

Roads Near Schools and Their Design Safety Analysis of an Indian City

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Abstract
School siting and street design in school neighbourhoods need special considerations in line with user behaviour propensities, road use profile, street type and design, and street design features. School based streets have very specific time surge profiles followed by limited or normal usage at other times of the day. Traffic conflict pattern in these areas also indicates specific profile for hazards, conflicts, and incidents. There is need for guided design that draws from theory, user feedback, road typology, and accident profile of the area. Road safety considerations and road use profile need to be benchmarked for appropriate traffic circulation and calming measures for school street design. Schools may implement preventive mechanisms for ensuring road safety of children. The application of specific design features, including choice editing, user – centred design, and traffic flow management are essential for improved road safety considerations around schools.
Keywords: Road Safety, Children, School, India, Urban Design

1 Introduction

The UN Sustainable Development Goal 11 refers to inclusive, safe, resilient and sustainable cities and settlements. In recent years, there has been some expansion of the relationship between urban transportation, citizens' health and sustainability. City planners and policy makers have focused on creation of efficient and inclusive multi-modal public transportation systems, building pedestrian and cycle friendly systems, exploring strategic traffic restrictions particularly in residential neighbourhoods and inner city streets for better walkability, as also expansion of public spaces and culture. Under the goal, Target 11.2 refers to safe, affordable, inclusive transport systems, improvement in road safety and access to public transport, and makes a reference to the special situation of vulnerable citizens including children.

Children are at risk when travelling to school on account of their higher vulnerability and are therefore in need of higher safety provisions (Elvik and Amundsen, 2000). Transfer of students to and fro from schools forms an intrinsic part of their daily activity routine. Research in this context has focused on school mode choice, divided into personal vehicle, bus/van, walking and bicycling to school with reference to physical activity and road safety concerns. In recent years, evidence of consistent reduction in public transport and active commuting modes for transport to and from schools has been noted and accounted to multiple reasons including school distance (Kweon, et al., 2006; McDonald, 2007), perceived and real safety concerns, neighbourhood aesthetics (Kerr, et al., (2006); Davison, Werder, and Lawson 2008) heavy city traffic, and other age and gender specific reasons. The adverse impact on health, including sedentary lifestyle and obesity has been extensively studied (Frank, Andresen and Schmid (2004); Schlossberg et al., 2006; Spence, et al., (2008); Van Hulst, et al., (2013)). At the same time, measures for improving road safety has hitherto been confined to creation of school zones with speed limit reduction, driver information and education, improved vehicle safety, adult escorts (Rothman, et al., 2014) and work on seat belt restraint and driver/ passenger helmet related legislation rather than including all aspects of the traffic system.

In this paper we study the school siting, street type and design, street design features, and road usage profile for 10 schools in Bhubanesar, the Capital of Odisha State in India. Road safety concerns of policy makers and school administrators as stated in official documents are identified and compared with best practices for improved traffic management at the local school level. Through a mix of secondary data, urban design theory, and geographical understanding of traffic concerns, we attempt to identify desired street features and existing best practices. Recommendations for school administrators, local traffic administration, urban planners and policy makers shall be provided.

2 Background

2.1 Road Traffic Accident Trends

Globally, road traffic injuries (RTIs) are the ninth leading cause of unnatural deaths, and estimates suggest that RTIs shall be the seventh highest cause of death by 2030 (World Health Organization (2015). Deaths are expected to rise in low and middle income countries, powered by increasing urbanization and rising income standards leading to higher vehicular purchase rates (Downing, Baguley, and Hills, 1991; see also Hazen and Ehiri, 2006 for a review of road crashes in developing countries). Koornstra (2007), predicted, through modelling a cyclically modulated risk decay function, the continuation of high road traffic injuries for India and similar developing nations upto 2030. (cited in Mohan et al., 2009).

Traffic conflicts and road traffic injuries in India have been steadily increasing over the recent decades (Mohan, 2009). Increase in vehicular population, high dependence on two wheeler vehicle usage (Mohan, et. al, 2009) (16.9 million domestic two-wheeler production in 2013-14, of which 2.1 million units were exported (Government of India (2014)), poor driver education, lack of enforcement of traffic rules and regulations, underreporting of crashes and fatalities are some of the associated reasons (Nantulya and Reich. 2002; Mohan, Tiwari and Bhalla, 2015). In 2015, the country observed a total of 5,01,423 road accidents, with 1,46,133 fatalities and 5,00,279 reported injuries. The severity of road accidents, with 29.1 persons killed per 100 accidents remains considerably high.

