.4	Children, self-report	Frequency of travel modes

					vs. 1.2%), who were driven more often than boys (27 vs. 18.3%)		
Panter/ 2010/ [258]	2012	Children 9-10 Yr, parents	M, F	UK	40% walked, 9% driven by car	Parents, children. BMI measured at school, as part of SPEEDY study	Independent association between child and parent perceptions & ACS, stratified by distance
Wen/ 2008/ [259]	1603 stu+ their parents	Children 9-11, parents	M, F	Australia	41% car, 32% walked, 1% cycled, 22% used more than 1 mode.	Parents, children, as part of 24 prim school linked parent-child surveys	Being a car traveller or not, adjusted Odds Ratios
Zhou/ 2009/ [133]	14 sch, 489 classrooms	Children, parents	M, F	USA	10%walked, 2% cycled, 40% car, 38% school bus	Children, Parents- questionnaires sent through children SRTS	Prevalence of various modes of travel, parent perceptions of barriers to ACS
Ziviani/ 2004/ [260]	164	Children, parents	M, F	Austra-lia		Parent questionnaires, sent through children, adapted from Young Transnet and National Centre for Chronic Disease Prevention and Health Promotion	Walking, distance wise
McDonald, N. C (2008)/ [120]	6508	Children 5-13 Yrs		USA		Parent questionnaire NHTS	Travel time
Schlossberg (2006)/ [130]	292		M, F	USA	84% non-active commute, 15% ACS. 10% walked to school, 20% walked from school,	Parent mailed questionnaire	Prevalence of modes of travel to school

van Sluijs (2009)/ [261]	4688	Primary carers of 11 Yr olds	M, F	UK		Carer, objective physical activity measure through 'Actigraph' worn by children- Part of ALSPAC study	Distance, daily counts of physical activity: counts/min and minutes of MVPA
DiGuiseppi (1998)/ [12]	2476	Parents of 6-10 Yr olds	M, F	UK	69% walked, 26% bus, 5%. tube/train	Parents, using validated tool, based on published studies	That day's school journey mode, distance, Odds Ratios of relationships between mode & distance

Appendix (iii)

Details of excluded studies

S. no.	Study reference no.	Reason for exclusion
1	[262]	Only described distance to school in the context of being a barrier to ACS
2	[263]	Only described distance to school in the context of being a barrier to ACS
3	[264]	Only described distance to school in the context of being a barrier to ACS
4	[265]	Only described distance to school in the context of being a barrier to ACS
5	[266]	Only described distance to school in the context of being a barrier to ACS
6	[267]	Only described distance to school in the context of being a barrier to ACS
7	[268]	No access to full text
8	[269]	Only described distance to school in the context of being a barrier to ACS
9	[270]	No access to full text
10	[46]	Only described distance to school in the context of being a barrier to ACS
11	[271]	No access to full text
12	[272]	Only described distance to school in the context of being a barrier to ACS
13	[273]	No access to full text
14	[274]	Only described distance to school in the context of being a barrier to ACS
15	[275]	Only described distance to school in the context of being a barrier to ACS
16	[276]	Only described distance to school in the context of being a barrier to ACS
17	[277]	Only described distance to school in the context of being a barrier to ACS
18	[258]	Only described distance to school in the context of being a barrier to ACS
19	[141]	Systematic review
20	[278]	Only described distance to school in the context of being a barrier to ACS
21	[279]	No access to full text

22	[280]	No access to full text
23	[180]	Only described distance to school in the context of being a barrier to ACS
24	[281]	Only described distance to school in the context of being a barrier to ACS
25	[282]	Only described distance to school in the context of being a barrier to ACS
26	[283]	Only described distance to school in the context of being a barrier to ACS
27	[284]	Systematic review
28	[285]	No access to full text
29	[286]	No access to full text
30	[287]	Only described distance to school in the context of being a barrier to ACS
31	[288]	Only described distance to school in the context of being a barrier to ACS

Appendix (iv)

Summary of measure of relationship between distance to school and mode of travel

Reference	Participants	Factor of interest: Distance and mode of travel	Outcome measure	Relationship
Fed highway admin/2008	All members of selected household	< ¼ mi = 80% ACS ¼- ½ mi= 55 % ½-1 mi=10% 2mi=1%	Prevalence of ACS	Pvt vehicle is dominant mode, 50% when distance>1mi
Natl Cent SRTS-Baseline results-Parent survey, Stu tallies/2010	Children, parents	< ¼ mi=45% ¼- ½mi=23%, ½-mi=13% 1-2mi=2% >2mi=1%	Prevalence of ACS	Walking falls drastically as distance increases (41%, 18%, 9%, 2%), cycling falls slowly (4%, 5%, 4% and 2%)
Babey/2009	12-17 Yr olds	< ½ mi, OR of ACS=11.9 ½-1mi, OR=5 1-2mi, OR=1.8	Odds ratios	As distance increases, Odds of ACS decreases.
Bringolf-Isler/ 2008	Parents	At a distance of 1/2Km, prevalence of non-active commute ranged from 3-27%	Prevalence of non-active commute	At a distance =1/2km, prevalence of non-active commute ranged from 3-27%
Dalton/ 2011	Parents, adolescents	When distance < or equal to 1 mi= 80% ACS. Distance 1.01-2 mi= 47% 2.01-3 mi= 30%	Prevalence of ACS	As distance increases, prevalence of ACS decreases
D'Haese/ 2011	Parents of children	A distance of 3Km was significantly associated with cycling instead of walking OR=7.24	Odds ratios	As distance increased, odds of cycling increased

He/2011	5-18 Yrs, K-12	If distance=.5 mi, 50% ACS If distance>2 mi, 15% ACS, 70% car	Prevalence of ACS	As distance increased, ACS fell and car use increased
Landsberg/ 2007	8th grade	Active commuters spent 2.5 hours/week and 15 min/ trip of commuting and an average of 2.5 Km distance/day	Comparison of groups for ACS, physical activity, nutrition	Not clear
McDonald/ 2007	Children 5-14 Yrs	Elementary & middle school students living <.25 mi away from school are 14 times more likely to walk than students living 1-2 mi away	Probability of walking	As distance increases, probability of walking reduces
McDonald/2008	Children 5-18 Yrs	For distance <or equal .5mi, prevalence ratio of ACS=3.9 For distance= .5-1mi, prevalence ratio=1.30	Prevalence ratios of ACS	As distance increases, prevalence ratio of walking reduces
McDonald/ 2011	Children 5-15 Yrs	Distance <1 mi =86% ACS (1969) Distance 3 or more miles=1% ACS Distance <1 mi=49% ACS (2001)	Prevalence of ACS	As distance increases, ACS reduces, seen across the years
Merom/ 2006	Parent/ caregiver	Distance up to .75, OR=1, .76- 1.5, OR=.41, 1.51- 2.5, OR=.23, >2.5 mi, OR=.15	Odds Ratios	As distance increases, odds of ACS reduces
Moudon/ 2011	Children 5 -18 Yrs	Strong inverse association between distance & ACS for all age groups & elementary school children	Prevalence of ACS	As distance increases, ACS for all ages reduces
NCSRTS/How children get to school-travel patterns 1969-2009	Children 5-18 Yrs	In 1969, distance<1mi=89% ACS, 7% car In 2009, 35% ACS, 43% car Distance>2mi, car travel 15% & 44% in 1969 and 2009 respectively. Although 31% lived<1mi, only 35%	Prevalence of ACS	As distance increases, ACS reduces and car use increases. Trend is seen from 1969-2009

		ACS in 2009		
Nelson/ 2010	16 Yr olds living within 2.5 mi	Mode measurement as part of fixed distance of 2.5 mi	Prevalence of ACS	Not clear
Panter/ JECH/2010	Children 9-10 Yr, parents	Distance<1km=18% motorized travel, 11% cycle, 70% walked Distance >2km=87% motorized travel, 4% cycled, 8% walked	Prevalence of ACS	As distance increases, motorized travel increases, walking and cycling falls
Wen/ 2008	Children 9-11, parents	Distance<.5mi, OR car use=1 .5-1mi, OR= 4, 1.1- 1.5mi, OR =7.8, 1.6-2mi, OR =10.6, >2 mi, OR =15	Odds Ratios	As distance increases, odds of using car increases
Zhou/ 2009	Children, parents	No explicit categories. ACS expressed with distance <1/4 mi	52% students living <.25m walk	Not clear
Ziviani/ 2004	Children, parents	For distance of 1km, walking=62%, 1-3km, walking=27%, >3.1 km, walking=8%	Prevalence of walking	Steady fall in prevalence of walking as distance increases
McDonald, N. C (2008)	Children 5-13 Yrs	1min increase in travel time led to .2% decline in probability of walking, a 10% increase in walking travel time led to 7.5% decrease in walking.	Travel time was measured	Children are much less sensitive to auto travel times than they are to increases in walking time
Schlossberg (2006)		1- 1.5mi, OR=.27, 1.5- 2.5 mi, OR =.05, >2.5mi, OR=.07	Adjusted Odds ratios for walking	Odds of walking reduces with increasing distance
van Sluijs (2009)	Primary carers of 11 Yr olds	% ACS, by distance: <.5mi=84%, .5-1mi= 61%, 1-5mi=15%	Prevalence of ACS	Prevalence of ACS falls as distance increases
DiGuiseppi (1998)	Parents of 6-10 Yr olds	0.5-<1mi, OR=4.9, 1-2mi, OR=37.2, >2mi, OR=82.1	Odds ratios of being driven to school	With increasing distance, odds ratios of being driven to school also increase

Appendix (v)

Summary of methodological quality assessment

Author/ Year	Specific objective	Study design	Method of selection of participants described	Data sources/ measurement	Efforts to address source of bias	Sample size- Explained how study size arrived at	Limitations discussed	Generalisability
Fed highway admin/ 2008	Time trends of transportation, including to school	Ecological study, time trends 1969-2001	Yes	Secondary data (NHTS) List-assisted random digit dialling computer-assisted telephonic interview survey	Nationally representative sample	Yes	No	Yes
Natl Cent SRTS 2010]	To collect national data on elementary & middle school travel data & study change in travel patterns to school	Cross sectional	Yes	Parent questionnaire, student tally-children's show of hands in school	Large sample size	Yes	Show of hands/ no training to data collectors, self-report	Maybe generalisable to SRTS schools
Babey/ 2009	Association of socio-demographic, family, environmental	Cross sectional	Yes	Parents, adolescents 2005 California health interview	No	Yes	Break-up of modes of transport not mentioned, don't know if	May not be generalisable

	factors with ACS			survey			walking is more sensitive to distance than cycling, as shown by other studies	
Bringolf-Isler/ 2008	Prevalence of ACS across communities, personal& environmental correlates of ACS	Cross sectional	Yes	Parents, of children visiting SCARPOL centres	No	Yes	Cross sectional design, parental report of family, personal factors, straight line measure of distance may not be fully accurate	May not be generalisable
Dalton/ 2011	Built environmental correlates of ACS among rural adolescents	Cross sectional	Yes	Parents, children computer assisted telephonic survey tool, observation	No	Yes	Parents perceptions not measured	May not be generalisable
D'Haese/ 2011	Environmental correlates of ACS	Cross sectional	Yes	Parent proxy report. Parent version of Neighbourhood Environment Walkability Survey (NEWS-Y)	Yes. Random selection of schools and classes	Yes	Over/under estimation with 'routeplanner'/ mixed transport not studied	May not be generalisable
He/2011	Impact of school quality,	Multinomial logit models	Yes	Secondary data (Regional	No	No	No	May not be generalisable

