

## Managing Road Safety in Ahmedabad

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### ABSTRACT

*Road crash is not just a chance event and it is possible to identify sources of crashes and take preventive measures. Effective management would include analysing data on a continuous basis, developing strategies and monitoring effectiveness. The Geographic Information System (GIS), big data and video surveillance data come in handy in undertaking these tasks. This paper focuses on analysing the trends in road fatalities and injuries in the city of Ahmedabad in India, their spatio-temporal distribution, identification of 'black-spots' and monitoring of user behaviour using First Information Reports<sup>1</sup> (2009–2018), big data and video surveillance data.*

*There are four important observations of the research. First, 'two-wheeler users' along with pedestrians have emerged as a vulnerable group and 'cars' have emerged as the major responsible mode for fatal road crashes. Second, highways in urban areas are more road crash prone than other city roads. Third, using kernel density estimation method, the study identifies hot spots and concludes that 64 locations (46 percent of the total road crash prone areas) in the city are more prone to road crashes than others. Lastly, this study confirms that effective monitoring using video surveillance does contribute to change in user behaviour.*

**Key words:** Road safety, road crashes trends, responsible and affected modes, hotspot analysis, kernel density estimation

### 1. Background

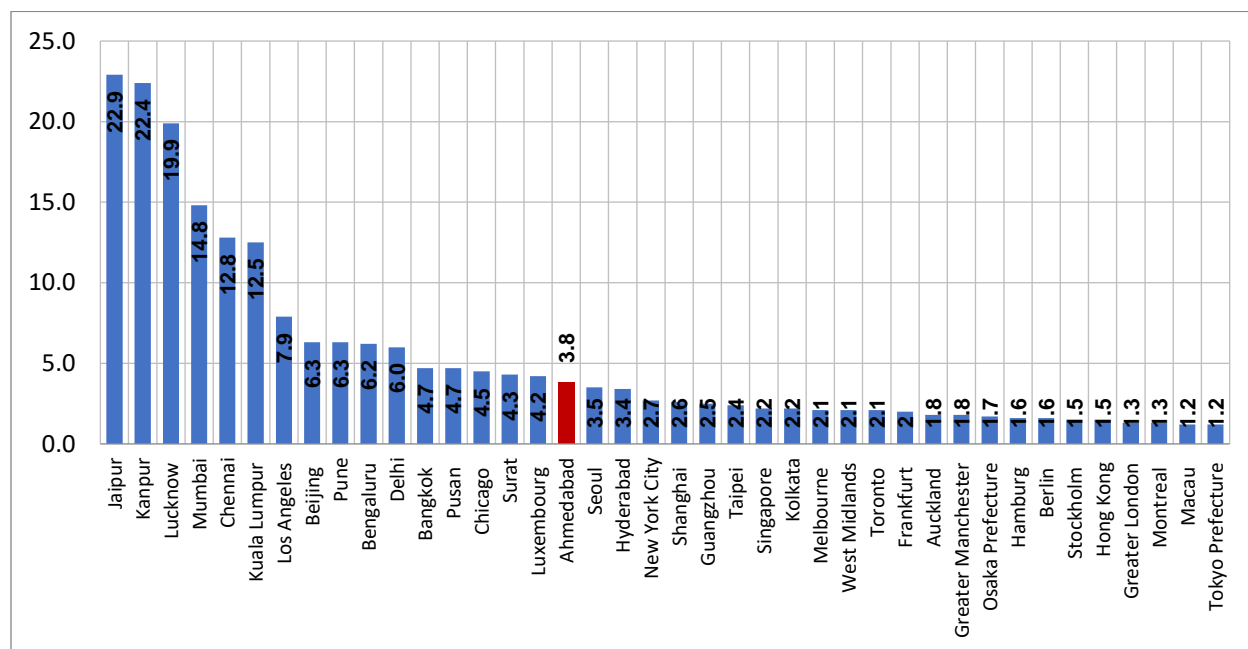
Road safety has emerged as a prime concern globally over the past few decades. Despite significant advances in road safety knowledge, 1.35 million people are killed every year in road traffic crashes around the world. Over 93 percent of the deaths are reported to occur in low- and middle-income countries even though they have only 60 percent of the world's vehicles (World Health Organisation, 2018). The rate of death at the global level per 100,000 people is 18—however, this rises to about 27.5 in low and middle income countries while it reduces to about 8.3 for high income countries. Road crashes cost about 3 percent of the GDP across countries (World Health Organisation, 2018). The most vulnerable groups include pedestrians, bicyclists and motorcyclists who account for almost half the road crash deaths (World Health Organisation, 2018). It is observed that road crashes are the 8th leading cause of death in all age groups whereas in the case of children and young people aged 5 to 29, road crashes are now the leading cause of death (World Health Organisation, 2018). It is also recorded that up to 50 million people are seriously injured, many suffering life-long disability due to road crashes (World Health Organisation, 2018).

Globally, India is ranked 58th in terms of road crash fatality rate (22.6 deaths per 100,000 population) (World Health Organisation, 2018). According to official statistics 147,913 persons were killed and 470,975 injured in road traffic crashes in India in 2017 (Ministry of Road Transport and Highways Government of India, 2018). India faces more than double the current roadway crashes when compared to the United States, whereas the roadway length in India is about half of that in the United States (Kar & Datta, 2009).

Urbanisation and increased motorized vehicle ownership in recent years have seen many Indian cities report an escalation in 'road traffic accident' (RTA) or 'crash' fatalities and serious injury recordings. As per the Ministry of Road Transport and Highways (MoRTH), Government of India, urban areas accounted for about 42.9 percent (195,723) of the total road crashes in 2017 (MoRTH, 2008). Road fatalities in urban areas in India have reduced by about 11 percent from 57,840 in 2016 to 51,334 in 2017 (Ministry of Road Transport and Highways Government of India, 2018). A decline of about 13 percent is also observed in the case of serious injuries, which have come down from 212,346 in 2016 to 183,703 in 2017.

Indian cities have very high fatality rates (5 to 16.5 per hundred thousand population) compared to other international cities. Data for 50 million-plus cities reported in National Crime Record Bureau (NCRB) and MoRTH reports published in 2015 shows that the average death rate for all million-plus cities combined was 14.7 per 100,000 (NCRB, 2015). It is observed that in a third of these cities, the death rate increased by more than 50 percent in a period of 10 years.