In the 2004 WHO Global Burden of Disease Report, road injuries were ranked the highest in causes of death for children in the 15 – 19 age group, as also second for the 5 – 9 and 10 – 14 age groups, the need for prioritizing road safety measures can be understood (Peden, 2008). Further, in recent years, WHO statistics indicated that children in the age group 5 – 14 years suffered an estimated 13,800 fatalities due to road traffic crashes while in the 15 – 29 age group, the fatalities were estimated to be 79000 (WHO, Global Health Estimates 2015). RTIs in India also are a leading cause of death among young people, with data showing that 54.1 per cent of all fatalities were from the 15 - 34 years age group (MORTH, 2015). Road traffic crashes also accounted for 3 percent loss of the country's GDP in 1999-2000 and amounted to Rs.100,000 crore in 2011 (WHO, Global Health Estimates 2015, Government of India, Report of the Working Group on Engineering (Roads), 2011). A six city study of fatalities suggested that Vulnerable Road Users (VRUs) (i.e., bicyclists and pedestrians) are most impacted in Road Traffic Accidents. Fatalities of vulnerable road users across the six cities ranged from 84% to 93% in comparison to car occupant fatalities (2 – 4%) and three – wheeler scooter taxis (TSTs) (less than 5%) except for in the city of Vishakhapatnam (8%). (Mohan, D.et al., 2013) (cited in Tripp, IIT Delhi, 2015).

2.2 Child specific characteristics and road safety

Children continue to undergo the process of physical growth, including bone development and hence more at risk from crash impact. Smaller children are, on account of their height, at higher risk for head and neck injuries. Their sensory facilities are also less refined – hence they may be inadequately prepared to fully assessing highly complex environments – such as the speed and trajectory of multiple vehicles. Smaller children also display risky behaviours, such as sudden darting across the road, often with hazardous consequences. Their smaller size obscures their vision, esp. if they are standing close to stationary/ parked vehicles and also prevents drivers from noticing them, leading to higher probability of pedestrian – vehicle crashes (Peden, 2008). Older children, on the other hand, have higher risk taking propensities, including, during teenage years, impulsiveness, rebelliousness, sensation – seeking and affinity for speed, resulting in dangerous driving and higher rates of involvement in traffic accidents, both as pedestrians and as young drivers (Peden, 2008). As pedestrians, the risks for younger children are therefore more pronounced in heavy/fast motorised traffic, limited visibility, and driver error or inability to consider pedestrians or cyclists (Racioppi et. al, (2004)). In case of child passengers in motorised vehicles, lack of appropriate use of child restraints is a major factor, an element that varies considerably across countries and even states, and is highly dependent upon driver education and enforcement. Young drivers may have additional vulnerabilities on account of inexperience, alcohol or drug use, peer influence, mobile phone use, and also not wearing seat-belts (Peden, 2008).

2.3 Operating Characteristics: Roads and School proximity streets in Developing Nations

In developing countries, urban street environments are generally classified as heterogeneous or mixed use. Additionally, alongside four – wheelers/ two wheeler vehicles (or motorized vehicles), streets abound with non – motorized vehicles, human powered vehicles, commercial load bearing vehicles of various capacities, street vendors, buses, trucks, cyclists, and pedestrians. Street junction design may in some cases, be ambiguous, with multiple exit and entry points. Additionally, legal enforcement of traffic rules is at best erratic, resulting in lower statistics of drivers and passengers wearing seatbelts, helmets, or consistently adhering to speeding, parking and directional rules. The laxity also extends to first aid measures, proximity of ambulance services or trauma facility hospitals, resulting in higher fatalities following a crash incident in comparison to developed countries. In this context, strategies for road safety in developing countries were put forth by Bener et. al., (2003) including stress on contributing factors, improving road safety among others.

Schools and educational institutions have a very specific road usage profile. In urban areas, school neighbourhoods are marked by high pedestrian and vehicular traffic around timelines for dropping and picking children from school. In large majority of cases, there may not be fixed drop off or collection points resulting in chaos outside the school gates at opportune moments. Neighbourhoods in close proximity to schools may have their own internal roads taken over by school based traffic and parked vehicles, leading to blockage, traffic congestion, and occasionally, accidents.

Transport providers, parents, older children navigating on their own, are generally the primary road users at these times. The high traffic in school vicinity often requires specific traffic management, both informal and formal. In India in 2015, road traffic injuries in the vicinity of schools, colleges or other educational institutions accounted for 5.8% of the total traffic related injuries nationally (27,059 out of 4,64, 674 cases) (NCRB, ADSI Report, 2015). The breakup of incidents comes to a total of 13849 cases, in which 16311 persons were injured and 5278 died (2015 data) (NCRB, ADSI Report, 2015). Of these, just by school buses, 1622 persons got injured while 422 died (NCRB, ADSI Report, 2015).