	residential environment on mode of choice			Transportation Survey, Personal travel diary, Academic performance index)				
Landsberg/ 2007	Association between adiposity, lifestyle& ACS	Cross sectional	Yes	Children-Supervised questionnaire at school. KOPS study tool	No	No	Cross sectional, modest sample size	May not be generalisable
McDonald/ 2007	Document estimates of school travel modes in 09 & compare with '69. '95 & '01	Data used was from population based study	Yes	Secondary data NHTS 2009 special school travel records, travel diary, information on trip distance, duration, adult accompaniment	Nationally representative sample	Yes	No	Yes
McDonald/ 2008	Document rate of walking/cycling to school among low income & minority youth	Data used was from population based study/ models created	Yes	Secondary data NHTS	Nationally representative sample	Yes	Self-selection bias- endogeneity of res location & preferred school commute mode/ cross sect study/no info on sidewalks, land mixed use	Yes

							nature	
McDonald/ 2011	Document proportion of students' ACS, influence of trip, child, household characteristics	Data used was from population based study	Yes	Secondary data National personal transportation survey	Nationally representative sample	Yes	Difference in survey method: small sample size in early years, in-person-interview to telephonic interview, shift from clustered sampling to random digit dialing	Yes
Merom/ 2006	Correlates of ACS among primary children	Cross sectional	Yes	Parent/ caregiver proxy report computer assisted telephonic interview	Random selection of households	Yes	Only parent report, can under-estimate walking after bus	May not be generalisable
Moudon/ 2011	Influence of home, school, neighbourhood, environment, on mode	Cross sectional	Yes	Secondary data 2006 PSRC and HATS- Household activity& travel survey	No	Yes	Self-reported data, sample of high school children who walked/cycled was less	May not be generalisable
NCSRTS/	Monitor changes in US student school travel from '69 to 2009	Cross sectional	Yes	Parents, children. Parent questionnaire, student tally- show of hands in school	No	No	Show of hands by children	May not be generalisable

Nelson/ 2010	Perception of physical environment as correlates of ACS	Cross sectional	Yes	Children, self-report	No	No	Cross sectional nature of study	May not be generalisable
Panter/ 2010	Quantify association between personal, social, environmental characters according to distance	Cross sectional	Yes	Parents, children. BMI measured at school, as part of SPEEDY study	No	No	Cross sectional nature of study, no causality can be ascribed	
Wen/ 2008	Examine mode of travel to school, attitudes, distance	Cross sectional	Yes	Parents, children, as part of 24 primary school linked parent-child surveys	No	No	Cross sectional nature of study, no causality. Parent attitudes may not have represented full range of attitudes, student attitudes, beliefs about ACS not measured	May not be generalisable
Zhou/ 2009	How children arrive & depart from school, factors associated with parent decisions	Cross sectional	Yes	Children, Parents- questionnaires sent through children SRTS	No	No	No	May not be generalisable

Ziviani/ 2004	Whether children walk to school and why	Cross sectional	Yes	Parent questionnaires, sent through children, adapted from Young Transnet and National Centre for Chronic Disease Prevention and Health Promotion	No	No	No	May not be generalisable
McDonald, N. C/ 2008	Understand mode choice for trip to school	Cross sectional, multinomial logit model	Yes	Parent questionnaire NHTS	Nationally representative sample	Yes	No	Yes
Schlossberg/ 2006	Relationship between urban form, distance & ACS in middle school students	Cross sectional	Yes	Parent mailed questionnaire	No	No	Cross sectional nature of study, low response rate	May not be generalisable
van Sluijs /2009	Association between ACS and physical activity	Cross sectional, population based sample	Yes	Carer, objective physical activity measure through 'Actigraph' worn by children Part of ALSPAC study	No	No	Use of unvalidated measure of parent reported distance to school in broad categories, non-validated measure of travel mode, low proportion	May not be generalisable

							of ethnic minority children & cross sectional nature of analyses	
DiGuiseppi /1998	Study travel patterns of urban primary school children	Cross sectional	Yes	Parents, using validated tool, based on pub studies	Yes Random sampling of schools	Yes	No	Yes

Appendix (vi)

Some examples of Stata commands used for survey analysis

1. Mean distance from home to school

mean log_dist

svy: mean log_dist

estat sd

svy: mean distance

estat sd

svy, subpop(if type=="01"): mean distance

svy, subpop(if type=="02"): mean distance

svy, subpop(if type=="03"): mean distance

2. Estimating proportion of children walking, under each distance category 3, by type of school

svy, subpop(if type=="01"): tab walk1usual dist_gp3, col percent

svy, subpop(if type=="02"): tab walk1usual dist_gp3, col percent

svy, subpop(if type=="03"): tab walk1usual dist_gp3, col percent

svy: tab walk1usual dist_gp3, col percent

3. Estimating proportion of children walking, by grade

svy, subpop(if grade==6): tab at1usual dist_gp3, col percent

svy, subpop(if grade==7): tab at1usual dist_gp3, col percent

svy, subpop(if grade==8): tab at1usual dist_gp3, col percent

svy, subpop(if grade==9 | grade==10): tab at1usual dist_gp3, col percent

4. Multivariate logistic regression model for factors associated with RTI

svy: logistic RTI_temp i.dist_gp4 i.grade i.gender i.type i.mandalId i.mod1usual

test 2.dist_gp4 3.dist_gp4 4.dist_gp4 5.dist_gp4 6.dist_gp4 7.dist_gp4 8.dist_gp4 9.dist_gp4 10.dist_gp4 11.dist_gp4

test 7.grade 8.grade 9.grade

test 2.gender

test 2.type 3.type

test 2.mandalId 3.mandalId 4.mandalId 6.mandalId 7.mandalId 8.mandalId 9.mandalId 10.mandalId 11.mandalId 12.mandalId 13.mandalId 14.mandalId 15.mandalId 16.mandalId 17.mandalId

test 2.mod1usual 3.mod1usual 4.mod1usual 5.mod1usual 6.mod1usual 7.mod1usual 8.mod1usual 9.mod1usual 10.mod1usual

Appendix (vii) Questionnaire in English

Survey on the Public Health Impacts of Children's Travel to School

Please answer the following questions as best as you can- there are no right or wrong answers. The answers you give will be kept private. Thank you for your help.

1.Name: [ ]

2. Age: [ ] years

3. Gender: 1.Boy [ ] 2. Girl [ ]

4. Home address & landmark:

Travel to School

5. How did you travel to school today?

No.	Mode of travel	From	To	Time taken (minutes)
1	Walk			
2	Cycle			
3	School bus			
4	Car			
5	2-wheeler			
6	RTC bus			
7	Auto-rickshaw			
8	Cycle-rickshaw			

9	Train				
10	Other				

6. With whom did you come to school today?

1. Parent ☐ 2. Grand-parent ☐ 3. Other children ☐ 4. Other adult ☐ 5. Alone ☐

7. How do you travel to school during a usual week?

1. Walk ☐ 2. Cycle ☐ 3. School bus ☐ 4. Car ☐ 5. 2-wheeler ☐

6. RTC bus ☐ 7. Auto ☐ 8. Rickshaw ☐ 9. Train ☐ 10. Other ☐

Travel to Home

8. How will you go from school to home today?

1. Walk ☐ 2. Cycle ☐ 3. School bus ☐ 4. Car ☐ 5. 2-wheeler ☐

6. RTC bus ☐ 7. Auto ☐ 8. Rickshaw ☐ 9. Train ☐ 10. Other ☐

9. With whom will you go from school to home today?

1. Parent ☐ 2. Grand-parent ☐ 3. Other children ☐ 4. Other adult ☐ 5. Alone ☐

10. How do you travel home during a usual week?

1. Walk ☐ 2. Cycle ☐ 3. School bus ☐ 4. Car ☐ 5. 2-wheeler ☐

6. RTC bus ☐ 7. Auto ☐ 8. Rickshaw ☐ 9. Train ☐ 10. Other ☐

11. How would you LIKE to or WISH to travel to and from school?

1. Walk ☐ 2. Cycle ☐ 3. School bus ☐ 4. Car ☐ 5. 2-wheeler ☐

6. RTC bus ☐ 7. Auto ☐ 8. Rickshaw ☐ 9. Train ☐ 10. Other ☐

12. How do you travel to school during the RAINS?

1. Walk	☐	2. Cycle	☐	3. School bus	☐	4. Car	☐	5. 2-wheeler	☐
6. RTC bus	☐	7. Auto	☐	8. Rickshaw	☐	9. Train	☐	10. Other	☐

13. How do you travel to school during HOT WEATHER?

1. Walk	☐	2. Cycle	☐	3. School bus	☐	4. Car	☐	5. 2-wheeler	☐
6. RTC bus	☐	7. Auto	☐	8. Rickshaw	☐	9. Train	☐	10. Other	☐

14. Are you allowed by your parents to cross <u>main roads</u> alone? (Main roads are important, busy roads with lots of traffic)

1. Always	☐	2.Sometimes	☐	3. Rarely	☐	4. Never	☐

15. Are you allowed by your parents to cycle on main roads alone?

1. Always	☐	2. Sometimes	☐	3. Rarely	☐	4. Never	☐	5. I don’t know cycling	☐

16. How safe do you feel when you travel to and from school? (Safe means not worried, not feeling uneasy about anything in particular)

1. Very safe	☐	2. Fairly safe	☐	3. Not very safe	☐	4. Not at all safe	☐

17. What are you worried about, during your journey to school?

1. Traffic	☐	2. Strangers	☐	3. Being late	☐
4. Getting lost	☐	5. Being teased	☐	6. Nothing	☐

18. During the past week, after school, on how many <u>days</u> did you exercise?

(Example: running, fast walking, playing games, cycling, dancing, sports).
<u>Do not include your PT or games period</u>.

None	☐	1 day	☐	2 days	☐	3 days	☐	4 days	☐
5 days	☐	6 days	☐	7 days	☐				

19. During the past week, after school, how many <u>hours</u> did you exercise?
<u>Do not include your PT or games period</u>.

None	☐	half an hour a week	☐	1 hour a week	☐
2- 3 hours a week	☐	4-6 hours a week	☐	7 hours a week	☐

20. During the past week, how many PT or games periods did you attend?

None	☐	1 period	☐	2 periods	☐	3 periods	☐	4 periods	☐
5 periods	☐	6 periods	☐	7 periods	☐				

21. During the past 12 months, were you injured in a road accident?

*(An injury is when it makes you miss at least one full day of usual activities **OR** requires treatment by a doctor or nurse).*

1. Yes ☐ 2. No ☐

Appendix (viii) Questionnaire in Telugu

పాఠశాలకు వెళ్లడానికి బడి పిల్లలు ఉపయోగించే ప్రయాణ సాధనం వలన కలిగే ప్రజా ఆరోగ్య ప్రభావాల పై సర్వే

దయచేసి ఈ క్రింది ప్రశ్నలకు మీకు తెలిసిన జవాబు వ్రాయండి ఇందులో తప్పు ఒప్పు సమాధానం అనేది ఏమి లేదు మీరు చెప్పిన సమాదానాలను ఎవరితోను పంచుకోము

1.పేరు: ______

2. వయసు: ______ సంవత్సరాలు

3. లింగం: 1.బాలుడు ☐ 2. బాలిక ☐

4. ఇంటి చిరునామా/ గుర్తు : ______

బడికి వెళ్ళడం

5. ఈరోజు మీరు బడికి ఏ విధంగా వచ్చారు?

