COMPARISON OF ROAD TRAFFIC CRASH SCENARIO IN MEGA, MEDIUM AND SMALL SIZED INDIAN CITIES

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ABSTRACT

The burden of Road Traffic Injuries in India has been rising as the number of deaths has more than doubled from 1991 through 2011. Thus it is imperative that the issues are figured out at the root level so that timely actions can be taken to avoid worsening the scenarios. The paper examines the immensity of the problem of road safety in small sized Indian cities of Patiala and Rajpura by computing the risk to personal safety of an individual and risk of motor vehicles involvement in fatal crashes. Further, it assesses the traffic safety scenario in mega, medium and small sized Indian cities by comparing the modal share of fatalities from the fatal road traffic crash data. The study concludes that the individual relative risk to personal safety is greater in Rajpura but the relative risk of vehicle occupant fatality is higher in Patiala. Comparing the traffic safety scenario in all sized Indian cities it has been found that the pedestrian fatalities increases and MTW fatalities decrease with the increase in city size. It has been observed that the average pedestrian fatalities in mega-sized Indian cities are 2 times higher than the small sized cities. The average MTW fatalities in small, medium and megacities account for 48%, 39% and 28% of the total fatalities respectively. The high proportion of MTW fatalities in small cities is possibly because the proportion of MTW ownership is higher in smaller cities than in megacities. The underlying reasons for such trends require further research.

KEYWORDS: Risk, urban traffic safety, Indian cities

1. INTRODUCTION

The importance of issues in different countries can be examined by the number of scholarly articles published on those subjects in those countries. India is the second most populous country after China in the world. In spite of being the second most populous country, it contributes only 0.7% of the peer-reviewed papers on road safety and out of which only one third included modeling and statistical analysis. The developed countries have shown that increasing research in the problematic areas has lead to substantial reduction in the size of the problems in many countries (*1*) (*2*) (*3*) and specifically so in the United States in the field of road safety (*4*).

India has been witnessing a continuous increase in the number of road traffic fatalities with the deaths having approximately doubled in two decades since 1991 (*5*) (*6*) resulting in an estimated 3% GDP loss (*7*). Simultaneously the number of vehicles has grown exponentially during this time (*8*) (*9*). Thus certain active measures need to be adopted by understanding the traffic safety scenarios in Indian cities.

The study examines the seriousness of the problem of road safety in the small sized Indian cities of Patiala and Rajpura by estimating road safety indices. The second part of the study compares the safety scenario of small sized Indian cities to medium and mega-sized Indian cities to obtain

prevalent trends of most vulnerable victims so that pre-emptive measures can be taken to improve the overall safety scenarios.

2. ROAD SAFETY INDICES

In transportation, risk is the likelihood of an injury or a crash and risk factor is anything which increases the likelihood of a crash. Risk assessment can be done in two ways- risk estimation by making estimates of probabilities and consequences and risk evaluation by making overall judgement on the importance of risk. Road safety professionals estimate the probability of crash occurrence by calculating the size or seriousness of its consequences for making effective policy decisions.

There are several different indicators or indices available to study the immensity of the problem of road safety. The risk due to road traffic crashes can either be expressed as an absolute or relative risk. The absolute risk statistic gives statistical certainty that a given percentage of the exposed population (say MTW riders) will suffer a fatality or injury over a certain distance traveled in given period of time. The relative risk statistic, however, conveys how much more or less likely it is that people with the risk factor (say people not wearing seat belts in a car) will sustain injuries or a fatality as compared to those exposed to a different risk factor other conditions remaining the same.

Several road safety indicators are rates which are estimated using various numerators and denominators. The numerators can include events counted in crashes, fatalities, etc. The denominator can be grouped into two general categories. The first includes the number of crashes or fatalities during a certain period of time, say a year, per unit vehicle, persons or road length, for example, fatalities per million population, per 10000 registered vehicles or 1000 km highway. The second category includes the number of harmful events per unit of exposure for a given type of road user, for example, fatalities per 10 million motorcycles, cars, trucks, etc. The absolute value of road traffic fatalities can be used for comparison with other causes of mortality. This conveys about the burden of road traffic injury as a public health burden.

2.1 Fatalities Per Unit Population

The index highlights the relative effect of road traffic crashes on the population compared to other causes of death. Fatalities per 100,000 population is an indicator of personal safety or the extent to which road traffic crashes affect the safety of a population.