3 Literature Review

In context of road traffic system, much work has focused on the application of the Haddon Matrix to the creation of an integrated risk – management based system (see WHO report on road traffic injury prevention, 2004; Edmonston and Sheehan, 2001; Hazen and Ehiri, 2006). The matrix has been applied specifically in relation to RTIs for children by WHO (Peden, 2008), including child factors, vehicle and safety equipment, physical environment and socioeconomic environment. An example of the risk – management based approach using Haddon Matrix could be seen in the instance of establishment of a school transport safety matrix through a participative methodology by Queensland Task Force (see Edmonston and Sheehan, 2001). Further, Loukaitou-Sideris (2006) suggested four broad areas of study in context of pedestrian safety and road crashes 1) driver and victim linked social and behavioural characteristics; 2) built environment and road design characteristics; 3) vehicular and pedestrian traffic characteristics; and 4) area based socio-demographic and physical characteristics. Following the above, the review of literature is clustered around the social and behavioural and built environment and road design aspects with special reference to school transport.

3.1 Social and behavioural considerations of road users

Under social and behavioural aspects, the Haddon Matrix may include user attitudes, knowledge, driver experience and use of drugs and stimulants as well as established mechanisms such as seat belts and helmets. The action mechanisms studied under this category therefore includes driver education, training, improved knowledge and impact on driving and pedestrian behaviour and risk – taking behaviour of all types of road users including pedestrians, cyclists and drivers.

Researchers have suggested that children's road safety behaviour does not alter with increase in knowledge (see Zeedyk, et al., 2001). Similarly, the ineffectiveness of driver education or training programmes in reducing traffic crashes, and moderate success of properly enforced traffic safety laws was emphasized by Archer and Vogel, (2000); O'Neill and Mohan, (2002); and Peden, (2008).

Harris, Waller and Wishart, 2013 studied driver education programmes in detail and suggested the type of programmes with young drivers and school based information education programmes that were found to be more effective. These include comprehensive, long – term programmes that are interactive, use trained teachers and peer educators, focus on social competencies, such as resistance – skills training for social influence and risk management, incorporating life – skills such as resilience, refusal and coping skills, highlighting school engagement and student connectedness and overall, following a whole school approach. Effective strategies also bring into account user characteristics, and focus specifically on high risk groups, characterized by higher risk taking propensity, impulsivity, have conduct disorder or other behavioural issues and may not have positive family influences. In contrast, ineffective programmes are generic, information or fear based, one – off events, or focused on improving driver skills but fail to have any impact on behaviour. In context of developing countries where road safety education is generally not a part of school curriculum, there is therefore a need to bring these learnings' from existing programmes while devising educational content and programmes for children and parents.

Research has also established substance use as a positive marker for unsafe driving behaviour among young drivers (Peden et al, (2004); Toroyan and Peden (eds) (2007); Peden et al, (2008)), particularly in USA with its high prevalence of substance usage among youth (see Terry-McElrath, O'Malley, and Johnston 2014). In India, alcohol usage and road crash frequency has been studied in some detail using hospital based data and police reports though not specifically for young drivers (see Mohan et al., 2009; Mohan, 2009). Peer influence on young drivers was studied by Pradhan, et al., (2014) as a possible variable affecting driving behaviour.

Seraj et al., (2012) undertook a multivariate analysis to understand parental attitudes on active school transport. They suggesting that apart from school distance and accessibility, other factors included work patterns of parents, vehicle ownership and household usage, and socio-demographic characteristics. (see also Pont, Wadley, Ziviani, and Khan 2013). Timperio et al., (2006) examined personal, family, social, and environmental correlates of active school transport. They concluded that in addition to parental concerns and relevant social/ personal factors, elements of built environment linked to active transport measures included school distance, manoeuvring and crossing across heavy traffic, and street lighting and junction design.