No.	ప్రయాణ సాధనం	నుండి	వరకు	ఎంత సమయం (నిమిషాలలో)
1	నడచి			
2	సైకిల్ పై			
3	స్కూల్ బస్ లో			
4	కార్ లో			

5	రెండు చక్రాల వాహనం పై			
6	ఆర్టిసి బస్ లో			
7	ఆటో రిక్షా లో			
8	సైకిల్ రిక్షా లో			
9	రైల్ లో			
10	ఇతరములు			

6. ఈరోజు ఎవరితో స్కూల్ కి వచ్చా వు?

1. తల్లి/తండ్రి ☐ 2. తాత/మామ్మ ☐ 3. ఇతర పిల్లలతో ☐ 4. ఇతర పెద్దలతో ☐ 5. ఒంటరిగా ☐

7. సాధారణంగా వారం లో స్కూల్ కి ఏ విధంగా వస్తా వు?

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5. రెండు చక్రాల బండి ☐

6. ఆర్టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. ఇతరములు ☐

ఇంటికి ప్రయాణం

8. ఈరోజు ఇంటికి నీవు ఎలావెళ్లావు?

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5. రెండు చక్రాల బండి ☐

6. ఆర్టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. ఇతరములు ☐

9. ఈరోజు స్కూల్ నుండి ఇంటికి ఎవరితో వెళ్లావు?

1. తల్లి/తండ్రి ☐ 2. తాత/ మామ్మ ☐ 3. ఇతర పిల్లలతో ☐ 4. ఇతర పెద్దలతో ☐ 5. ఒంటరిగా ☐

10. సాధారణంగా వారంలో ఇంటికి ఎలా వెళ్తావు**?**

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5. రెండు క్రాల వాహనం ☐

6. ఆర్‌టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. తరములు ☐

11. స్కూల్ కి రావడానికి మరియు ఇంటికివెళ్లాడానికి ఏవిదంగా ప్రయాణం చేయడానికి ఇష్టపడతావు లేదా ఏవిదంగా ప్రయాణం చేయాలనుకుంటావు?

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5. రెండు చక్రాల వాహనం ☐

6. ఆర్‌టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. ఇతరములు ☐

12. వర్షం (వాన) వచ్చినప్పుడునీవు స్కూల్ కి ఏవిధంగా వెళ్తావు?

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5.రెండు చక్రాల వాహనం ☐

6. ఆర్‌టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. ఇతరములు ☐

13. వాతావరణం వేడిగా ఉన్నప్పుడు స్కూల్ కి ఏవిధంగా వెళ్తావు?

1. నడచి ☐ 2. సైకిల్ ☐ 3. స్కూల్ బస్ ☐ 4. కారు ☐ 5. రెండు చక్రాల వాహనం ☐

6. ఆర్టిసి బస్ ☐ 7. ఆటో ☐ 8. రిక్షా ☐ 9. రైల్ లో ☐ 10. ఇతరములు ☐

14. మీరు (నీవు) ఒంటరిగా మెయిన్ రోడ్ ని (ప్రధాన రహదారిని) దాటడానికి మీ తల్లితండ్రులు మిమ్మల్ని అనుమతిస్తారా? (ప్రధాన రహదారులు ముఖ్యంగా, ఎక్కువ ట్రాఫిక్ తో రద్దీగా ఉండే రహదారులు)

1. ఎప్పుడూ ☐ 2. కొన్ని సార్లు ☐ 3. అరుదుగా ☐ 4. ఎప్పుడూకాదు ☐

15. నీవు ప్రధాన రహదారిపైన సైకిల్ తొక్కడానికి మీ తల్లి తండ్రులు అనుమతిస్తారా?

1. ఎప్పుడూ ☐ 2. కొన్ని సార్లు ☐ 3. అరుదుగా ☐ 4. ఎప్పుడూ కాధు ☐ 5. నాకు సైకిల్ తొక్కడం రాధు ☐

16. మీరు పాఠశాలకు వెళ్ళిరావడం ఎంతవరకు సురక్షితం అనుకుంటున్నావు? (సేఫ్ /(సురక్షితం) గా అంటే దేని గురించి భయపడకుండా/కలతపడకుండా)

1. చాలా **సురక్షితం** ☐ 2. **సురక్షితం** గానే ☐ 3. అంత **సురక్షితం** కాదు ☐ 4. అసలు **సురక్షితం** కాదు ☐

17. నీవు స్కూల్ కి వెళ్తున్నప్పుడుదేనిగురించి భయపడుతుంటావు?

1. ట్రాఫిక్ ☐ 2. అపరిచితులు ☐ 3. ఆలస్యం అవుతుంధని ☐

4. తప్పిపోతామెమో అని ☐ 5. ఆట పట్టిస్తారని ☐ 6. ఏమీలేదు ☐

18. గడచిన వారంలో స్కూల్ అయిన తర్వాతఎన్ని రోజులు వ్యాయామము (ఎక్సర సైజ్) చేశావు**?** *(ఉధాహరణ: పరుగెత్తడం, స్పీడ్ గా నడవడం, ఆటలాడటం, సైకిల్ తొక్కడం, డాన్స్ చేయడం, క్రీడలు).* మీ పి టి లేదా ఆటల పిరియడ్ ని కలపవద్దు.

ఏమీలేధు ☐ 1 ఒక్క రోజు ☐ 2 రోజులు ☐ 3 రోజులు ☐ 4 రోజులు ☐

5 రోజులు ☐ 6 రోజులు ☐ 7 రోజులు ☐

19. గడచిన వారంలో స్కూల్ అయినతర్వాత ఎన్ని గంటలు ఎక్సర్ సైజ్ చేసావు/ హాజరయ్యారు**?** ఆటల లేధా పి టి పిరియడ్స్ ని కలపవద్దు.

ఏమీలేధు ☐ వారానికి అర గంట ☐ వారానికి ఒక గంట ☐

వారానికి 2- 3 గంటలు ☐ వారానికి 4-6 గంటలు ☐ వారానికి 7 గంటలు ☐

20. గడచిన వారంలో ఎన్ని ఆటల లే**దా** పి టి పిరియడ్స్ కి హాజరయ్యారు**?**

ఏమీలేధు ☐ 1 పిరియడ్ ☐ 2 పిరియడ్స ☐ 3 పిరియడ్స ☐ 4 పిరియడ్స ☐

5 పిరియడ్స ☐ 6 పిరియడ్స ☐ 7 పిరియడ్స ☐

21 గడచిన 12 నెలల్లో, రోడ్ ఏక్సిడెంట్ లో గాయపడటం జరిగిందా? *(ఏదైనా వలన నీవు ఒకరోజు సాదారణ కార్యక్రమానికి దూరంగా ఉండేటట్లు చేసింధా లేదా డాక్టర్ చే గాని నర్స్ చే గాని చికిత్స అవసరం అయింధా)*

1. అవును ☐ 2. కాధు ☐

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Journal article manuscripts

Tetali S, Edwards P, Murthy G, Roberts I. Development and validation of a self-administered questionnaire to estimate the distance and mode of children's travel to school in urban India. *BMC Medical Research Methodology* October 2015, **15**:92.

Tetali S, Edwards P, Murthy G, Roberts I. *Road traffic injuries to children during the school commute in Hyderabad, India: cross-sectional survey.* Inj Prev. 2015 Dec 23. pii: injuryprev-2015-041854. doi: 10.1136/injuryprev-2015-041854.

Tetali S, Edwards P, Murthy G, Roberts I. *How do children travel to school in urban India? A cross-sectional study of 5,842 children in Hyderabad.* BMC Public Health (2016, 16:1099)

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RESEARCH PAPER COVER SHEET

PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

Student	Shailaja Tetali
Principal Supervisor	Phil Edwards
Thesis Title	Distance, transport mode, and road safety on school journeys in urban India

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	Injury Prevention		
When was the work published?	2015		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	**Yes**	Was the work subject to academic peer review?	**Yes**

**If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.*

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
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Road traffic injuries to children during the school commute in Hyderabad, India: cross-sectional survey

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ABSTRACT

Background India is motorising rapidly. With increasing motorisation, road traffic injuries are predicted to increase. A third of a billion children travel to school every day in India, but little is known about children's safety during the school commute. We investigated road traffic injury to children during school journeys.

Methods We conducted a cross-sectional survey in Hyderabad using a two-stage stratified cluster sampling design. We used school travel questionnaires to record any road injury in the past 12 months that resulted in at least 1 day of school missed or required treatment by a doctor or nurse. We estimated the prevalence of road injury by usual mode of travel and distance to school.

Results The total sample was 5842 children, of whom 5789 (99.1%) children answered the question on road injury. The overall prevalence of self-reported road injury in the last 12 months during school journeys was 17% (95% CI 12.9% to 21.7%). A higher proportion of boys (25%) reported a road injury than girls (11%). There was a strong association between road injury, travel mode and distance to school. Children who cycled to school were more likely to be injured compared with children who walked (OR 1.5; 95% CI 1.2 to 2.0). Travel by school bus was safer than walking (OR 0.5; 95% CI 0.3 to 0.9).

Conclusions A sixth of the children reported a road traffic injury in the past 12 months during school journeys in Hyderabad. Injury prevention interventions should focus on making walking and cycling safer for children.

INTRODUCTION

Background

Road traffic injury is a growing public health problem among adults and children in India. In 2013, the rate of road traffic crashes, injuries and deaths per 100 000 population in India was 39, 40 and 11, respectively.[1] The number of registered motor vehicles in India is increasing by 12% each year[2] and is projected to increase from 112 million in 2010 to 500–600 million by 2014.[3] The increasing motorisation is likely to have huge implications for air quality, road traffic injuries and physical activity. Road traffic deaths are predicted to more than double by 2020.[4]

Hyderabad is one of the fastest growing urban areas in India.[5] Nearly 1 in 14 people report a non-fatal road injury annually, requiring a recovery period of over 7 days. Disability due to road injury in Hyderabad is estimated to be 35 per 100 000 people.[6] The annual rate of overall road injury among children in 2009 was 11% for boys and 6% for girls,[7] yet little is known about children's injury during the school commute in Hyderabad.

A third of a billion children travel to school every day in India. Children's travel to school is a routine and necessary activity. But we do not know about the safety of children who walk, cycle or use motorised modes. It is important to identify risk factors because the school trip is a part of children's daily activity and is amenable to interventions.[8] The objective of this study was to investigate the safety of school journeys in Hyderabad, by mode of travel and distance to school.

METHODS

Study design

We conducted a cross-sectional survey using a two-stage stratified cluster sampling design. The strata were geographical (mandals, equivalent to boroughs) and administrative (type of school management).

Study setting

The study was conducted in all 16 mandals of Hyderabad district and 1 mandal of the neighbouring Rangareddy district in 2014. The three main types of school management were included: government, semiprivate and private. Government schools are run by the Central or State Government, semiprivate schools receive a grant from the government and private schools are fully paid for by the parents' fees.[9]

Participants

We surveyed children aged 11–14 years, as this is typically an age when children may be expected to travel independently.[10] In school terminology, it refers to children in grades 6–9. We first randomly selected a school from a list of schools with grades 6–9 in each stratum. Next, the school principal randomly selected sections (ie, classrooms that normally have 30–40 children) in grades 6–9. All children who were present on the day of the survey were included in the study.

Data collection

We used a validated, self-completion questionnaire with 21 questions for information on various aspects of travel to school. The questionnaire underwent thorough piloting and revision, after two focus groups, seven cognitive interviews and two reliability studies.[11] This was done to ensure the suitability of the questions for the target age (11–14 years) and to assess the acceptability of the wording, as well as the sequence of the questions.