It must be noted that this measure should not be used for comparison of safety scenarios of highways at different locations as this does not account for the actual presence of the number of vehicles or persons (*10*). However, it can be used for comparing fatalities per unit population among countries or cities with similar population densities or travel patterns or vehicle ownership rates. It can be best used for evaluating the health burden of road traffic injuries in a community.

It gives us a measure of overall assessment of road traffic fatalities as a health burden for the society indicator for comparing the risk of motor vehicles involvement in fatal crashes. However, the indicator is misleading in comparing the effectiveness of road safety policies in different countries. It can be used for comparing two areas only when the two areas compared have similar traffic patterns on the roads and has similar vehicles, bicycles, and pedestrians present. Lower is the index better it is for the individuals or the governments.

2.2 Fatalities Per Unit Vehicle Population Per Year

It is the most commonly used indicator of risk and is often referred to as a measure of traffic safety. The numerator is the number of traffic fatalities during a fixed period of time and the denominator is the average population of the registered vehicles during the same period. It is a good measure for estimating the risk of motor vehicles involvement in fatal crashes. However, the indicator is misleading in comparing the effectiveness of road safety policies in different countries.

3. DATA

The data in the form of first information reports (FIRs) have been collected for the two cities from the Senior Superintendent of Police office of Patiala where monthly records of all the registered FIR's were available for the years of 2013, 2014 and 2015. From the records, all the fatal road traffic injuries cases of the police stations within the city boundary were enlisted and the print was taken out from the Punjab police website knowing the FIR number and the police station name. There are five police stations in Patiala and two police stations in Rajpura city. All the FIRs in which charge 304A was lodged were collected. These essentially include the cases in which at least one person died in a traffic crash. A total of 188 and 61 fatal road accidents were recorded in Patiala and Rajpura respectively in 3 years from 2013 to 2015.

3.1 Population Data

The population of Patiala and Rajpura has been obtained from the Registrar General and Census Commissioner India, Census of India 2011 website (11). The population of Rajpura is 92,301 persons with 48,340 males and 43,961 females and Patiala has 446,246 persons with 236,198 males and 210,048 females as per Census of India, 2011, as shown in Table 1 and Table 2.

TABLE 1 Population of Patiala in 2013, 2014 and 2015

Year	Population	Males	Females
2011	4,46,246	2,36,198	2,10,048
2012	4,55,001	2,40,600	2,13,963
2013	4,63,928	2,45,085	2,17,951
2014	4,73,030	2,49,653	2,22,014
2015	4,82,311	2,54,307	2,26,152

TABLE 2 Population of Rajpura in 2013, 2014 and 2015

Year	Population	Males	Females
2011	92,301	48,340	43,961
2012	94,111	49,241	44,874
2013	95,958	50,158	45,806
2014	97,841	51,093	46,757
2015	99760	52046	47728

The decadal population growth in the Patiala district is 19.6% with 18.6% decadal growth rate of males and 20.8% decadal growth rate of females (11). Thus using the compound interest per year growth rate the population for the years of 2013, 2014 and 2015 have been computed for Patiala and Rajpura as shown in Table 4.

3.2 Vehicle Registration Data

The data of the vehicles registered in Patiala and Rajpura have been obtained from the District Transport Office (DTOs) in Patiala. The details of all the vehicles registered in the years 2013, 2014 and 2015 have been obtained which includes vehicle classification type, date of registration, vehicle number, etc which have been described in Table 3.

TABLE 3 Vehicle Registration Details of Patiala and Rajpura in 2013, 2014 and 2015

	Total vehicles registered		MTWs registered	
Year	**Rajpura**	**Patiala**	**Rajpura**	**Patiala**
2013	1190	69218	1019	44219
2014	2259	72184	1646	48738
2015	1453	59538	871	41698
Total	**4902**	**200940**	**3536**	**152495**

The vehicle classification adopted by the government has 103 vehicle types which have been converted to twenty-six vehicle classifications as described in Table 4 below.