3.2 Walkability and active commuting to school: barriers and challenges

In preceding years, human physical activity, particularly in the street, such as walking and bicycling have seen decreasing trends, and have been correlated with perception of risk and safety, leading to growing patterns of sedentary lifestyles and obesity (Schlossberg et al., 2006). Researchers have focused on active commuting to school in a multitude of countries including USA (Kerr, et al., (2006)), Canada (Robertson-Wilson, Leatherdale, and Wong, (2008)), Denmark (Cooper et al., (2005)), Switzerland (Bringolf – Isler et al., (2008)), Netherland (de Vries Hopman-Rock, Bakker, Hirasing, and Van Mechelen, 2010), Belgium (De Meester et al., (2013)). For a review on walkability and bicycling to school, see Sirard and Slater, (2008); also Salmon J., et al., (2007) for individual, social and environmental barriers to walking or bicycling to school). Loukaitou-Sideris (2006) integrated literature from multiple perspectives linked to safety including criminology, public health, and planning and also presented a model of perceived risk for pedestrians and bicycles. In the tropical region, high ambient temperature at school timings may be a factor that has been studied minimally (see Lin and Chang, 2010 for a Taiwan based study)

3.3 Road design parameters and linkage to safety

While driver characteristics, socio demographic parameters and human factors are dominant, road traffic injuries and fatalities result from a combination of elements. In 2011, the Ministry of Road Transport and Highways formulated working groups with the focus on the 4 E's of road safety, i.e., Road Safety Education, Emergency Care, Enforcement, and Engineering including vehicle and road design, thus following a systems approach. In recent years, India has emerged as a global hub for automobile manufacturing, with a vibrant export base in addition to domestic market. As a consequence, manufacturers adhere to most globally followed vehicle safety regulations. Hence, adherence to the latest safety norms in context of motorised vehicles is a non – issue. However, India continues to remain a highly cost conscious market with majority of on road vehicles being compact car models, largely at the lowest of market range. Consequently, these models may not have the highest version of safety features installed and hence, have a role to play in existing high fatality statistics, particularly, those of drivers – passengers of motorised vehicles. Under vehicular and pedestrian traffic characteristics, the prevalence in developing countries of non – motorized road users becomes significant, requiring adequate priority in context of road design for this category of users (Ribbens, Everitt, and Noah, (2008)).

Apart from the recent stress on driver characteristics, human error and distraction as being the primary reasons behind a road accident, the design of roadways has been established as equally important (Mohan, 2008; Mohan and Bhalla, 2016). In India for instance, recent statistics show the predominance of road traffic accidents at the junctions (approximately 49 percent of total accidents in 2015). The Road Accidents in India 2015 report also states the paucity of proper street design and decreased priority of road safety measures particularly for pedestrians and cyclists/ non – motorized transport as a prominent reason for RTIs (MORTH, 2015)

3.4 Built environment and school transport

Schlossberg et al., 2006 studied the relationship between urban form and travel mode choice to school. In context of built environment correlates studied with reference to school transport, Nelson and Woods, 2010 suggested positive correlates of active commuting to include optimized street lighting, diverse land use mix zoning, proximity to shops/ public transport, dedicated lanes for cycles and pedestrians. Panter, Jones, Van Sluijs, and Griffin et al., (2010) studied neighbourhood characteristics and street design in context of school transport and suggested that barriers for active commuting to school for children were also correlated to living in high connectivity neighbourhoods, routing via direct, busy junctions/ crossings, and a lower socioeconomic neighbourhood profile. Napier, Brown, Werner, and Gallimore, (2011) studied three different types of community designs and parental concerns regarding walking to school. Ozbil, Peponis and Stone, (2011) analysed the linkage between street design/ network and pedestrian flows (see also Ozbil and Peponis, (2012)). Stevens and Brown, 2013 analysed new urban LEED community neighbourhood and physical activity correlates of children. Also see Gibson, et al., (2015).

3.5 Urban road design, land use pattern and safety

As part of an international study (IPEN), the New Zealand URBAN study focused on physical activity correlates with neighbourhood urban design with diverse communities (Badland et al., 2009). In developing countries such as India, urban cities often follow a mixed land use pattern, with consequences for traffic flows, urban growth pattern, population densities, and non – adherence to the traditional construct of origin and destination (Tiwari, 2000, Tiwari 2007, Tiwari, Fazio, and Gaurav, (2007). Developed countries have typically followed the old settlement paradigm, with high – density residential areas and compact commercial and office regions, allowing for smoother transportation planning. In contrast, developing countries, with their urban sprawl, and larger geographical spread, have resulted in mixed land – use zones, higher dependence on private vehicles, and informal modes of transport Mohan, (2015). Land – use policies focused on creation of 'smart growth' principles, with clustered, compact buildings and communities, locally accessible amenities (including schools) can play a crucial role in improving time spent in transportation as well as improving road safety (see Racioppi, et al., (2004)).