Detailed instructions were given to children on every question. The question on road traffic injury

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was 'During the past 12 months, were you injured in a road incident Road 'incident' was defined as 'any non-fatal injury sustained in the previous 12 months, on the road while going to, or coming from school, due to a collision with another vehicle, or due to a fall or skid from a bicycle or two-wheeler, while standing or walking on the road'. The number of injuries sustained was not required. Children were asked to only report injuries which led to the child missing at least one full day of their usual activities or which required treatment by a doctor or a nurse. This was included to focus only on the more severe injuries.

We used English questionnaires in private schools and a Telugu version (which is the local language of instruction) in government and semiprivate schools. The questionnaire was administered using pencil-and-paper methods during a regular class period and could be completed in 15–20 min. Research assistants with survey and interview experience conducted the survey in the schools, in the presence of the class teachers. They read out each question, allowing plenty of time for marking the responses. The study investigator made monitoring visits to schools to ensure that all questions were read out and explained to the children.

Variables

Outcome: any road traffic injury on the way to or from school in the past 12 months that resulted in at least one day of school missed or required treatment by a doctor or nurse.

Exposures: usual mode of travel; Distance to school. Mode of travel was categorised as *walking, cycling, autorickshaw, cycle rickshaw* (commercial three-wheeled passenger vehicles), *school bus* (private), van (private), *RTC bus* (public road transport corporation bus), *motorised two-wheeler* (motorbike), *car* or *train*. We combined *school bus* and *van* because both are private modes providing a door-to-door service. We used Google Earth to estimate distance from home to school, using the school location and the nearest landmark to home reported by children.[11] We created a categorical variable for distance (<1, 1–2, 2–3, 3–5 and >5 km) to investigate any non-linear relationship with injury.

Confounding variables: age, sex, parental permissions for independent travel and type of school. We considered the type of school to be a marker of socioeconomic status and parental influence: generally, government schools in Hyderabad cater to lower income families, semiprivate schools cater to middle income families and private schools cater to higher income families.

Study size

We estimated that a sample of 6000 children would be sufficient to detect important differences in the prevalence of road injury by travel mode and distance to school, while allowing for clustering of injury within mandals.

Statistical methods

We estimated the prevalence of self-reported road traffic injury in the last 12 months during school journeys by mode of travel and distance to school. We used logistic regression to estimate the RR (ORs with 95% CIs) of road injury for each mode of travel adjusting for potential confounding variables. We used the 'survey' commands in Stata to account for stratification, clustering and unequal probability of selection, and the 'test' command to test the associations in the logistic regression models. We retained variables that remained statistically significant at the 5% level in the 'best fit' model. We conducted a sensitivity analysis by fitting the model with distance as a categorical variable. Children who answered '*other*' to the question on their usual mode of travel to school were excluded from the analysis. We analysed data using STATA/SE V.12.0 (Stata, Texas, USA).

The Hyderabad District Education Office permitted the study to be conducted. The ethics committee approved consent being taken from the school principals. The parents/guardians of the children were made aware of the study. We obtained ethics committee approval from the London School of Hygiene and Tropical Medicine, London, UK, and the Indian Institute of Public Health, Hyderabad, India.

RESULTS

Participants

Of the 48 eligible schools that were selected, 45 agreed to participate. Three schools refused due to time constraints. Approximately 3% of eligible children in the participating schools were absent on the day of the survey. The total sample was 5842 children, of whom 5789 (99.1%) children answered the question on road injury.

Descriptive data

The average age of children in the sample was 13 years (SD 1.3 years), with a higher proportion of girls (54%). Of the children who completed the questionnaires, 40 (0.68%) did not provide information on their mode of travel to school. Almost all children (98.7%) provided a valid home address or nearest landmark for the estimation of distance to school.

Main results

The overall prevalence of self-reported road traffic injury in the last 12 months during school journeys in Hyderabad was 17% (95% CI 12.9% to 21.7%). A higher proportion of boys (25%; 95% CI 19.5% to 30.5%) reported road injury than girls (11%; 95% CI 6.8% to 16.1%).

The prevalence of road injury varied with mode and distance to school (table 1). Cyclists reported the highest prevalence of road injury (33%), followed by children who travel by motorised two-wheelers (20%) and children who walk to school (17%). The lowest prevalence was reported by children who travel by school bus (8%). The prevalence of road injury was highest (25%) among children who travel 2–3 km to school and lowest (9%) among children who travel over 5 km. The prevalence of road injury to children who walked or cycled increased with distance.

Table 2 shows the RRs and 95% CIs associated with travel mode. Children who travelled by bicycle were more likely to report an injury compared with children who walked (OR 1.5; 95% CI 1.2 to 2.0). Children who used the school bus were less likely to report an injury than those who walked (OR 0.5; 95% CI 0.3 to 0.9). This was after controlling for gender, school type, grade and mandal (table 2).

Girls were one third as likely to report an injury as boys (OR 0.3; 95% CI 0.2 to 0.4). We found no evidence for associations between road injury and grade, school type, independent travel, perception of safety or physical activity levels (see online supplementary appendix). We found that the results of the sensitivity analyses did not differ when categories of distance were used.

DISCUSSION

Main findings

This study estimated the prevalence of road traffic injuries during journeys to school in Hyderabad, by mode of travel and

Table 1 The prevalence of self-reported road traffic injury by mode and distance to school in Hyderabad

Mode	Prevalence (%) Children in sample (n)	Distance to school <1 km	1–2 km	2–3 km	3–5 km	>5 km	Total
Walk	%	13	19	30	26	42	17
	n	1859	1330	224	24	8	3445
Bicycle	%	33	30	33	49	0	33
	n	103	108	80	32	1	324
School bus	%	39	4	4	12	4	8
	n	13	31	64	92	207	407
Car	%	54	16	25	4	10	16
	n	16	24	22	40	58	160
Two-wheeler	%	14	17	34	21	4	20
	n	111	146	117	55	25	454
RTC bus	%	4	6	10	22	19	15
	n	37	73	132	140	139	521
Autorickshaw	%	17	7	26	9	11	13
	n	33	93	73	67	104	370
Other modes*	%	62	4	0	16	0	16
	n	9	11	4	12	9	45
All modes	%	16	18	25	16	9	17
	n	2181	1816	716	462	551	5726

*Cycle rickshaw, train and other.
RTC, road transport corporation.

distance to school. The principal findings suggest that cycling to school is more hazardous than walking, while travelling by the school bus is safest.

Limitations

Our estimates of the prevalence of road injury are based on self-reports, which are susceptible to recall bias. Children may have reported injuries that occurred outside of the 12-month period, or did not occur on the school journey or they may not have reported some injuries at all. The relatively long recall period of 12 months may have led to under-reporting of injury, especially if they were minor injuries.[12] Recall bias might have also occurred if children using some modes (eg, bicycle) were more likely to remember an injury than children using other modes (eg, school bus). This may have led to differential misclassification of the outcome by mode of travel. But there is no reason to suggest that children's ability to recall might differ by distance to school. The mode of travel in which the child was injured was not asked directly, and it was assumed based on their usual mode of travel. It is possible that the injury occurred because a different (and not usual) mode of travel or route was taken, which is a major limitation of our study.

Table 2 Association between road traffic injury and travel mode (walking as reference mode)

Mode	Children in sample	OR (95% CI) Model fitted with distance as linear term	Model fitted with categories of distance
Walk (reference category)	3494	1.0	1.0
Bicycle	329	1.5 (1.2 to 2.0)	1.4 (1.1 to 1.9)
School bus	410	0.5 (0.3 to 0.9)	0.5 (0.2 to 0.9)
Car	161	1.3 (0.7 to 2.4)	1.2 (0.7 to 2.3)
Two-wheeler	458	1.3 (0.8 to 1.9)	1.2 (0.9 to 1.7)
RTC bus	531	0.8 (0.6 to 1.2)	0.8 (0.6 to 1.1)
Autorickshaw	374	1.0 (0.5 to 1.8)	0.9 (0.5 to 1.7)
Total	5757		
Test for homogeneity		p<0.001	p<0.001

Logistic regression model including terms for gender, school type, grade and mandal.
RTC, road transport corporation.

Our definition of injury was one which resulted in at least a day of school missed or required treatment by a doctor or nurse. Some parents may have taken their child with a minor injury to see a doctor or nurse, while other parents may not. Also, our study did not record the number of injuries, severity of injury or location of injury, which limits interpretation. The severity of injury is unlikely to be the same for different travel modes. Specifically, among bicycle injuries, which were most common, it is likely that the majority did not involve collision with a motor vehicle (which usually causes greater severity of injury and disability). Similarly, the striking vehicle for pedestrian injury in the mixed traffic environment in Hyderabad may have been a bicycle, a motorised two-wheeler or an autorickshaw.[7] The mechanism of injury, however, was not recorded in any detail.

Children who were absent on the day of the survey were not included in the study. It is possible that they are different from those who were present or that they were absent because of a road injury. However, there were very few absent (<3%). This is similar to other estimates of absenteeism (1%) from South Indian schools.[13] Children are absent usually due to legitimate reasons, including sickness.[14] Forty children did not provide their mode of travel, 76 children did not give a valid address and 53 children did not complete the question on road injury. These children were excluded from analysis and this may have biased our results.

Due to the cross-sectional nature of the study, we were not able to investigate causal relationships. For example, it is possible that children changed their travel mode following a road injury. Children who were injured when cycling may have changed to a safer mode of travel, such as the RTC bus. This is perhaps less likely in India, where children who walk or cycle do so because they do not have a choice.[15]

The results may have been confounded by other factors. For example, we do not know if recall of road injuries is associated with age, sex, mode or other factors. We were also unable to account for the extent to which characteristics of the road environment, such as vehicle speeds and volumes differ between the mandals where children commute to school. The survey was conducted in the dry season when injuries may differ compared with other seasons. However, we asked about all road injuries in the last 12 months, which should cover all seasons.

Despite these limitations, there was a good response rate (99%). The sample size of 5842 children was higher than in previous studies (1820 and 2809) on injuries in Hyderabad.[7,16] We used a questionnaire that had been shown to be valid and reliable. It showed 'substantial agreement' using the kappa statistic for the question on road injury during reliability testing.[11] While test–re-test is a good measure of reliability, we were unable to validate self-reports against medical reports of the actual injuries due to financial and time constraints. We estimated distance to school based on children's home address and nearest landmark. Because our method was accurate to within 65 m (−30 to 159 m) of the true distance,[11] we are reasonably confident in the results of the relationship between distance and prevalence of injury. To our knowledge, this study was the first to examine road traffic injuries among children during school journeys in Hyderabad, which is a vital first step for informing policy.

Comparisons with other studies

Road injury estimates are inconsistent across studies, and this may reflect differences in the operational definition of road injury or origin-destination of trips (any travel and not necessarily school journeys). We estimated an overall prevalence of road injury during school journeys to be 17%. There were no studies in Hyderabad that particularly reported road injury by mode and distance during school journeys. One study reported the reason for being on the road as '*going/coming from school/work*' for 19% of all road injuries.[7]

Cycling was the most risky travel mode, followed by two-wheeler and walking. Our estimate of road injury as a cyclist (33%) and pedestrian (17%) was higher than that reported by a Palestinian study (11% for cycling and 8% for walking).[17] This is perhaps because it included the activity context (eg, sport) whereas our definition of road injury was specific to school travel.[18] Our estimates were lower than those reported by another Indian study on road use by children (46% for cycling and 42% for walking).[7] This could be because the estimates were from a household survey of all road injury among children aged 5–14 years, irrespective of the destination. Another study from Andhra Pradesh used a 3-year recall period for severe non-fatal injuries and found that of all injured children, 52% were cyclists and 20% were pedestrians.[16]

The overall prevalence of road injury among boys was higher than among girls, which is consistent with the results from other Indian studies.[7] Boys have a higher exposure to bicycle riding compared with girls, and many of the differences in hospital emergency attendance are thought to stem from different exposure rates.[19] We could not estimate the risk of bicycle injury for girls because the number of girls (n=5) who cycled was quite small, compared with boys (n=319).