The city of Ahmedabad with a population of 5.5 million (Office of the Registrar General & Census Commissioner, India, 2011) residing within 466 sq.km. of municipal area, fares better in terms of fatal and serious road crashes per hundred thousand population as compared to other cities in India. However, the overall level of service as per the Service Level Benchmarks in Urban Transport issued by Government of India is poor at Level of Service (LOS) 3. (Ministry of Housing and Urban Affairs, 2016b) On a comparative national scale, fatality rate of 3.8 per hundred thousand population in Ahmedabad with 2.8 million registered vehicles is higher than that of most international cities.



Source: (Transport Department Government of the Hong Kong Special Administration Region, 2017)  
(Ministry of Road Transport and Highways Government of India, 2018)

Figure 1: Fatalities per 100,000 populations – Indian and International City Comparison 2017

## 2. Database and Method Used

In India, the data regarding road crashes is jointly handled by the City Traffic Police and the City Police. The details of the day-to-day road traffic crashes are recorded in local police stations across the country in the form of an FIR (First Incident Report), once a road crash case is brought to the notice of the police (by anyone involved in the crash, anyone who knows about the crash, or a police officer who comes to know about the crash) or in the form of a 'Medico Legal Case' by a police officer stationed at hospitals. Once the FIR is registered, an investigation team prepares a case file which records the road crash in detail. This is submitted in court for further legal action. The City Traffic Police keeps a record of all road crashes in the city by collecting a copy of the relevant FIR from various police stations in the city. The road crashes data (Fatal and Serious Road Crashes) used for the purpose of this study have been sourced from FIRs (2009–2018) collected from the City Traffic Police Commissioner's office<sup>1</sup>.

<sup>1</sup> The source for Figures 2–14 in this paper is the unpublished data collected from the Traffic Police Department in Ahmedabad in 2018.

Along with the road crash locations, data relating to traffic offences was also collected from the traffic police department to understand the risks posed to the road users. The paper adopts a specific set of RTA data focusing on total road crashes, fatal road crashes, fatalities, serious road crashes and serious injury cases in Ahmedabad from 2009 to 2018, plotted spatially on GIS. At an aggregate level, the road crash trends have been analysed over a period of ten years in terms of numbers and rates (road crashes per 100,000 population, per kilometre length of road length). Comparison of road crashes, both spatially and temporally, has been carried out along with identifying the affected and responsible modes for both.

Spatial distribution of road crashes using the Kernel Density Estimations (KDE) has been used to identify the road crash hotspots. This is one of the most widely used methods for road crash analyses. This interpolation technique generalizes the road crash incident location to an area by calculating the density of crashes in the neighbourhood around the road crashes (Bailey & Gatrell, 1995). One of the main advantages of using this method is that the changes in the density are easily identified along with the spread of risk of road crashes. Cluster analysis was also performed to identify specific hotspots for road crashes. For this purpose, the base grid of 200m was used for analysis, based on the average link length, and using the spatial join tool, the fatalities and serious injuries were aggregated in these grids to identify locations.

Interviews were also carried out with the authorities to understand the causes and the remedial actions taken by them.

### 3. Fatalities and Serious Injuries Trend in Ahmedabad – Temporal and Spatial

Road crash trend analysis over the last decade suggests that fatalities as well as serious injuries have gradually risen in Ahmedabad. In 2018, road traffic road crashes cost 322 lives and seriously injured 440 people in the city (see Figure 2).

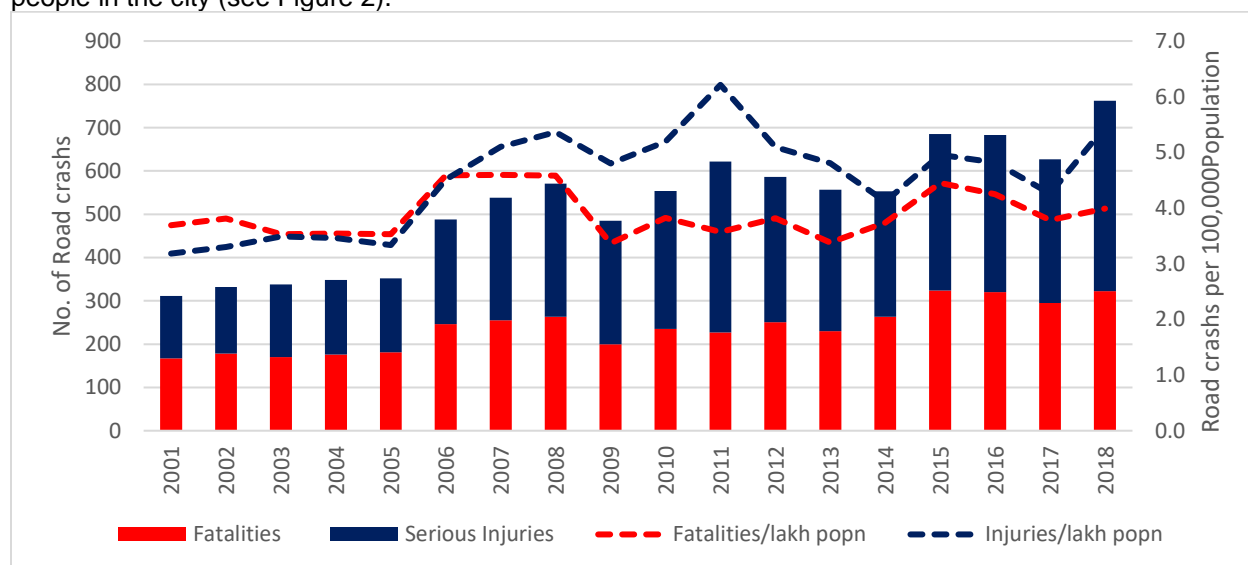


Figure 2: Trend of Fatalities and Serious Injuries in Ahmedabad

Of the total fatalities and serious injuries in the last decade, 80 percent of those affected are males, which is typical of any urban area in a developing country where the male work participation rates are higher than those of females. It is also seen that 78 percent of the fatal and serious road crashes are in the economically productive age groups (between 18–60 years) followed by senior citizens (refer to Figure 3). This indicates vulnerability of the family in the case of road crashes, as the male members are the earning members of the family and such incidents impact the overall socioeconomic condition of the family, affecting the

education of children, productivity of the working population and the overall quality of life (World Health Organisation, 2015).