3.6 Policy and Design Interventions

Loukaitou-Sideris (2006) conducted a comprehensive overview of policy and design interventions around protection from crime and traffic accidents in neighbourhood settings. Researchers have analysed and compared road safety policies in line with existing traffic regulations and standards, mapping their efficiencies (see Elvik R. (2003) for a cost – benefit analysis based comparison). Improving the efficiencies and convenience values of public transport is therefore a key element for future urban transportation issues.

Alrouf (2008) discussed the potential of planning for children specifically in the urban environment of Arab cities suggesting specific principles, patterns and guidelines for Child-Friendly Cities (Alraout, A. A. (2008)). Emagun and Samimi, 2015 presented a comprehensive review of policy initiatives for promoting active transport modes in school trips. Davison, Werder and Lawson, 2008, in their literature review of active commuting to school, highlighted public health programmes such as Safe Routes to School and the Walking School Bus as exemplifying the promotion of active school commute. Larsson, Dekker and Tingvall, 2010 compared the road – user approach (multiple) and Vision Zero approach (Sweden) as two separate instances of systems based approach to road safety stating that building a more comprehensive understanding of road traffic system as a complex hierarchical socio – technical system would assist in improving efficiency of the safety based component of the existing system. In 2009, School Drug Education and Road Aware (SDERA) and the Child Health Promotion Research Centre at Edith Cowan University (CHPRC, ECU) developed best practice principles for road safety education that have subsequently been adopted by all Australian jurisdictions (Cross et al., (2011)). Additionally, examples of road safety measures as demonstrated in a Tanzania based project (School Area Road Safety Assessments and Improvement (SARSAI) Programme) included smaller, doable additions such as speed bumps and road humps, bollards, pedestrian sidewalks, zebra crossings and redesigned school exit points World Health Organization (2015).

In context of legislative standards, India is yet to legislate a National Road Transport and Safety Act, with the most recent version being in draft form (Draft National Road Transport and Safety Bill. The progressive changes in the Bill include creation of child safety zones, introduction of child safety seatbelt restraint in passenger vehicle front (above 8 years) and rear seats (under 14), appropriate child restraint safety equipment, and motorcycle helmets for prescribed age groups of children. There is also lack of maximum speed limits in urban spaces, though speeding limits are prescribed near schools. In the current scenario, however, India does not have child seatbelt restraint law; neither does it have restrictions on children sitting in vehicle front seat. Motorcycle helmet laws are not high on enforcement and applicability to children is not a priority World Health Organization (2015).

Following International examples of road safety targets, India also has set for itself the Vision Zero benchmark. The working group on Road Safety – Engineering (Vehicles) suggested three stages for Vision Zero, under which, in Stage 1 (upto 2020), the focus shall be on reducing fatalities; stage 2 (upto 2030) hopes to reverse the increasing trend of fatalities and injuries, while only in Stage 3 (2030 and beyond), the Government hopes to achieve 'Vision Zero' or no road fatalities or road accident injuries.

4 Case Study: Road Traffic Safety for school students in Bhubaneswar

Bhubaneswar city is the Capital of the State of Odisha located in the Eastern region of India. The city is known for its strong focus on educational institutions, and has some of the best schools in Eastern India. It also came first among 20 shortlisted cities selected under the Government of India's Smart City Initiative in 2016 and has won a number of international awards since then for its innovative and comprehensive proposal (World Smart City Awards 2016, American Planning Association award, 2017). Under the proposal, one of the crucial areas for the city is a focus on urban mobility. Children too find mention in the proposal, which aims at providing safe, accessible, and inclusive public places for children (Government of Odisha Smart City Proposal, 2015). However, the considerations of children travelling to schools do not find a mention.

A 2012 study of road traffic injuries in Bhubaneswar based on traffic police records found total road traffic incidents reportage at 625, in which 754 persons were affected. Of these, 24.4% (184) lost their lives, while 37.5% were grievously hurt. Location wise, 39.4% of the accidents took place on National Highways while 32.8% occurred on unsurfaced roads (Kar et al, 2015). There are, however, no current studies that have conducted a multifaceted analysis of schools, modal choice, street design, and possibilities and recommendations for road traffic analysis. The current study, therefore, seeks to fulfil this gap through a geographical analysis with design suggestions and recommendations for policy makers and school authorities.