Travel by school bus was safer than walking, but the school bus is a private form of transport, paid for by wealthy parents to collect children at the door step. Not all parents can afford to send their children by school bus. The RTC bus (public transport) has approximately 15 million passengers per day and is used by 72% of the population as the primary mode of transport in Hyderabad. Our results show that it is as safe as the car. Private motorised vehicles were associated with a higher prevalence of road injury (20% for two-wheeler and 16% for car), than the public transport modes, and this has been found elsewhere.[20]

Interpretation

We acknowledge the limitations of the cross-sectional design and are cautious about interpreting our estimates of the prevalence of road injury by mode, for the reasons outlined above. The results, however, highlight the safety issues associated with children's journeys to school in urban India and that mode choice may alter injury risk. Robust study designs that can answer similar questions more reliably need to be used.[21] There is a need for future research to evaluate detailed exposure data on the number, severity and location of road injury near school zones. Measures such as the introduction of affordable school buses will be useful to explore. Children's journeys to school are a daily activity that ought to be pleasant and safe. This can only be achieved by improving the overall road safety in Hyderabad, with a strong emphasis on the construction of pavements and cycle lanes.

Generalisability

This study presents children's road traffic injury data in all the mandals of Hyderabad, thereby giving a city-wide estimate and satisfying external validity. We estimate that the 5842 children in the sample represent a population of 322 258 children and believe that our results might be generalisable to other urban school populations in India with comparable road infrastructure and travel behaviour.

CONCLUSIONS

A sixth of the children reported a road traffic injury in the past 12 months during school journeys in Hyderabad. Considering that a third of a billion children travel to school in India and a majority of them walk or cycle, this is a public health problem of enormous proportions. To prevent these injuries, interventions should focus on making walking and cycling safer for children.

What is already known on the subject?

- India is motorising rapidly: motor vehicle registrations are increasing by 12% each year.
- With increasing motorisation, road traffic injuries are predicted to increase.

What this study adds?

- A sixth of children aged 11–14 years reported sustaining a road traffic injury in the past 12 months during school journeys in Hyderabad.
- Children who cycle to school were most likely to report injuries.
- Travel by school bus was safer than walking.

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Contributors ST collected, analysed and interpreted the data and drafted the manuscript. PE guided the conception and design of the study, interpreted the data and made substantial contribution to drafting and revising the manuscript. IR refined the study design. IR and GVSM revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

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Competing interests None declared.

Ethics approval Ethics Committees of the London School of Hygiene and Tropical Medicine, London, UK, and the Indian Institute of Public Health, Hyderabad, India.

Provenance and peer review Not commissioned; externally peer reviewed.

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Student	Shailaja Tetali
Principal Supervisor	Phil Edwards
Thesis Title	Distance, transport mode, and road safety on school journeys in urban India

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I designed the study, collected, analysed and interpreted the data, and drafted and revised the manuscript.

Student Signature: Shailaja **Date:** April 19, 2016

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RESEARCH ARTICLE Open Access

Development and validation of a self-administered questionnaire to estimate the distance and mode of children's travel to school in urban India

Shailaja Tetali[1,2*], Phil Edwards[2], G. V. S. Murthy[1,2] and I. Roberts[2]

Abstract

Background: Although some 300 million Indian children travel to school every day, little is known about how they get there. This information is important for transport planners and public health authorities. This paper presents the development of a self-administered questionnaire and examines its reliability and validity in estimating distance and mode of travel to school in a low resource urban setting.

Methods: We developed a questionnaire on children's travel to school. We assessed test re-test reliability by repeating the questionnaire one week later ($n = 61$). The questionnaire was improved and re-tested ($n = 68$). We examined the convergent validity of distance estimates by comparing estimates based on the nearest landmark to children's homes with a 'gold standard' based on one-to-one interviews with children using detailed maps ($n = 50$).

Results: Most questions showed fair to almost perfect agreement. Questions on usual mode of travel (κ 0.73- 0.84) and road injury (κ 0.61- 0.72) were found to be more reliable than those on parental permissions (κ 0.18- 0.30), perception of safety (κ 0.00- 0.54), and physical activity (κ -0.01- 0.07). The distance estimated by the nearest landmark method was not significantly different than the in-depth method for walking , 52 m [95 % CI -32 m to 135 m], 10 % of the mean difference, and for walking and cycling combined, 65 m [95 % CI -30 m to 159 m], 11 % of the mean difference. For children who used motorized transport (excluding private school bus), the nearest landmark method under-estimated distance by an average of 325 metres [95 % CI −664 m to 1314 m], 15 % of the mean difference.

Conclusions: A self-administered questionnaire was found to provide reliable information on the usual mode of travel to school, and road injury, in a small sample of children in Hyderabad, India. The 'nearest landmark' method can be applied in similar low-resource settings, for a reasonably accurate estimate of the distance from a child's home to school.

Keywords: Active transport, Questionnaire development, Validity, Distance, Mode, Hyderabad, India

Background

About 300 million children travel to school every day in India [1]. However, little is known about how they get there. Research from high-income countries shows that children are more likely to use motorised transport if the distance to school is greater [2, 3]. Other factors associated with motor vehicle use are age [4–6], gender [2, 7], parental concerns about safety [8, 9], physical infrastructure, and weather conditions [10]. We do not have similar information in India that would help us better understand children's school travel. There is evidence to suggest that everyday travel by walking and cycling is associated with positive health benefits for children [11, 12]. We need information on children's travel to school in India to understand the public health impacts of these journeys. Developing methods to measure children's travel to school for use in low resource settings is therefore important.

A range of methods have been used in high-income countries to measure distance from home to school:

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Geographical Information Systems (GIS) [10, 13]; Geographical Positioning Systems (GPS) [14]; travel time [15]; or the 'straight-line' between school and home [4, 16]. Distances have been calculated using the shortest route possible along the road network [17] or by asking children to draw their routes to school on image maps which were then digitalized and measured, using GIS [18]. In many low resource settings in India, postcodes and addresses often do not identify dwellings and cannot be used to reliably estimate distance to school.

This paper presents the development and testing of a self-administered questionnaire on children's travel to school. This is part of a larger study that aims to estimate the distribution of children's mode of travel to school in Hyderabad (Telangana, India), a city with a population of almost 8 million [19]. A cross-sectional survey is planned to collect data from about 6,000 school children aged 11–14 years, which will be incorporated into a spreadsheet model of the public health impacts of school travel. Accurate estimates of distances and modes of travel by children in Hyderabad is an essential component of the study. The objective of this study was to develop a self-administered questionnaire and examine its reliability and validity in estimating distance and mode of travel to school.

Methods

We developed a questionnaire for use in children aged 11–14 years, as this is typically an age when children may be expected to travel independently [20]. In school terminology, it refers to children in grades 6–9.

Questionnaire development

We searched the literature to identify questions that could be applied in the context of a low resource setting like India (see Additional file 1) [8, 21]. We originally identified about 25 items from previously published work on children's independent travel and adapted them for the Indian context [20]. We conducted a focus group with four public health experts to discuss the appropriateness of the questions. We included a question that asked children about the nearest landmark to their home and used this to estimate the distance from home to school. The final questionnaire (Additional file 3) had 21 multiple choice items: four on demographics, nine on mode of travel and travel during dry or wet weather, two items on parental permissions for independent travel, three on children's perceptions of safety, including road traffic injuries, and three items on physical activity after school. These questions were included because of our interest in children's commuting to school in Hyderabad, and its impacts on health.

Reliability studies

We assessed the comprehension of the questionnaire by focus group discussions among children aged 12–15 years, to assess the suitability of questions for the target age. We piloted the questionnaire in a private school (run by a Society/Trust, without government aid) [22] with 12 children of grade nine, noting all requests for clarifications. For assessing the reliability of the questionnaire, we distributed Telugu translated questionnaires to children in grade eight of a government school ($n = 61$) and conducted a re-test one week later. Telugu is the first language spoken by about 80 million people in India and is the local language in Hyderabad, where this study was conducted. We back-translated the questionnaire, to ensure the correct interpretation of the questions. We conducted a second reliability study in another government school ($n = 68$). We administered questionnaires using pencil-and-paper methods and read out each question, allowing plenty of time for marking the responses.

Validation of estimated distance

We assessed the validity of the distance estimates based on the 'nearest landmark to home' method, by comparing with a 'gold standard' measure, based on in-depth one-to-one interviews with 50 school children in grades 7, 8 and 9, using detailed maps of their neighbourhood and routes to school. The class teacher randomly selected children using each mode of transport. Fifty children, with 56 % ($n = 28$) females participated in the 'in- depth interview' method. The distribution of school-type was government (30 %, $n = 15$); semi-private (26 %, $n = 13$) and private (44 %, $n = 22$).

Gold standard in-depth interview method

Google Earth [23] was installed on a laptop computer, with a 'place mark' on the map corresponding to the school. We visited one school of each type (i.e. Government, semi-private and private). After a brief orientation, each child traced the route from his/her home to school, using a finger. Each route was recorded in *Google Earth*. We used the *'Play tour'* viewing mode for children to see and confirm their routes to school, as well as the distance travelled.

Nearest landmark method

Using *Google maps*, [24] the 'nearest landmark' information of each of the 50 children was entered in the '*from*' box and the school address in the '*to*' box. The '*give directions*' button gave a suggested route and corresponding distance. [Example screenshots of both methods are shown in the Additional file 2].

Statistical analysis

STATA 12 (Stata Corp, College Station, Texas) was used for statistical analysis. For the reliability studies, agreement was assessed for each question using the kappa statistic. Standard categories were used for interpreting agreement (i.e. κ >0.81 'almost perfect' agreement; κ 0.61- 0.80 'substantial' agreement; κ 0.41- 0.60 'moderate' agreement; κ 0.21- 0.40 'fair' agreement; κ 0.01 - 0.20 'slight' agreement; κ 0.00 'less than chance' agreement) [25]. The difference between the distances estimated by the two methods was plotted against the average of the two distances using a Tukey/Bland Altman plot [26]. Limits of agreement were calculated as the mean difference $\pm 1.96 \times SD$, within which 95 % of the observed differences would be expected to lie. A paired sample *t*-test was used to assess whether the bias (mean difference) was statistically different from zero, where statistical significance was at the 5 % level.

Prior permissions were obtained from the Hyderabad District Education Office. The participating school principals gave verbal consent on behalf of the children, and parents/guardians were informed of the study. Ethics committee approved consent being taken only from the school principal. Ethical approvals were secured from the London School of Hygiene and Tropical Medicine, London, UK, and the Indian Institute of Public Health, Hyderabad, India.

Results

Questionnaire development

The pilot confirmed that the questionnaire could be completed in 15–20 minutes. After the first reliability study, definitions were added for *exercise, main roads*, and *feeling safe*.

Reliability studies

Table 1 shows the results of the reliability studies. There were 61 children in the first reliability study and 68 children in the second. Fifteen children absent during the re-tests were removed from analysis. There was perfect agreement for age, sex and name. Almost all children (67 out of 68) wrote the same landmark in the test and re-test. The first reliability study showed 'substantial' or 'moderate' agreement in 69 % (11/16) questions; 'fair' agreement in 6 % (1/16) questions and 'slight' agreement in 25 % (4/16) questions. The second reliability study showed 'almost perfect' agreement in 11 % (2/17) questions, 'substantial or moderate' agreement in 41 % (7/17) questions, and 'fair' agreement in 23 % (4/17) questions. Questions on usual mode of travel to school showed 'substantial' to 'almost perfect' agreement. The question on road injury showed 'substantial' agreement in both the reliability studies. Questions on parental permissions for independent travel, perceptions of safety, and physical activity after school were shown to be less reliable.