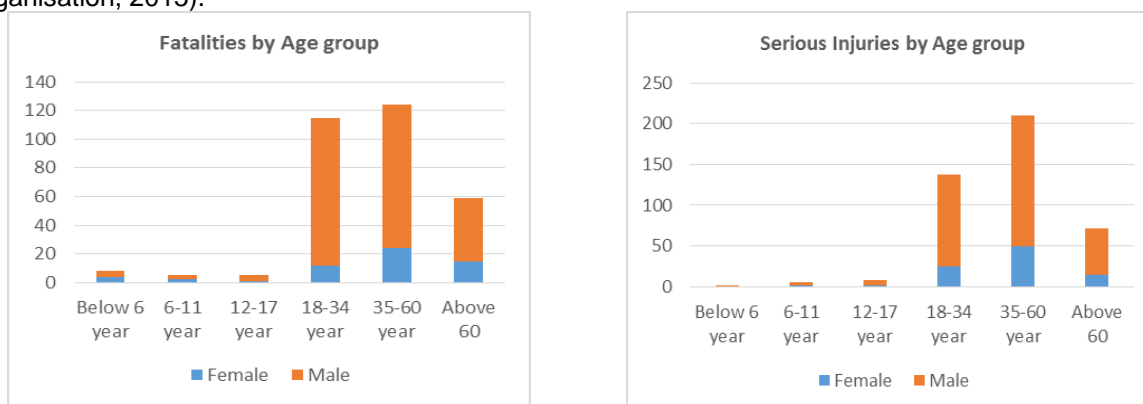


Figure 3: Distribution of Fatalities and Serious Injuries by Age Group

The time of the day also seems to have an impact on road crashes in the city. It is observed that in the case of Ahmedabad, most of the fatal road crashes take place during the peak hours (9am to 11am and 6pm to 8pm). If we compare the 2009 and 2018 numbers, it is seen that the share of fatalities in the evening peak hours have almost doubled, from 4 percent in 2009 to 7 percent in 2018. It is also observed that during the off peak hours between 11am to 6pm, the proportion of road crashes has increased. This could be attributed to high growth (about 9 percent annually) of motorised vehicles in Ahmedabad albeit with reasonable travel speeds of about 28 km per hour for private vehicles on the road.

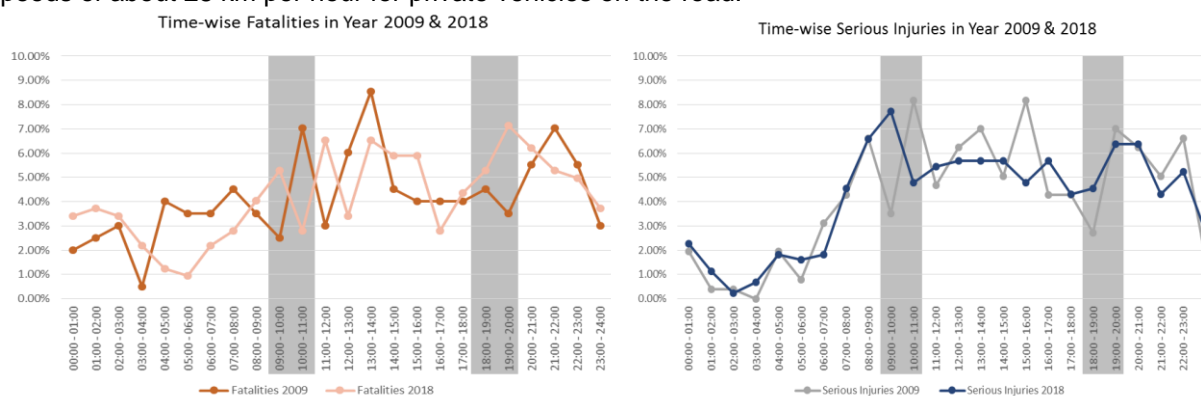


Figure 4: Distribution of Fatalities and Serious Injuries by the Time of the Day

In terms of spatial distribution of fatalities and serious injuries from 2009 to 2018, it is observed that fatalities are higher in the eastern side of the city (67 percent) in comparison to the western side (33 percent). This could be attributed to the intrusion of freight vehicles in the eastern side owing to the presence of industrial land use in the eastern part of the city. As observed, freight vehicles in the eastern part of the city alone account for about 15 percent of the total fatalities compared to 4 percent in the west of Ahmedabad. On the other hand, in the case of serious injuries, western Ahmedabad has a slightly higher share (56 percent) as compared to its eastern part (44 percent). It is also seen here that four-wheelers become the predominant mode contributing to about 26 percent of the injuries in the western part and 11 percent in the eastern part of the city, which could be attributed to higher car use in the western side of the city.

If we see the spatio-temporal variation in the road crash locations over the years and compare the numbers for 2009 and 2018 (refer to Figure 5), it is seen that fatal road crashes are further intensifying in the eastern part of the city, with a few new hotspots emerging in the west along the Sarkhej–Gandhinagar (SG) Highway and in New Vadaj.