In recent years, a number of policy developments have taken place in context of the road safety of school children including a guidance circular by Central Board of Secondary Education (CBSE, 2017) and, in Odisha, the unveiling of Odisha Policy on Transport of School Children in August 2016 (Government of Odisha, 2016). The recently introduced Odisha policy, 2016 seeks to establish a suitable framework for ensuring safety of school children. The predominant focus is on setting standards and statutory requirements for school buses and informal alternatives (smaller vehicles such as three - wheelers, school vans); qualifications and duties of drivers and attendants; school and district level transport committees. The policy fails to look into associated aspects of traffic congestion and management, and avoidance and mitigation measures such as traffic calming, junction design, dedicated parking areas and pedestrian movement as also policies for student driver stipulations and education.

4.1 Methodology

The study analyses geographical information based data in context of schools and proximate streets to bring forth interaction of school siting, entry and exit points, and their relationship with street design, traffic flow and congestion probability for 10 schools in the city of Bhubaneswar. The use of geographical information systems (GIS) based software in context of road traffic accidents and safety has been extensively studied. For instance, Austin, Tight, and Kirby (1997) applied GIS software for locating hotspots in traffic flow, route analysis and optimization, and road traffic hazards and incident based information. Further, Wong, Faulkner and Buliung, 2011 reviewed studies that made use of GIS for studying the correlates of built environment and active school transportation (i.e., walking and bicycling to school. GIS based analysis of physical activity patterns has also been used in other studies including Carlson, et al., 2015. In contrast, Larsen, Buliung, and Faulkner 2013 did a mapping exercise with parents and children as an improvement over network shortest path analysis method.

In the current methodology, identified schools were analysed using the following aspects – school location (latitude and longitude), positioning and number of entry and exit points, proximate street typology, land – use pattern, and school specific design features. For this purpose, school geographical location and street typology was identified through the school GIS website that only indicates school locations in a given geographical area. Backdated school transport information was obtained through Google Earth platform (Fig. 2).

TABLE 1

A few characteristics of the selected schools need to be specified prior to discussion. The selected schools are large enrolment schools, with more than 500 students enrolled in each school. There is no relationship between enrolment and distance from school, i.e., a student may be located in near proximity to the school or may be travelling across the city to reach the school. Barring two of the schools, all the schools have assigned buses and mini – buses that ferry students from across the city, though parents are also free to pick and drop their wards each day. Some of the schools are located in the middle of the city while others have recently come up in newer, though rapidly expanding neighbourhoods. This arrangement provides heterogeneity and a comparison of built environment across schools.

5 Results and Discussion

Analysis of secondary data on Road Traffic Incidents from Government of India, 2015 indicates that 38.5% (highest) accidents occurred in T junctions followed by 19.8% in Y junctions. The data also indicated that in a 24 hour window, the highest percentage of traffic accidents occurred between 3 to 6 pm (17.5%) followed by the time slot of 9 am to 12 pm (16.3%) while the early morning zone of 6 to 9 am showed a substantial percentage as well (11.1%).

Through the analysis of selected schools the following aspects were identified. A correlation exists between number of exit points, the type of road that the exit connects to, and the timing of school drop and pickup. The aggravating factors for traffic congestion include high population density of proximate neighbourhood and mixed land use including existence of commercial, institutional and residential spaces in a compact geographical zone. Other aggravating factors are location of tourist spots or other important landmarks present nearby. Two-way non – median (14 ft) roads not just create severe traffic congestion and chaos but also intensify road safety issues for the children. Schools located on the main arterial roads or close to National Highways pose serious safety concerns for transiting children. Mitigating factors for road safety during school transport include the presence of appropriately designed traffic calming features (i.e., speed bumps, speed segregated lanes, slowing down diversions and signage, appropriate kerb designs, central medians, and proper street and footpath design), dedicated personnel near traffic hotspots on either side of 500 m of the school exit points or at connecting junctions for optimized traffic management.

6 Way Forward and Recommendations

Analysis of the representative schools, policy and literature documents, and accident statistics illustrate the need for a system based approach for school transport focusing on student safety, health, environment, and sustainability. Current policy documents focus on school buses as the predominant mode of transportation and do not take into account the interaction between traffic flow patterns, surrounding land use mix, street design features and possible mitigation measures such as speed zones and traffic calming features. The WHO 2008 Report on Child Injury Prevention outlined a number of external factors that increased the risk of child road injury, including busy roads (classified as movement of above 15,000 vehicles in a day), poor interaction pattern of land use and street design features, lack of dedicated lanes for pedestrians and cyclists, low priority for children's needs (such as play and recreational spaces), inappropriate and ineffective speed monitoring in high pedestrian use areas, and finally, ineffective, or impaired public transport system (Peden, 2008).