Table 1 Results of reliability studies

Questionnaire item	Questionnaire version 1 kappa	Questionnaire version 2 kappa
How did you travel to school today?	0.67	0.79
With whom did you come to school today?	0.53	0.31
How do you travel to school during a usual week?	0.73	0.75
How will you go from school to home today?	0.75	0.66
With whom will you go from school to home today?	0.58	0.58
How do you travel home during a usual week?	0.76	0.84
How would you like or wish to travel to and from school?	0.48	0.44
How do you travel to school during the rains?	0.56	0.64
How do you travel to school during hot weather?	0.66	0.88
Are you allowed by your parents to cross main roads alone?	0.18	0.24
Are you allowed by your parents to cycle on main roads alone?	0.30	0.20
How safe do you feel when you travel to and from school?	0.02	0.00
What are you worried about, during your journey to school?	0.54	0.31
During the past week, after school, on how many days did you exercise?	0.07	0.01
[a]During the past week, after school, how many hours did you exercise?	n/a	0.01
During the past week, how many Physical Training (PT) periods did you attend?	0.07	−0.01
During the past 12 months, were you injured in a road accident?	0.61	0.72
[a]Mention the nearest landmark to your home	n/a	n/a

[a]Question included only in the revised version

Validation of estimated distance

Table 2 shows the average difference between the two methods of measurement for different modes of travel. It shows that no mean differences were statistically significant. Only one child reported coming by 'van' (private transport paid by parents) and was combined with 'school bus' (also private) for analysis. The 'nearest landmark' estimates were not significantly different from the 'in-depth interview' estimates. The distance estimated by the nearest landmark method was not significantly different than the in-depth method for walking , 52 m [95 % CI -32 m to 135 m], 10 % of mean difference, and for walking and cycling combined, 65 m [95 % CI -30 m to 159 m], 11 % of mean difference. For children who travelled by school bus/van, the 'nearest landmark' method under-estimated the distance by approximately 2.4 km (37 % of the mean difference). For children who travelled by motorized transport excluding the school bus, the 'nearest landmark' method under-estimated distance by an average 325 metres [95 % CI −664 m to 1314 m], 15 % of the mean difference.

Figure 1 shows the mean difference plot for walking. The dotted lines show the limits of agreement, and the solid line shows the bias (−52 m).

Figure 2 shows the mean difference plots for different modes. The dotted lines show the limits of agreement.

Discussion

Principal findings

The questionnaire on children's travel to school showed that the questions on usual mode of travel, and road injury were reliable. Distance to school measured by asking for the nearest landmark to a child's home was found to be a valid measure of distance when compared to a method based on in-depth interviews with children. This was true for different modes of travel to school in Hyderabad, but to a lesser extent with the school bus.

Strengths and weaknesses

Questionnaires were administered one week apart and some children's motivation and interest may have differed between occasions, altering the quality of their responses. There was a difference in the number of children who took the test and re-test, but it is not expected that the exclusion of the absentees would influence the results. Compared to those present, absentees had similar age (12.9 vs 13.1 years, $p = 0.09$), and sex (44 % vs 47 % boys, $p = 0.55$), and prevalence of walking (74 % vs 69 %, $p = 0.99$).

Due to limited resources, we could not use objective measures of distance such as GPS. Children's home address was not included because many urban areas in India including several localities in Hyderabad are growing rapidly. As a result, they do not have uniformly structured or geocoded searchable addresses on the web [27]. In the absence of searchable addresses, our questionnaire provides a cost-effective alternative. Reliability was assessed using written survey forms instead of 'hand-raising' protocols used in other studies [28].

Google Earth is increasingly being used in Public Health [29, 30]. We used *Google Earth* and *Google Maps* as they are freely available and easy to use, and due to a lack of access to other GIS tools. It is suggested that *Google Earth* images should be checked for accuracy [31] because they may not reflect recent changes in landscape like new urban development and recent disasters [32]. The distance from home to nearest landmark was not accounted for in this analysis, and could therefore slightly alter the distance estimated.

Strengths and weaknesses in relation to other studies

The 'in-depth' method of recording children's journeys enabled good quality data to be collected, which was the strength of this study. Other studies have relied on parent's reports [18, 33] but we did not involve parents because of concerns about high levels of illiteracy among

Table 2 Mean difference between methods by mode

Mode of travel[a]	n	Mean distance m (In-depth)	Mean difference m (In-depth - landmark)	95 % CI	Difference as % of mean distance	*P* value
Walk	20	525	−52	(−135, 32)	−9.9	0.27
Walking or cycling	23	602	−65	(−159, 30)	−10.8	0.10
Auto rickshaw	5	2309	−391	(−918, 137)	−16.9	0.10
Motorbike	8	2403	91	(−190, 371)	3.8	0.53
Car	3	5356	523	(−1464, 2510)	9.8	0.37
RTC bus (Public)	7	3640	69	(−263, 402)	1.9	0.62
School bus/ Van	4	6436	2386	(−847, 5619)	37.1	0.10
Motorized travel (excluding school bus/van)	23	2202	325	(−664, 1314)	14.8	0.17

[a]Other response categories like train were not marked by any child in this study

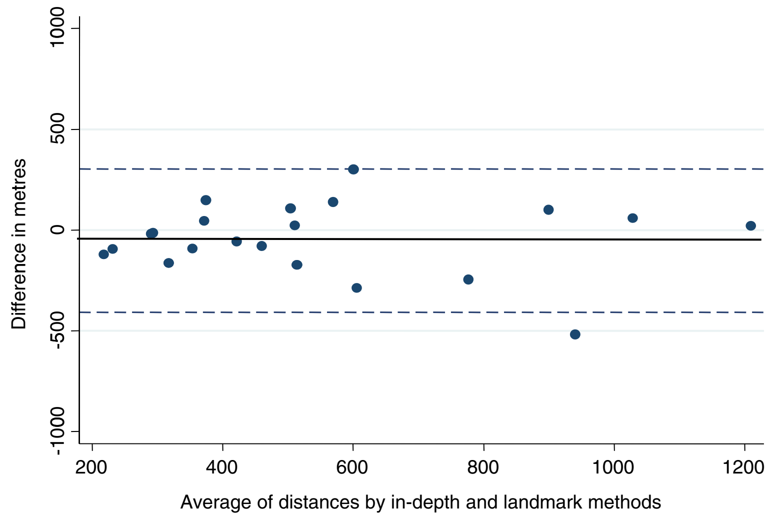

Fig. 1 Differences between 'in-depth interview' and 'nearest landmark' methods (walking). Limits of Agreement = Mean difference +/− 1.96SD = −407 m to 304 m. Mean difference = − 52 m

low-income parents in India. The kappa score for the question on "mode of travel to school today" was lower than that obtained by another study that also used pen and paper (i.e. 0.79 vs 0.98) [25]. This was perhaps because it administered the questionnaire on the same day rather than one week apart. The difference in kappa in our survey could also be due to the difference in the travel behaviour on the day of the survey.

Questions on the usual mode of travel and road injury were found to be more reliable than those on parental permissions, perception of safety, and physical activity, and this must be considered before using the questionnaire. The question on physical activity adapted from the WHO Global School Health Survey [34] was found to be especially challenging and many children asked for clarification. No evidence of bias was found in the distance estimate when walking and cycling were combined. The nearest landmark distance was slightly greater for walking, and when walking and cycling were combined, and for auto-rickshaw. Children probably take short-cut

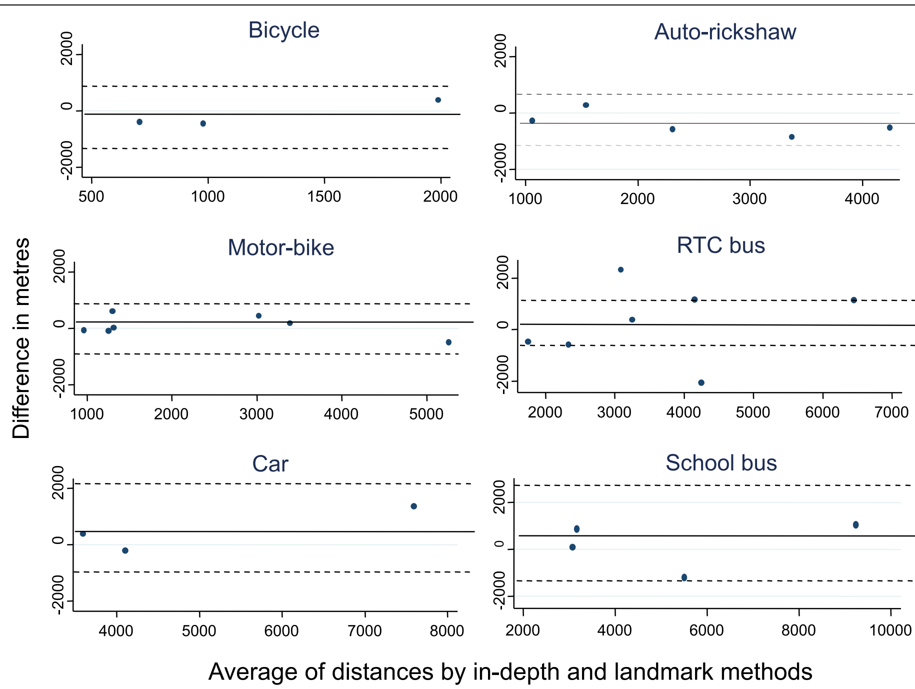

Fig. 2 Differences between 'in-depth interview' and 'nearest landmark' methods (different modes)

routes which *Google* may not consider. This was not the case with the school bus, which undertakes long winding routes to collect children from their homes, and does not reflect the distance from home to school that would be travelled using other modes. For all types of motorized travel, the 'nearest landmark' distance was shorter than the 'in-depth interview' distance, with the exception of auto rickshaw, perhaps due to its ability to take short-cut routes, possibly leading to traffic violations [35].

Meaning of the study and future research

This study developed a questionnaire on mode of travel to school and a method to estimate the distance that children travel to school in Hyderabad, India. It may be used to determine whether these are journeys that could be made by walking or cycling. In the absence of searchable databases to pinpoint the home location, we used *Google Earth* and *Google Maps* to estimate distance. When we compared the 'nearest landmark' versus 'in-depth' distance, they differed by 10 % for walking and cycling. We consider this margin of error to be within acceptable limits of accuracy. For other modes like the school bus, the mean difference is higher, but this is because the school bus does not use a direct route. Future studies can therefore use the nearest landmark method to estimate the true distance that a child would walk or cycle to school. It confirms that the nearest landmark method is feasible, in the absence of GPS equipment and software, especially in low resource urban settings.

This method should be tested in rural areas, which have a different pattern of land-use. Further development of this approach, for example using factor analysis to refine the items, may also improve the questionnaire.

Conclusions

A self-administered questionnaire was found to provide reliable information on the usual mode of travel to school, and road injury, in a small sample of children in Hyderabad, India. The 'nearest landmark' method can be applied in similar low-resource settings, for a reasonably accurate estimate of the distance from a child's home to school.