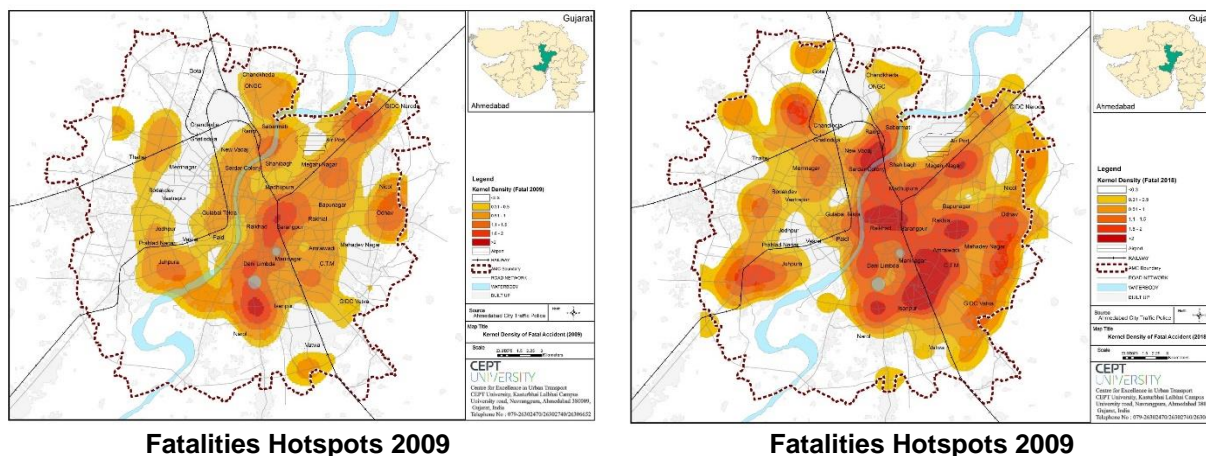


Figure 5: Spatial Distribution of Fatalities Hotspots 2009 and 2018

However, in the case of serious road crashes (see Figure 6), the denser clusters are seen in both the eastern and the western parts of the city along the arterial roads, especially the newly developing areas such as Chandkheda towards the north of the city, along SG Highway and 132 Feet Ring Road. An intensification of road crashes resulting in serious injuries is also seen in the core city area.

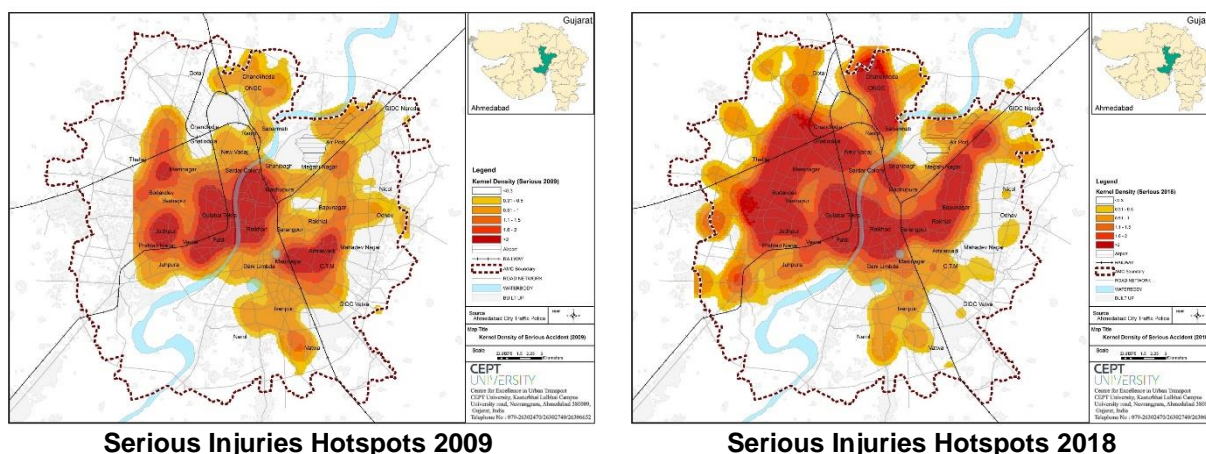


Figure 6: Spatial Distribution of Serious Injuries Hotspots 2009 and 2018

#### 4. Road Crashes along Urban Roads and Highways

Looking at the concentration of hotspots, major road crash prone corridors (road crashes per km) were identified (see Figure 7). Though the overall average speeds in the city are not very high (28 kmph), high speeds were observed on some of the road crash prone corridors like SG Highway and 132 Feet Ring. Almost 85 percent of the total fatal and serious road crashes occur along these stretches, which is an increase of almost 30 percent from the 2009 level. It is seen that the road crash density per km of road is above 3 in the case of SG Highway in the west and the Inner Ring Road, especially on the eastern side of the city. In terms of the urban roads, intensification of road crashes (increase in the road crashed per km) is seen along the 132 feet ring road near Odhav and Chandkheda. On comparing the 2009 and 2018 data, it is evident that intensification of road crashes has occurred along highways as seen in Figure 7 below:



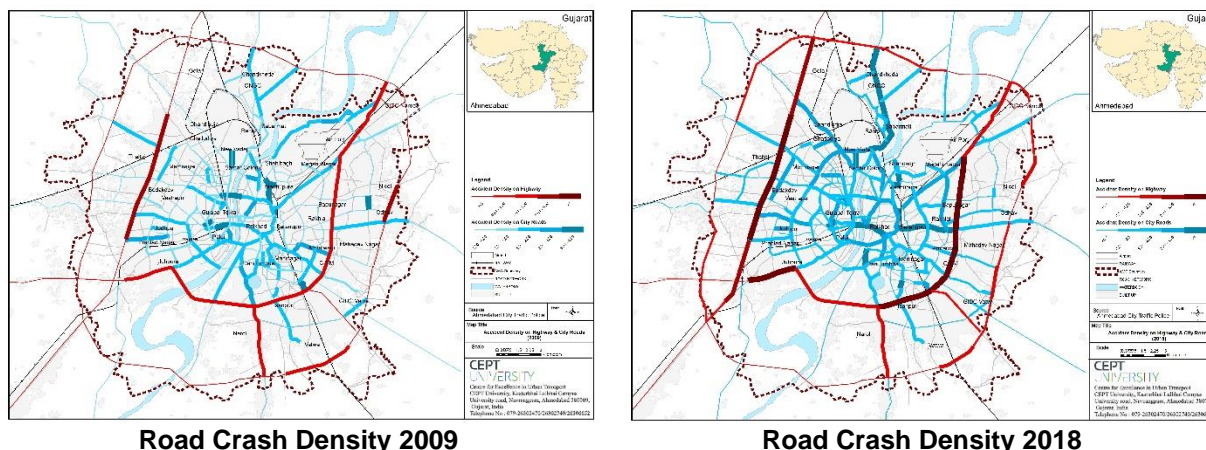


Figure 7: Comparison of Road Crash Prone Roads 2009 and 2018

## 5. Affected and Responsible Modes

Affected modes are defined as the modes that are at the risk of fatalities and serious injuries during a road crash. Pedestrians (including public transport users) and two-wheeler users emerge as the most affected user group in 2018, with 42 percent and 39 percent fatalities belonging to these groups. It is seen that the overall proportion of these two groups alone has risen by 9 percent since 2009. On comparing the data for 2009 and 2018, it is observed that the proportion of pedestrian fatalities occurring during the day (5am to 8pm) has reduced from 71 percent in 2009 to 61 percent in 2018. On the other hand, fatalities occurring during the night (8pm to 5am) have increased from 29 percent in 2009 to 34 percent in 2018. It is also seen that the proportion of cyclist fatalities reduced from 14 percent to 4 percent. However, it should also be noted that the mode share of cyclists in the city is low at 9 percent, as per a survey conducted in 2012.