Recommendations

1. School interface with land use pattern of proximate neighbourhoods: Every school, particularly with student enrolment above 500 students should get a traffic flow analysis done by recognized experts. This should enable the school management to incorporate type of vehicular traffic in proximate areas, peak traffic movement timings, nearby traffic congestion hotspots, in the design of school shift timing. This may involve matching as well as staggering entry and exit timings of the school.
2. Traffic management and coordination mechanisms: School transport policies and guidelines have stipulated the formation of school transport committees and higher, district level coordination committees. While the existing committee functional areas include school bus inspection and certification, a broader role could be envisaged for these committees. Each school should have a local traffic management committee and traffic management personnel identified and deployed at key hotspot areas both on the school exit road as well as all connecting roads. The neighbourhood road grid connectivity, traffic movement and inter-connectedness should be understood and suitably managed. Suitable city level traffic administration role sharing should be done as part of stakeholder engagement. The committees are also the appropriate platform for ideation on a future transportation linked vision based on sustainable city planning principles and incorporating futuristic conceptions of alternate vehicles.
3. School specific entry and exit points: Schools with suitable infrastructure availability should have a proper exit plan in place inclusive of a) multiple exits for different standards/ age groups of students, or as per mode choice type b) boarding/ deboarding facility from school bus inside the school premise or off – the road. Schools that are in a position to take advantage of multiple entry/ exit points should ideally close the exit directly opening unto major city roads or key arterial roads. At the bare minimum, schools should designate specific areas as drop off points, selected for minimization of traffic congestion. Appropriate street design features near entry/ exit points should include traffic calming features, barricading props and speed based segregation of vehicles that should be designed upto approximately 500 m on either side of the exit. Periodic drills for emergency related circumstances should be an integral part of the plan.
4. Transport facility planning: Each school should carry out a transport facility mapping exercise on an annual basis in accordance with its existing student enrolment profile. The school specific transport policy should promote the use of public transport system, vehicle sharing and pooling and create mechanisms for optimizing greater utilization of public transport. Schools should be able to predict exact number of vehicles during a given timeframe and accordingly carrying capacity assessment of roads in nearby proximity should be done. The learning from the above mentioned steps shall allow schools to develop a comprehensive traffic management policy.
5. Stakeholder engagement: Since schools are part of a larger system, it is imperative to bring together multiple stakeholder including parents, drivers and bus attendants, transport vendors, local traffic enforcement functionaries, residential welfare association representatives, neighbouring institutional facility management personnel, city traffic administration, and urban planners. School level traffic management committee and deployed personnel should be part of a periodic review committee which assesses the efficiency and effectiveness of the existing traffic management system. The committee should also carry out periodic risk assessment exercises with the understanding that safety of children and other vulnerable road users is linked to better traffic management near school premises.
6. Walkability and cycling to school: walking and cycling to school by nearby residential area children should be encouraged with a view to promote physical activity and sustainable lifestyles in citizens. School authorities therefore need to engage with the urban planning department and promote street design features such as dedicated cycling and walking paths and appropriate road crossing designs, particularly for specific junction and major road typologies. Supportive features that are age appropriate are essential for on – ground selection of these school transport options, and include safe routes, adult accompaniment, group based walking groups. Climatic features such as shaded pathways, refuge for sudden incessant rain, and other assistive features are an integral part of both policy formulation and practice.
7. Outreach and Behavioural Communication: Each school should have in place an adequately sized and appropriately placed infographic based visual representation of their traffic plan. This should be supported by sharing of school traffic policy document and guidelines which should be given to all stakeholders and displayed prominently on the school website. In physical space around the school, marking of school safety zones, traffic safety and rules related banners and signages should be prominently displayed for all vehicles and pedestrians.

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Table 1: Road Safety Analysis of Selected Schools in Bhubaneswar