Additional files

Additional file 1: Appendix Screen shots of two methods of estimating distance to school. (PDF 658 kb)

Additional file 2: Appendix Search methods. (DOCX 16 kb)

Additional file 3: English version of questionnaire. (PDF 468 kb)

Abbreviations

GIS: Geographical Information Systems; GPS: Geographical Positioning Systems; WHO: World Health Organisation.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

ST collected, analysed and interpreted the data and drafted the manuscript. PE guided the conception and design of the study, interpreted the data and made substantial contribution to drafting the manuscript. IR refined the study design. GV and IR revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

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Student	Shailaja Tetali
Principal Supervisor	Phil Edwards
Thesis Title	Distance, transport mode, and road safety on school journeys in urban India

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Stage of publication	**Undergoing revision**

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I designed the study, collected, analysed and interpreted the data, and drafted and revised the manuscript.

Student Signature: Shailaja **Date:** April 19, 2016

Supervisor Signature: ________________ **Date:** April 19, 2016

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RESEARCH ARTICLE Open Access

How do children travel to school in urban India? A cross-sectional study of 5,842 children in Hyderabad

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Abstract

Background: Millions of children travel to school every day in India, yet little is known about this journey. We examined the distribution and determinants of school travel in Hyderabad, India.

Methods: We conducted a cross-sectional survey using a two-stage stratified cluster sampling design. School travel questionnaires were used to collect data from children aged 11–14 years, attending private, semi-private and government funded schools in Hyderabad. We used Google Earth to estimate the distance from home to school for each child and modelled the relationship between distance to school and mode of travel, adjusting for confounders.

Results: Forty five of the 48 eligible schools that were selected agreed to participate, providing a total sample of 5842 children. The response rate was 99 %. Most children walked (57 %) or cycled (6 %) to school but 36 % used motorised transport (mostly bus). The proportion using motorised transport was higher in children attending private schools (41 %) than in those attending government schools (24 %). Most (90 %) children lived within 5km of school and 36 % lived within 1km. Greater distance to school was strongly associated with the use of motorised transport. Children living close to school were much more likely to walk or cycle.

Conclusions: Most children in Hyderabad walk (57 %) or cycle (6 %) to school. If these levels are to be maintained, there is an urgent need to ensure that walking and cycling are safe and pleasant. Social policies that decrease distances to school could have a large impact on road traffic injuries, air pollution, and physical activity levels.

Keywords: Walking, Cycling, Children, Travel, School, India

Background

India, the second most populous country in the world, is rapidly motorising. The number of registered motor vehicles in India is increasing by over 12 % per year [1]. There were 112 million registered motor vehicles on India's roads in 2010 and by 2030 there could be 500 to 600 million vehicles [2]. This enormous increase in motor vehicle use will have important implications for air quality, road traffic injuries, physical activity and climate change.

Although millions of children travel to school every day in India, [3] relatively little is known about their journeys. However, escorting children to school is known to account for a large proportion of household travel, and in most cities, peak traffic density coincides with the beginning and the end of the school day [4]. Given the number of school related trips in India, the choice of transportation modes used is likely to have major public health implications.

Studies in high income countries show that distance to school is one of the most important determinants of transportation mode. The prevalence of walking and cycling decreases and the use of motorised travel increases with increasing distance to school [5–8]. Other factors associated with motor vehicle use are young age, [9–11] female gender, [12, 13] parental concerns about

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safety, [8, 14] physical infrastructure, and weather conditions [6]. Information on travel to school in rapidly developing Indian cities is needed to inform public policy decisions in education, transport and public health.

This study examines travel to school in Hyderabad, the fifth largest city in India with a population, employment mix and transport network that is comparable to other large Indian metropolitan cities.

Methods

Survey design

We conducted a cross-sectional survey using a two-stage stratified cluster sampling design. The strata were geographical (16 mandals, equivalent to boroughs) and administrative (types of school management).

There are three main types of schools in Hyderabad: government, semi-private and private schools. 'Government' schools are run by the Central or State Government; 'semi-private' schools are government-aided schools which are managed privately but receive regular maintenance grant from the government, local body or any other public authority; and 'private' schools which are run by a Society or a Trust without government aid [15]. There are 802 government schools, 342 semi-private schools, and 1,899 private schools in Hyderabad. We considered type of school to be a marker of socio-economic status and parental influence: generally, government schools cater to lower income families, semi-private schools cater to middle income families and children from higher income families attend private schools.

Participants

We obtained lists of all schools in each mandal in Hyderabad district with grades 6–9 (typically children aged 11–14 years) from the District Education Office. We selected one school of each type from each mandal at random, using random numbers generated using the software R. In each school selected the principal randomly selected two sections (i.e. classrooms which normally have 30–40 children) in grades 6–9. Where schools had only one section in grades 6–9, it was selected. All children in grades 6–9 who were present on the day of the survey were included in the study. Assuming that the true prevalence of walking to school was 50 % [16], we estimated that a sample of 6,000 children would be required to be 95 % confident that the sample estimate would be within 5 % of the true prevalence.

Questionnaire

We prepared a self-completion questionnaire with 21 questions about distance and mode of travel to school and conducted extensive piloting of the questionnaire [17]. The questionnaire collected information on the usual mode of travel to school, mode of travel during wet or dry weather conditions, parental permissions for independent travel, children's perception of safety, and physical activity after school. We used an English version of the questionnaire in private schools, and a Telugu version (which was the language of instruction) in government and semi-private schools. The questionnaire was administered during a regular class period and could be completed in 15–20 min.

Variables

The outcome variable was children's usual mode of travel to school. The exposure variable was distance to school. Potential confounding variables were grade, gender, school type, physical activity, and parental permissions for independent mobility. We estimated distance from home to school using Google Earth^{TM} based on the school location and self-reported nearest landmark to home. The estimated distance has been shown to be accurate to within 65m (-30m to 159m) for walking and cycling and to within 325m (-664m to 1314m) for motorised transport [17].

Modes of transport were categorised as *walking, cycling, auto-rickshaw* and *cycle rickshaw* (commercial three-wheeled passenger vehicles), *school bus* (private), *RTC bus* (public road transport corporation bus), *motorised two-wheeler* (motorbike), *car* and *train*. We assessed independent mobility by asking whether children were allowed to cycle and to cross main roads on their own. Distance to school was categorised as: 0.25 to 0.5km; 0.5 to 0.75km; 0.75 to 1km; 1.0 to 1.25 km; 1.25 to 1.5km; 1.5 to 2km; 2 to 2.5km; 2.5 to 3km; 3 to 5km and >5 km. These distance categories were chosen to ensure similar sample sizes in each group. Grades were categorised as grade 6, 7, 8 or 9. Physical activity was categorised as the number of days and hours exercised after school during the past week.

Data collection

Research assistants with survey and interview experience conducted the survey in the schools, in the presence of the class teachers. The survey was conducted from November 2013 to February 2014. Each question was read out aloud by a study investigator, allowing plenty of time for the children to give their responses. Only after all children in a class had answered one question did the study investigator read out the next question, until all questions had been answered. This ensured that any questions, or doubts, that children had were attended to immediately, so no child would feel left out. The study investigator made monitoring visits to schools to ensure that each question was read out and explained to the children.

Probability weights

For each stratum, we estimated the probability of each school being selected (first stage of sampling), followed by the probability of each section being selected (second stage). The probability of selection at the first stage was the reciprocal of the number of schools in each stratum. The probability of selection at the second stage was the number of sections of each grade selected by principals, divided by the number of sections of each grade in each school (which was recorded when principals selected the sections). We checked the probability weights by comparing the population size estimated when applying the weights, with the numbers of children in grades 6–9 in each mandal recorded in state education department reports [18, 19].

Statistical analysis

We examined associations between travel mode and distance to school, stratified by school type. We used logistic regression to estimate odds ratios with 95 % confidence intervals for the association between walking and cycling and distance to school, adjusting for potential confounding factors (e.g. grade, gender, school type, independent mobility, physical activity). We used the 'survey' commands in Stata to account for stratification, clustering and unequal probability of selection, and the 'test' command to test the associations in the logistic regression models. We retained variables that remained statistically significant at the 5 % level in the 'best fit' model. We analysed data using STATA/SE V.12.0 (Stata Corporation, Texas, USA).

Results

Sample characteristics

Forty five of the 48 eligible schools that were selected agreed to participate, providing a total sample of 5842 children (Table 1). Three schools refused due to time constraints. Three percent of children in the participating schools were absent on the day of the survey (n = 179). Compared to those present, absentees had similar age (12.9 vs 13.1 years), and sex (44 % vs 47 % boys), and prevalence of walking (74 % vs 69 %). Almost all children (99 %) provided a valid home address, or nearest landmark, for the estimation of distance to school. Forty children did not answer the question on mode of travel, and 76 children did not provide the information on the nearest landmark. The mean age of the children in the sample was 13 years (SD 1.3 years). There was a higher proportion of girls (54 %) in the sample.

Main results

Mode of travel

All the children surveyed were capable of walking or cycling to school. Most children walked (57 %) or cycled (6 %) to school but 36 % used motorised transport (mostly bus). Greater distance to school was strongly associated with the use of motorised transport. Sixty-four children responded that they walked as well as travelled by RTC (public transport) bus and were assigned to the category 'RTC bus.'

Distance to school

The average distance to school was 2 km (SD 2.6 km). Most children (90 %) lived within 5km of school, many (69 %) lived within 2 km, and about a third (36 %) lived within 1km.

Relationship between distance and walking or cycling

Walking to school was inversely associated with distance. Compared to children living within 0.25km of school (baseline group), children living 0.25–0.5km from school were half as likely (OR = 0.5) to walk to school, and children living 0.5–0.75km from school were around 70 % less likely (OR = 0.3) to walk to school (Fig. 1). Compared to children living within 1km of school (baseline group), children living 2–3km from school were over three times as likely to cycle to school (OR = 3.3) (Fig. 2).

Other factors associated with walking and cycling

Children in the 8th grade were twice as likely to cycle as those in the 6th grade (OR 2.5; 95 % confidence interval 1.4 to 4.2).) Girls were less likely to cycle (OR 0.15; 95 % CI 0.07 to 0.3) than boys. Children who travelled to school alone were approximately three times more likely to walk or cycle to school, compared to those who were accompanied (OR 3.3; 95 % CI 2.3 to 4.6) Similarly, children who reported exercising after school were more likely to walk to school than those who did not exercise. Children who exercised for 7 h a week were almost twice as likely to cycle to school as children who got no exercise (OR 1.9; 95 % CI 0.92 to 4.1).