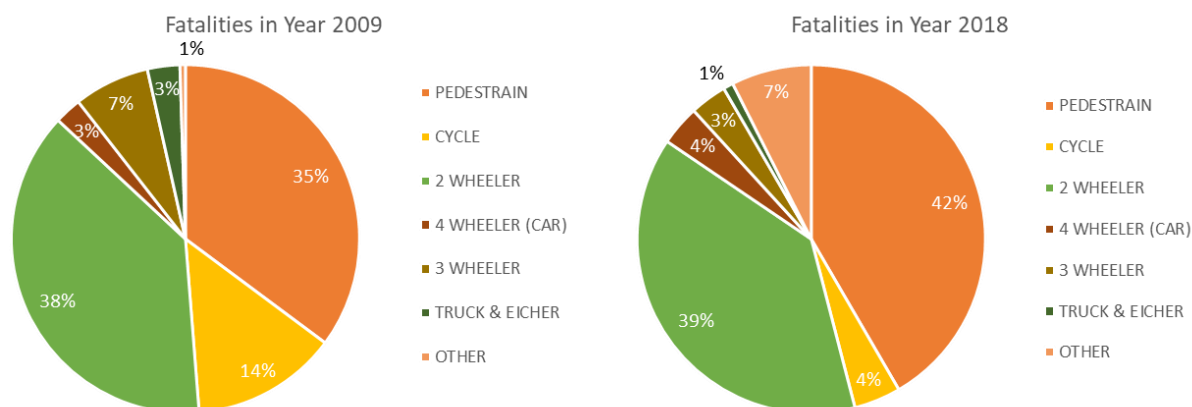


Figure 8: Comparison of 2009 and 2018 Affected Modes for Fatalities

In the case of serious road crashes, two-wheeler users (49 percent) and pedestrians (41 percent) as affected modes account for almost 90 percent of the total injuries, the numbers has increased by about 10 percent when compared to the data from 2009 (see Figure 9). Even though the proportion of pedestrians has remained the same, it is still very high in terms of the sheer number. Apart from poor pedestrian facilities in the city, poor lux levels as indicated by LOS 4 (Ministry of Housing and Urban Affairs, 2016a) on city roads may also contribute to high number of fatalities and serious injuries during night time. On the other hand, two-wheeler users have become more vulnerable, with their proportion in serious injuries increasing from 39 percent in 2009 to 49 percent in 2018. The proportion of cyclists has reduced by half due to a decline in cycle users across the city; the absolute number however is still high. The use of two-wheelers offering speed, flexibility and door-to-door service is increasing at a fast rate. However, safety of this

transportation mode still remains a question, given the poor adherence to traffic norms by users and non-compliance of the helmet wearing rule.

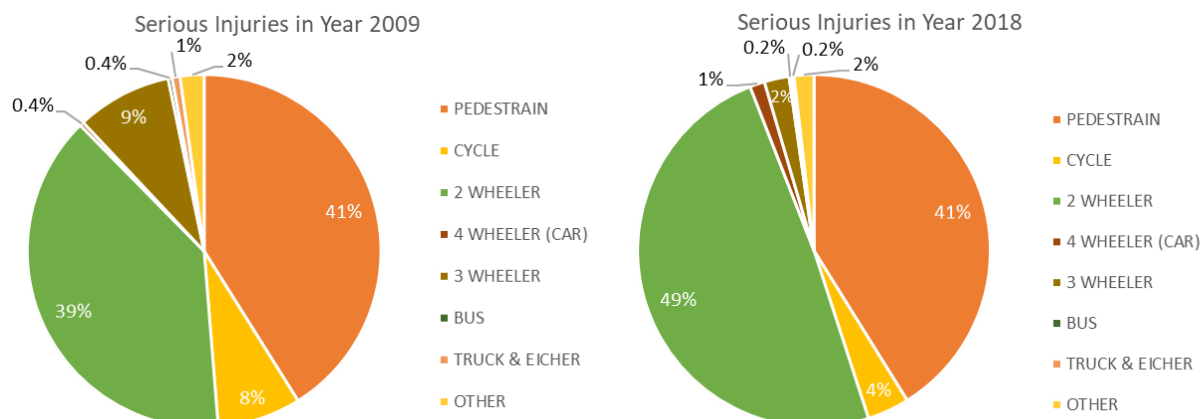


Figure 9: Comparison of 2009 and 2018 Affected Modes for Serious Injuries

Spatial distribution of pedestrian fatalities and serious injuries indicates that the spatial extent of the same, which was mostly concentrated in the old city areas and small pockets near Narol in 2009, has now spread throughout the city (refer to Figure 10). The eastern side of the city is impacted more as compared to the western one, owing to the dominance of low income households, with walking being the predominant mode of travel. Newly developing areas towards the outskirts of the city have emerged over the years as new hotspots of fatality and serious injury prone areas. It is also seen that while high concentration of fatalities and serious injuries in the Old City area was concentrated near the railway station in 2009, it has now spread to cover most of the Old City areas. Apart from this, the incidence of fatalities in areas near Nava Vadaj, CTM (Calico Textile Mill) and Bapunagar has worsened. Only 16 percent of the city is covered with footpaths of width 1.8 meters and above. Besides, only 41 percent of the junctions are signalized and, of these, almost 39 percent have signalized intersection delays. Hence, poor pedestrian facilities in the city with overall LOS of 3 contribute to the vulnerability of pedestrians in the city (Ministry of Housing and Urban Affairs, 2016b).