School Name	Students Enrolled (2015-16)	Lat Long	No. Of Exit	Type Of Street	Type Of Junction	Road Leading To Main City Road	Road Leading To Junction	Settlements Around School	Type Of Transporation
School 1	3149	85.828196 20.346897	1	Inner Road 14 Ft Two Way	T	N	Arterial Road Single Side 14 Ft Each	Institutional / Lpd	Heterogenous
School 2	1500	85.816523 20.354519	1	Inner Road 14 Ft Two Way	T	N	Arterial Road Single Side 14 Ft Each	Institutional / Lpd	Heterogenous
School 3	3488	85.814270 20.333122	1	Arterial Road 30 Ft Two Way	T	Y	Arterial Road Single Side 14 Ft Two Way	Residential+ Commercial Hpd	Heterogenous
School 4	2020	85.815723 20.308092	1	Inner Road 14 Ft Two Way	T	Y	Main Arterial Road	Institutional + Residential	Heterogenous
School 5	1798	85.842714 20.278621	1	Inner Road 14 Ft Two Way	T And Y	Y	Main Arterial Road	Institutional + Residential+ Tourist Attraction	Heterogenous
School 6	2035	85.830691 20.262126	1	Inner Road 14 Ft Two Way	No	N	Inner Road	Residential	Heterogenous
School 7	1717	85.809147 20.282454	1	Inner Road 14 Ft Two Way	T	Y	Main Arterial Road + Nh	Institutional + Residential	Heterogenous
School 8	2127	85.811391 20.235197	1	Inner Road 14 Ft Two Way	T	Y	Main Arterial Road	Institutional + Residential+ Flyover	Heterogenous
School 9	3106	85.817801 20.275529	1	Arterial Road 30 Ft Two Way	Y	Y	Main Arterial Road	Institutional + Residential+ Main Junction + Governor House	Heterogenous
School 10	956	85.840664 20.278810	1	Arterial Road 30 Ft Two Way	Y	Y	Main Arterial Road	Institutional + Residential+ Commercial	Heterogenous

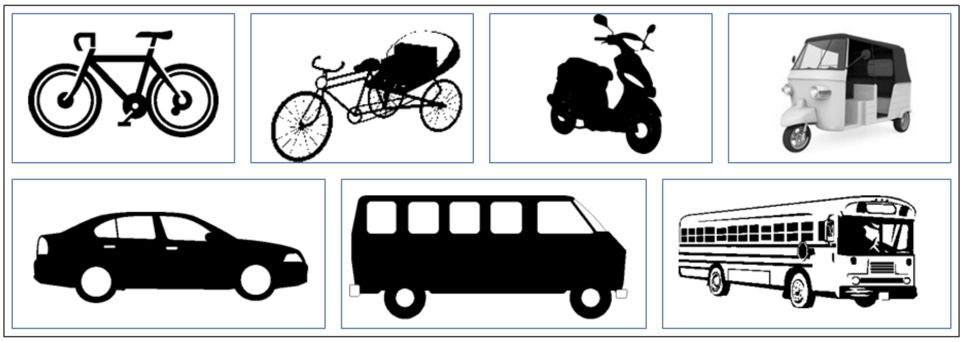

Fig. 1 Heterogenous Vehicle Transport Options for School Transport

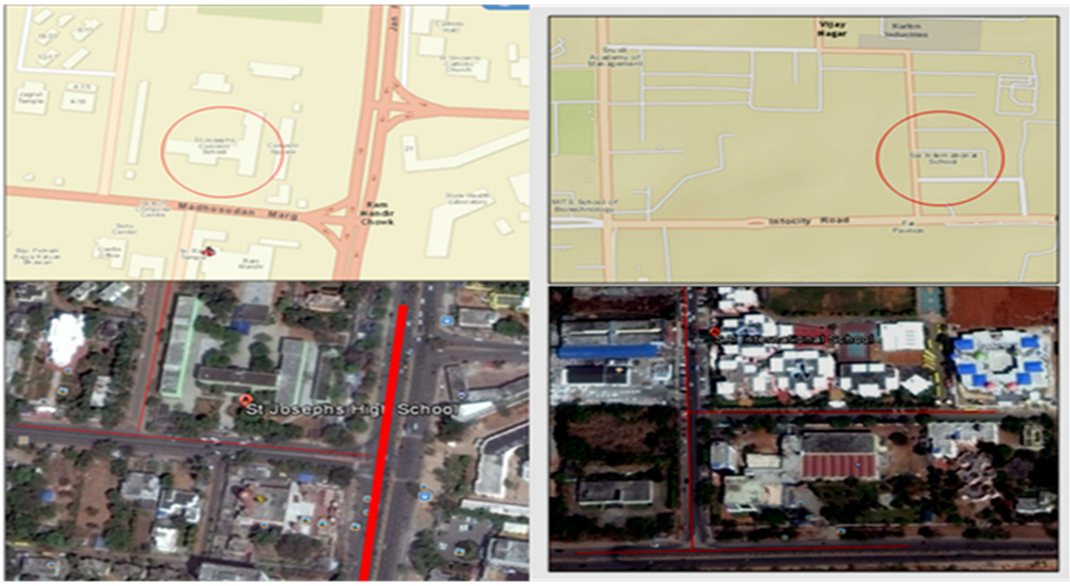

Fig 2. Representative samples of the School and Street Design Mapping exercise