Mode of travel by type of school

A higher proportion of children in government schools walked (69 %) compared with those in private schools

Table 1 Characteristics of the sample

	Government	Semi-private	Private	Total
Number of schools	16	15	14	45
n (%)	1,836 (31)	1,585 (27)	2,421 (41)	5,842 (100)
Boys n (%)	768 (42)	762 (48)	1,129 (47)	2,659 (46)
Girls n (%)	1,068 (58)	823 (52)	1,292 (53)	3,183 (54)
Age in years (mean, SD)	13 (2)	13 (2)	13 (1)	13 (1.3)

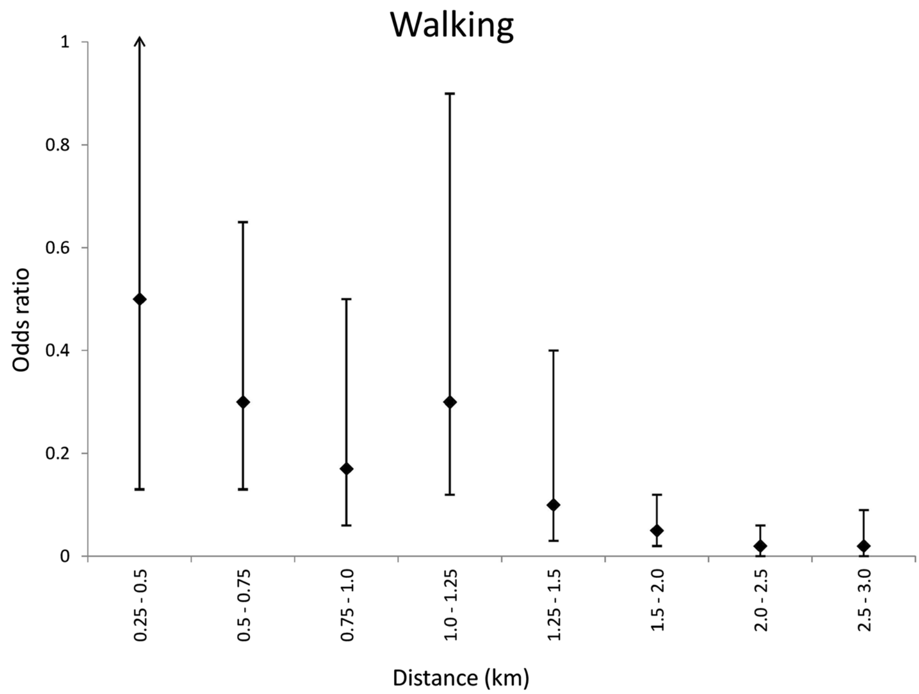

Fig. 1 Relationship between distance and walking to school. Odds ratios adjusted for gender, grade, type of school, mode of travel, hours of exercise and travel alone

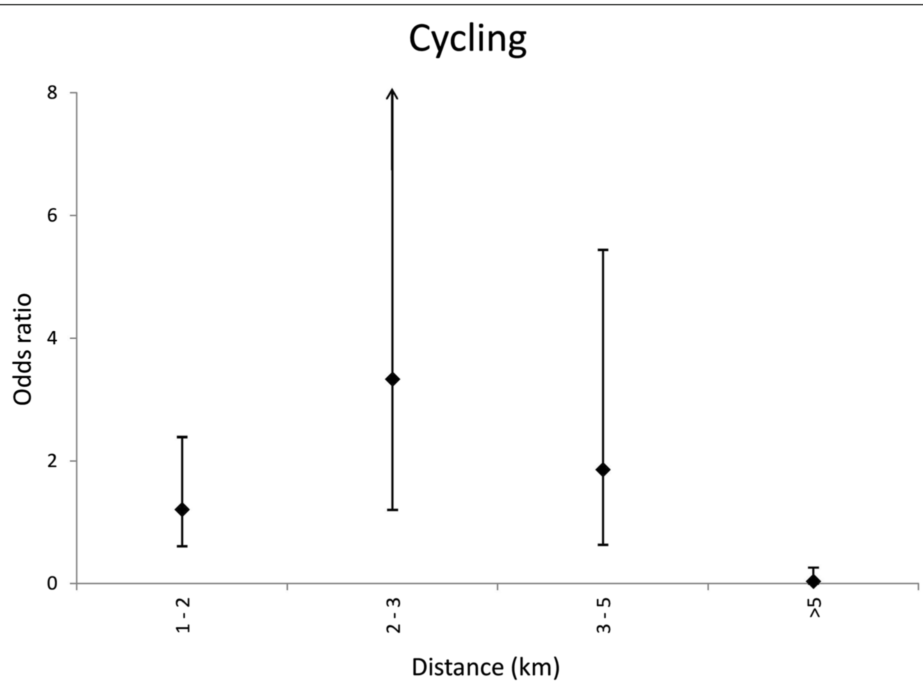

Fig. 2 Relationship between distance and cycling to school. Odds ratios adjusted for gender, grade, type of school, mode of travel, hours of exercise and travel alone

(53 %) (Table 2). Prevalence of cycling was similar (6 %) across school types. The proportion using motorised transport was higher in children attending private schools (41 %) than in those attending government schools (24 %). RTC bus use was more common in children attending government schools than in private schools (19 % versus 2 %). Children attending private schools also travelled 0.9 km further, on average, than their counterparts attending semi-private schools.

Discussion

This study found that most children in Hyderabad (57 %) walk or cycle (6 %) to school. Distance to school was strongly associated with the use of motorised transport. Children attending private schools travelled almost 1km further and were more likely to travel by car (5 %) instead of those attending semi-private schools (0.2 %). Compared to children living within 1km of school, children living 2–3km from school were over three times as likely to cycle to school.

Limitations of this study

Our estimates of children's usual mode of travel to school are based on self-reports, which are susceptible to information bias. Children who were absent on the day of the survey were not included in the survey. They might well be different; however, they were very few. We used information based on children's home address and nearest landmark, to estimate the distance to school. The landmark based method showed minimal evidence of bias and gave reasonably accurate estimates of distance to school. It is found to be a feasible method, in the absence of GPS equipment and software, especially in low resource urban settings [17]. We were not able to select classrooms, which were selected by school principals, based on the availability of a free period for children to complete the survey. This could introduce bias if the principal selected the most literate or physically active children, but this is unlikely because classrooms are generally balanced for good, average, or moderate performers. Therefore the probability of any child being in the survey should be the same. Forty children did not provide their mode of travel, and 76 children did not give a valid address. These children were excluded from the analysis and this may have biased our results. We did not collect information on religion which is another potentially confounding variable.

Despite these limitations, this is the first study of children's commuting to school in India. We achieved a 99 % response rate from children attending private, semi-private and government schools. The large sample size and high response rate are important strengths. We used a questionnaire that had been shown to be valid and reliable, (which confirmed that children were capable of answering questionnaires by themselves). The question on usual mode of travel showed 'almost perfect' agreement using the kappa statistic during reliability testing. We estimated distance to school based on children's home address and landmark. Because our method was accurate to within 65m (-30m to 159m) of the true distance, [17] we are reasonably confident in the results of the relationship between distance and walking/cycling to school.

We used a stratified clustered sampling design to ensure that the sample included government, semi-private and private schools in each of the geographical boroughs of Hyderabad. We used survey commands in Stata for analysis to adjust for probability of selection, stratification and clustering. We estimate that our random sample of 5,842 children is representative of the target population of 322,258 children in Hyderabad. Our results might therefore be generalised to children aged 11–14 in other urban areas in India, with similar population sizes and transport networks as Hyderabad.

Table 2 Distribution of usual mode of travel to school by type (adjusted for survey design)

Travel mode to school	Government		Semi-private		Private		Overall	
	%	(95 % CI)	%	(95 % CI)	%	(95 % CI)	%	(95 % CI)
Walk	69.0	(58, 79)	68.0	(59, 76)	53.0	(34, 71)	57.0	(41, 71)
Cycle	6.0	(4, 11)	6.0	(4, 9)	6.0	(3, 9)	6.0	(4, 8)
School bus	0.6	(0.2, 2)	1.0	(0.2, 8)	11.0	(5, 21)	8.0	(4, 17)
Car	0.5	(0.2, 1)	0.2	(0, 1)	5.0	(2, 16)	4.0	(1, 12)
2 wheeler	2.0	(1 , 3)	10.0	(6, 16)	11.0	(7, 16)	9.0	(6, 14)
RTC bus	19.0	(10, 34)	10.0	(4 , 25)	2.0	(1, 5)	5.0	(3, 10)
Auto-rickshaw	2.0	(1, 6)	4.0	(2, 7)	12.0	(5, 27)	10.0	(4, 21)
Cycle-rickshaw	1.0	(0, 1)	1.0	(0.2, 1)	0.3	(0.1, 1)	0.3	(0.1, 0.5)
Train	0.0	(0, 0)	0.0	(0, 0.3)	0.0	(0, 0)	0.0	(0, 0)
Other	0.1	(0, 1)	0.1	(0, 1)	1.0	(0.3, 3)	0.07	(0.3, 2)
Distance (km) to school (mean, SD)	1.7	(2.4)	1.4	(2.9)	2.3	(2.1)	2.0	(2.6)

Comparisons with other studies

Distance to school has a strong effect on mode choice [5, 20]. Two-thirds of the children in our study lived within a mile from school, and overall, most (63 %) walked or cycled. In comparison, a fifth of the children lived within a mile from school in the USA and overall, 12 % walked or cycled [21].

As shown in high income settings, boys were more likely to cycle to school than girls and older children were more likely to cycle than younger children [12, 22]. These findings reflect cross-cultural social norms related to children's independent travel.

Walking was more common in government and semi-private schools than in private schools. The Indian government provides free education but it does not pay for transportation. Children in lower income families walk if they cannot afford bicycles. Children in higher income families have greater access to motor vehicles and we found that a greater proportion of children at private schools travel by motorised transport. The type of school in India is an indicator of socio-economic status. Similarly, a British study found attendance at an independent school to be a strong predictor of car travel [14]. We also found that children who exercised after school hours were also more likely to walk to school.

The prevalence of active commuting of 63 % in our sample is higher than in countries which have pavements and cycle lanes. Although commuting by car is currently available to only 4 % of children in Hyderabad, it is likely to increase, given the 12 % annual growth of motor vehicles in India. India can avoid the mistakes of other motorised countries and could mitigate unintended consequences like road traffic injuries [23]. Infrastructure such as pavements for walking and safe space for cycling need to be improved, to preserve independent travel and increase children's physical activity.

Meaning of the study and future research

There is evidence to suggest that everyday travel by walking and cycling is associated with positive health benefits for children [24, 25]. School journeys provide this opportunity to walk and cycle, with the associated public health impacts of these journeys. The relationship between distance and mode presented in this study is new information, especially among children in urban India.

Compared to children in the UK and USA, most children in India walk or cycle to school. This is in spite of few pavements and cycle lanes [26]. The reasons for mode choice including barriers to walking and cycling, and the extent of parental influence will be useful to explore through future research. Ensuring that walking and cycling are safe, enjoyable and convenient modes of urban transport for short journeys is critical for improving health and ensuring ecological sustainability [27]. This study contributes to understanding children's school travel in Hyderabad, which is a crucial first step for drawing attention to an area which has so far been neglected. More work is needed (e.g. constructing pavements) to support the high prevalence of walking reported in this study.

Conclusions

Most children in Hyderabad walk (57 %) or cycle (6 %) to school. If these levels are to be maintained, there is an urgent need to ensure that walking and cycling are safe and pleasant. Social policies that decrease distances to school could have a large impact on road traffic injuries, air pollution, and physical activity levels.

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Availability of data and materials
The datasets generated during and/or analysed during the current study are not publicly available because the study is not concluded, but are available from the corresponding author on reasonable request.

Authors' contributions
ST collected, analysed and interpreted the data and drafted and revised the manuscript. PE guided the conception of the study, interpreted the data and helped revise the manuscript. IR refined the study design. IR and GV revised and reviewed the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
We obtained prior permissions from the Hyderabad District Education Office. The participating school principals gave verbal consent on behalf of the children. In each school, information regarding the study was provided by the study investigator to the teacher, who wrote it on the blackboard in their respective classrooms. It was emphasised that children's participation was entirely voluntary. Children in each class were asked to copy the information in their school journal/diary to inform their parents/guardians, and obtain their signature. This was the routine way of transfer of information between school and parents. Individual consent was not obtained from the parents/guardians, although they could opt their children out of the study, and the school principals gave consent for the children to participate. We secured ethics committee approval from the London School of Hygiene and Tropical Medicine, London, UK, and the Indian Institute of Public Health, Hyderabad, India. The Indian Institute of Public Health was aware of this consent procedure, and knowing this, they explicitly approved it.

Research checklist
This manuscript has been prepared using the Strobe guidelines for reporting the results of cross sectional studies.

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