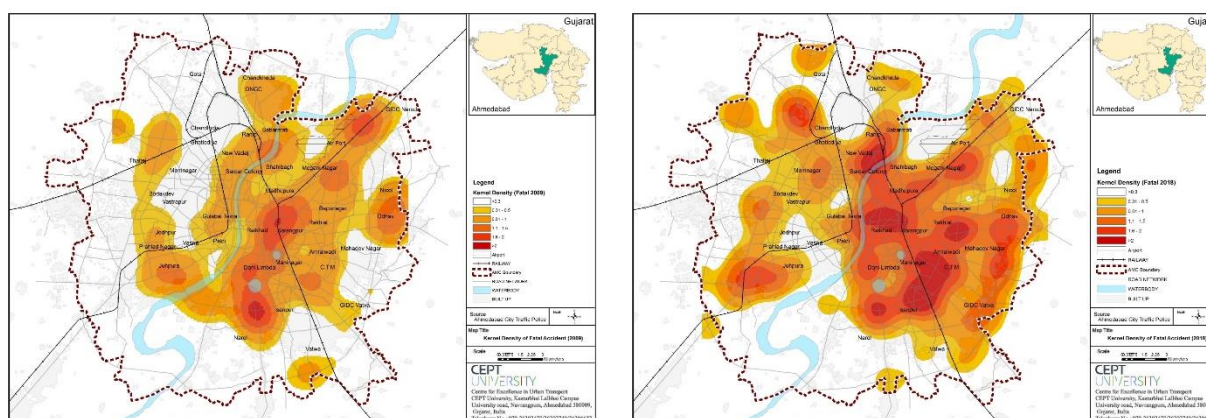


Figure 10: Distribution of Pedestrian Fatalities and Serious Injuries 2009 and 2018

If we look at the responsible modes that contribute to road crashes, it is observed that private motorised vehicle cars (26 percent) and two-wheelers (25 percent) contributed to about 41 percent of the fatalities in 2018 (refer to Figure 11). Apart from these, freight vehicles also contributed a significant 23 percent of fatalities in the same year. When compared to the 2009 numbers, the road crash trend indicates that the

fatalities due to private mode of vehicles (two-wheelers and four-wheelers) are on the rise. However, within the privatized modes, fatalities in the case of two-wheelers have more than doubled in the last 10 years. In the case of cars, the number has almost doubled. On the other hand, fatalities by freight vehicles in the city are on a declining trend and has almost halved. This reduction could be attributed to the efforts made by the city authorities in terms of imposing restrictions on the movement of heavy vehicles in the city during morning peak hours (9am to 1pm) and evening peak hours (4pm to 9pm).

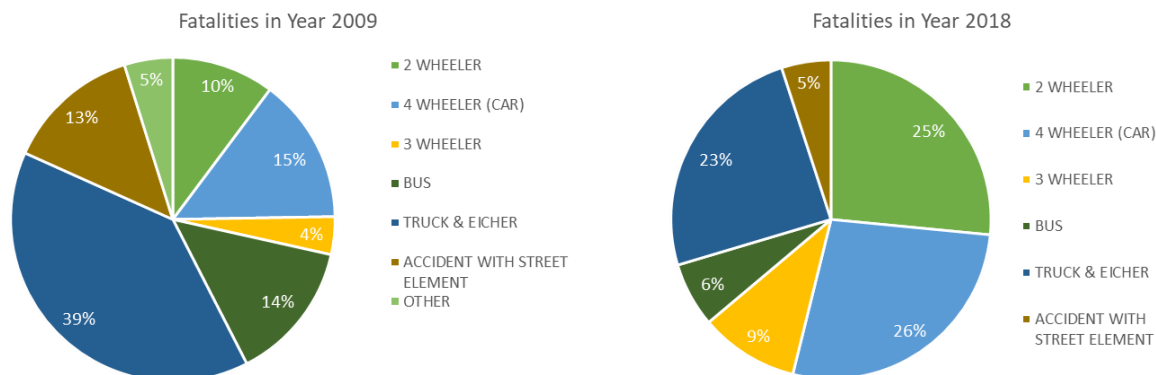


Figure 11: Comparison of 2009 and 2018 Responsible Modes for Fatalities

However, in the case of serious injuries, it is observed that 73 percent of the total serious injuries were attributed to cars and two-wheelers in 2018 (refer to Figure 12). It is seen that the private vehicles (cars and two-wheelers) have been growing at the rate of about 11 percent annually. As of 2012, about 25 percent of the total trips in the city were carried out on two-wheelers and only 4 percent on four-wheelers. Hence, the increase in both fatalities and serious injuries attributed to private vehicles is a matter of concern, especially in the case of four-wheelers, which have registered an increase in both fatal (63 percent) and serious injuries (43 percent) despite having a smaller proportion in the mode share. Reduction in road crashes due to street elements has also been observed. It could be attributed to road design improvement made by the city authorities. However, in terms of absolute numbers, road crashes due to street elements is still high.

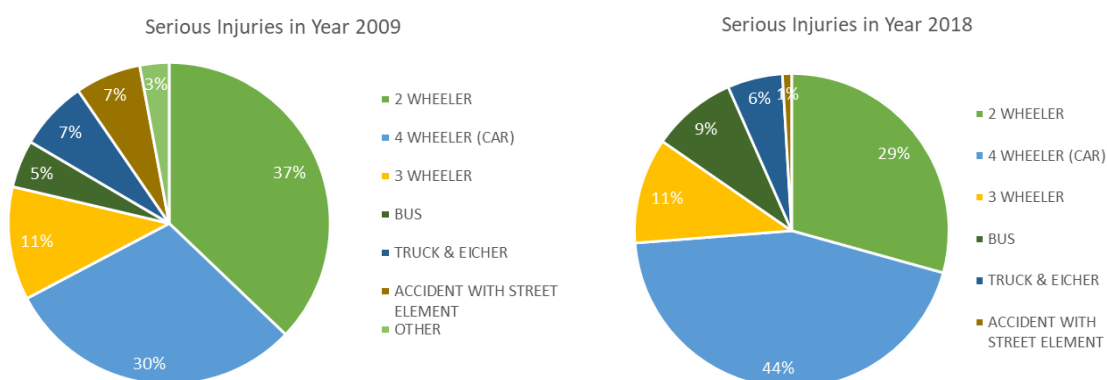


Figure 12: Comparison of 2009 and 2018 Modes Responsible for Serious Injuries

Increase in motorization, especially two-wheelers, is most evident in the South East Asian region. Studies have indicated that two-wheeler users are among the most vulnerable group in terms of fatalities and serious injuries attributed to traffic road crashes (World Health Organisation, 2015).



A recent research on compliance levels in the city on helmet usage indicates that almost half of the two-wheeler users do not wear one. The study covered 15 locations across the city and indicated that the overall compliance level in the city is at 53 percent (Centre of Excellence in Urban Transport, CRDF, CEPT University, 2019). Some of the locations, such as Kargil Petrol Pump along the SG Highway, Kalupur Railway Station and Dafnala along Airport Road, with high fatalities are found to have high compliance in 2019 owing to strict enforcement of helmet use. This may aid in bringing down fatalities at these locations (refer to Figure 13).

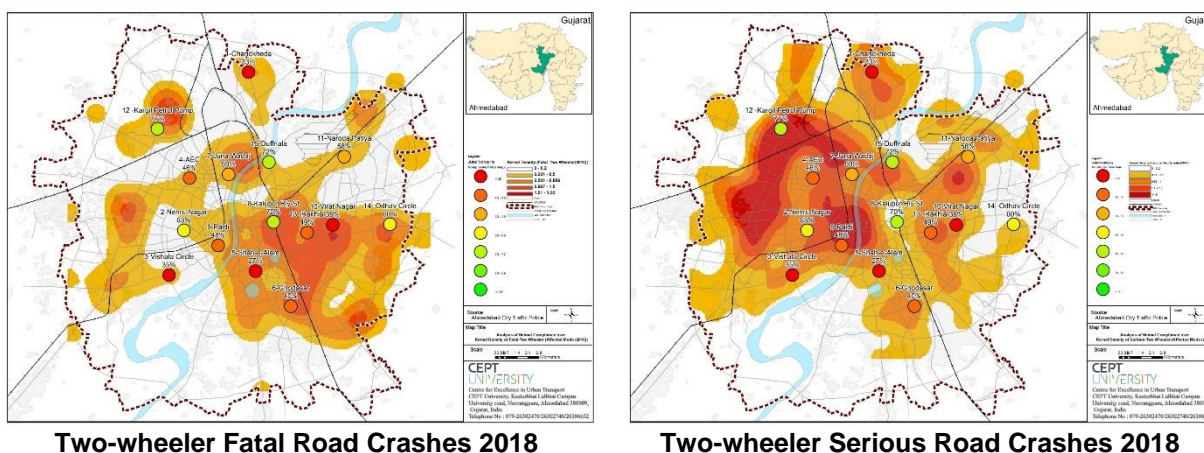


Figure 13: Helmet Use Compliance and Two-wheeler Road Crashes

## 6. Prioritizing Road Crash Hotspots for Safety Action Plan

Identification and ranking of the road crash hotspots are important to prioritise resources for a safety management plan. Hence, using the cluster analysis technique, spatial location of road crashes that occurred between 2009 and 2018 were analysed by classifying them into junctions/ intersections and mid-blocks. Results have revealed 64 hotspots locations in Ahmedabad where fatalities and serious injuries have occurred over the last 10 years (refer to Figure 14). These were further classified as per intensity as: severe locations (7–11 fatalities and serious injuries), moderately severe (11–21 fatalities and serious injuries), most severe (21–32 fatalities and serious injuries) and extremely severe (32–39 fatalities and serious injuries) locations. It was found that these locations alone contributed to about 22 percent of the total road crashes in the city. Of these, 48 locations are junctions and 16 are mid-blocks. Amongst the junction locations, almost 50 percent of them are non-signalized junctions on major arterials.

The top ten road crash locations include seven junctions and three mid-block locations: Vadaj, between Narol and Aslali junction (2), Narol Junction, Sarangpur Circle, Iskon Junction, between Narol and Aslali junction (1), Swastik Cross Road, Ellis Bridge, RTO and Aarvee Denim. These locations can be helpful in prioritizing the interventions.

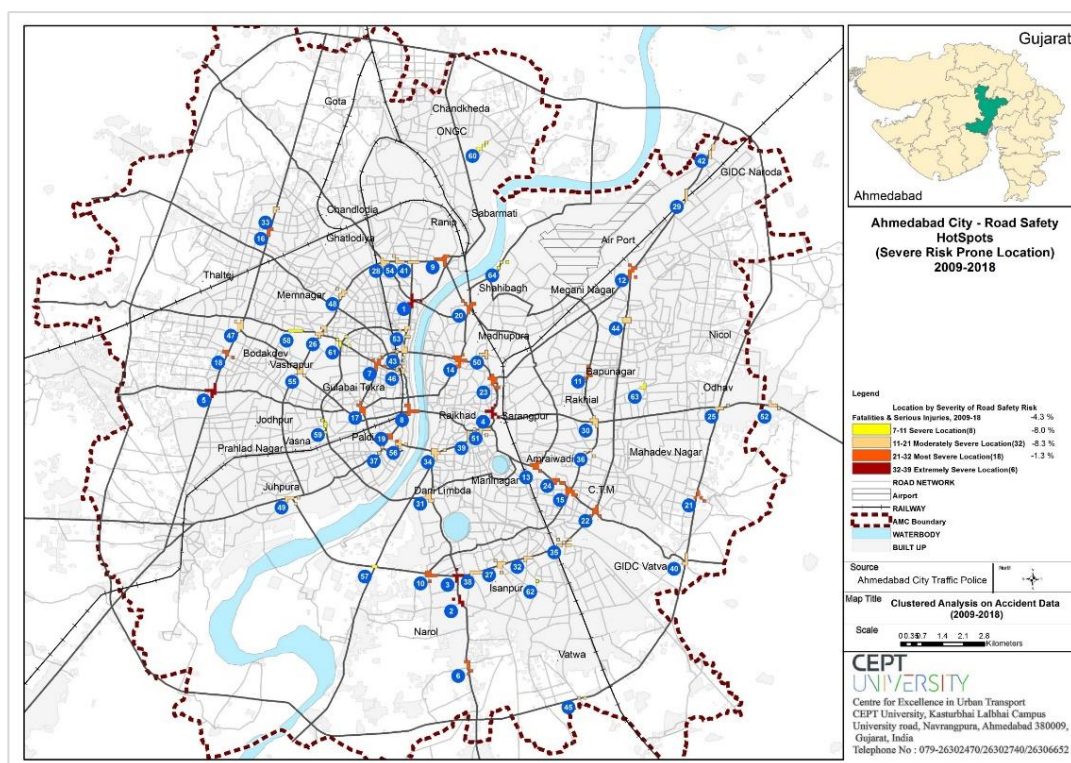


Figure 14: Road Crash Hotspots in Ahmedabad 2009 to 2019

## 7. Initiatives Taken by the Traffic Police to Improve Safety

The results of the road crash analysis were discussed with the Traffic Police Department to help them devise a safety action plan for the city. As per the discussions, it was found that the city authorities have taken up various initiatives to improve road safety. These include more vigorous enforcement of traffic rules. In this regard, traffic surveillance cameras that were installed as a part of the Smart City Mission are now being used to issue E-challan (online traffic violation penalty system) to the offenders especially in the case of stop line violation. According to the authorities, this alone has resulted in behavioural changes in the drivers who are generally seen to be abiding by regulations, especially in areas where traffic cameras have been installed.

Furthermore, safety drives on helmet use have also been carried out across the city and this has resulted in city-wide improvement of helmet rule compliance. It is expected that this will also result in reduction in two-wheeler fatalities and serious injuries in the city. Another development has been that junction improvements have been made a priority and efforts by the Traffic Police Department are underway to improve road junction design by measuring line of vision and blocking the traffic conflicting points on highways during peak hours. The Iskcon Junction, Bodakdev Crossroad have recently seen these measures being implemented. Additionally, efforts have also been made by the Traffic Police Department to keep road traffic signals working for 24 hours at major junctions to minimize collisions in the city.

The traffic authorities have already imposed restrictions on the entry of heavy vehicles which has resulted in reduction in freight related road crashes. Entry restrictions between 7am and 11pm are also in place now for long distance private bus operators in the city. Plans are also being prepared to revise speed limits on highways that pass through the city.

Ahmedabad has also introduced the BRT (bus rapid transport) as a public transport mode to discourage use of personal vehicles, along with investments along the entire street with focus on providing pedestrian facilities. On the promotional side, initiatives such as car-free day have also been introduced to bring back

the focus on pedestrians. However, more will have to be done in terms of managing the growth of privatized vehicles in the city to see reductions in fatalities and serious injuries in the longer run.

## 8. Conclusions and Learnings

Analysing road crashes data for Ahmedabad revealed that road crashes in the city are increasing and the overall road crashes per hundred thousand population is high at 3.8. Exposure of the working age group (18 to 60 years) to road crashes including fatalities also indicates a serious issue. Research conducted by the World Health Organization in the South East Asian region suggested that the indirect cost of RTI (road traffic injuries) is high and it imposes a great burden on not only individuals but also families and the government. It also estimated that about 2 percent of the GDP is lost due to road traffic injuries in India alone (Aeron, Jacob, Sexton, Gururaj, & Rahman, 2004). The vulnerability of the poor in developing countries is also underlined as they are exposed to unsafe traffic environment and are unable to afford healthcare (World Health Organisation, 2015).

Pedestrians and two-wheeler users have emerged as the predominant affected mode users. Poor pedestrian facilities across the city remain as one of the predominant reason behind pedestrian fatalities and serious injuries. Two-wheeler users have replaced cyclists due to reduction in their overall numbers over time. Tackling the issue of two-wheelers as a choice mode (owing to the flexibility it provides and the sheer number of users in the city) will remain a difficult challenge to manage.

On the other hand, in terms of contributing modes towards road crashes, the dominance of heavy freight vehicle as a responsible mode is no longer observed. It is cars which have now become the predominant contributor to fatalities across the city. The growing trend of cars in the city in conjunction with poor traffic regulation adherence has become a pressing issue. Today, although cars as a transportation mode have become safer for car drivers, the on-street behaviour of the car users' requires attention. Hence, ways to reduce car use and calm vehicle speeds will need to be explored.

While the proportion of fatalities and serious injuries as a result of road crashes attributed to poor street elements has reduced in the city from 9 percent in 2009 to 2 percent in 2018, their absolute number (17 in 2018) is still high.

The above trend is not restricted to just Indian cities—in fact urban areas of most of the developing countries in South East Asia are struggling with similar issues, especially given the high prevalence of two-wheelers. In this context, helmet use and adhering to traffic rules assumes paramount significance. Ahmedabad is known for poor adherence to traffic laws. However, the introduction of video surveillance under the Smart City Mission has been helpful in improving the overall adherence to traffic regulation in the city. In line with the efforts to improve road safety, the city police authorities have initiated the online traffic violation penalty system for road traffic violations in 2016, to compel wider public use of helmets and safety belts while driving. E-surveillance has resulted in changing driver behaviour for the better in most parts of the city. It was also seen that continuous enforcement of regulations, such as wearing helmets and seat belts, has also resulted in improvement in user behaviour in areas where the enforcement drives were carried out as compared to areas where they were not.

Highways passing through Ahmedabad have high incidence of fatal and serious road crashes. High speeds coupled with intrusion of freight vehicles on these corridors seem to be the reasons for this. Even though the traffic police has been able to reduce road crashes as a result of entry restrictions for freight vehicles in the city to almost half, more needs to be done in this regard. Speed restrictions enforcement could help significantly towards reduction in the quantum of road crashes. This should be supplemented by a more stringent overall enforcement of traffic regulations as a step towards ensuring greater road safety.

Techniques like hotspot analysis have provided 64 specific high risk locations in the city which needs to be further investigated by the authorities. These locations become important from the perspective of reducing road crashes in the city—the city authorities can take up these locations on a priority basis to ascertain the exact cause of the road crashes along with enforcing the mitigating measures in these areas. Since resources are a constraint in most of the developing cities across the world, this technique can be helpful

in devising an effective and economical road crash reduction plan for the city. Simple measures like signalization, speed restrictions, improvement in pedestrian facilities and lux levels could go a long way in reducing the overall incidence of road crashes in the city. However, focus on public transportation modes and discouraging the use of personal private vehicles will remain the substantial measure if significant reductions in road crashes are to be seen.

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