TABLE 4 Vehicle Classification Adopted in the Study

Vehicle Classification		
Sl. No.	**Value**	**Group**
1	Multi Axle Heavy Goods Vehicle	Truck
2	2 Axle Heavy Goods Vehicle	Truck
3	Light Goods Vehicle	Truck
4	Mini Bus	Bus
5	Bus	Bus
6	Car/ Van/ Jeep/ Taxi	Car
7	Ambulance	Bus
8	Fire Fighting Vehicle	Truck
9	Three Wheeler Passenger	TSR
10	Three Wheeler Goods	TSR
11	Thela	Others
12	Electric Cycle	MTW
13	Tractor without Trailer	Truck
14	Tractor with Trailer	Truck

Vehicle Classification

Sl. No.	Value	Group
15	Cycle Rickshaw	Cycle
16	Motorcycle/ Scooter/ Moped	MTW
17	Animal-drawn vehicle	Others
18	Bicycle	Cycle
19	Tree	Others
20	Kerb	Others
21	Median	Others
22	Pole	Others
23	Pedestrian	Pedestrians
24	Others	Others
25	Unknown	Unknown

4. COMPUTATION OF ROAD SAFETY INDICES

4.1 Fatalities Per 100,000 Population

Using the available data of population, vehicles registered per year and the number of fatalities per year using the FIR reports, fatalities per 100,000 population and fatalities per 10,000 vehicles registered per year for Patiala and Rajpura have been computed. Table 5 and Table 6 describes the fatalities per 100,000 population index computation for Patiala and Rajpura respectively. The Table 5 and Table 6 shows the total fatalities year wise with the number of male and female fatalities in Patiala and Rajpura. Thus we see the variation of fatalities per 100,000 population in the two small cities of Patiala and Rajpura.

TABLE 5 Population and Road Traffic Fatality Details for Patiala

Year	2013	2014	2015
Population	4,63,928	4,73,031	4,82,312
Total Fatalities	58	67	50
Fatalities per 100,000 population	13	14	10
Male Population	2,45,086	2,49,654	2,54,307
Male fatalities	50	58	44
Male Fatalities per 100,000 male population	20	23	17
Female Population	2,17,952	2,22,014	2,26,153
Female fatalities	8	9	6
Female Fatalities per 100,000 female population	4	4	3

TABLE 6 Population and Road Traffic Fatality Data for Rajpura

Year	2013	2014	2015
Population	95,958	97,841	99,761
Total Fatalities	23	15	26
Fatalities per 100,000 population	24	15	26
Male Population	50,159	51,094	52,046
Male fatalities	18	12	23
Male Fatalities per 100,000 male population	36	23	44
Female Population	45,806	46,757	47,729
Female fatalities	5	3	3
Female Fatalities per 100,000 female population	24	15	26

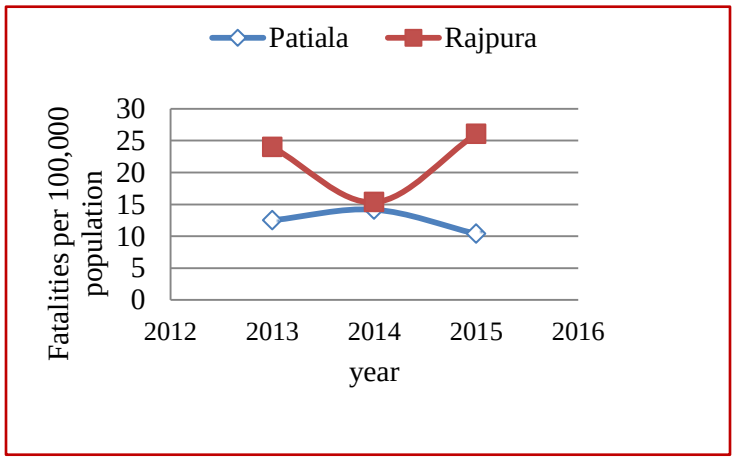

FIGURE 1 Fatalities per 100,000 population indices in Patiala and Rajpura in 2013, 2014 and 2015

It has been observed in Figure 1 that fatalities per 100,000 population indicator in Rajpura decreases from 24 in 2013 to 15 in 2014 and then dramatically increases to 26 in 2015. However, in Patiala, the indicator rises from 13 fatalities per 100,000 population in 2013 to 14 and then drops down to 10 fatalities per 100,000 population in 2015, assuming the population increases at the rate of 1.96% and other factors remaining the same. No probable cause for the dip in the indicator in the year 2014 can be figured out. A similar trend in the male fatalities per 100,000 male population and female fatalities per 100,000 female population variations year-wise has been observed in Patiala and Rajpura as shown in Figure 2 and Figure 3 respectively.

However, as shown in Figure 4 the variation of fatalities per 100,000 population category wise in Patiala and Rajpura it is observed that the index has very large values for males for each of the years relative to females. This conveys that males are prone to the greater risk of road traffic fatalities relative to females in small cities. Also, the individual risk on the personal safety of the population is greater in Rajpura as compared to Patiala.

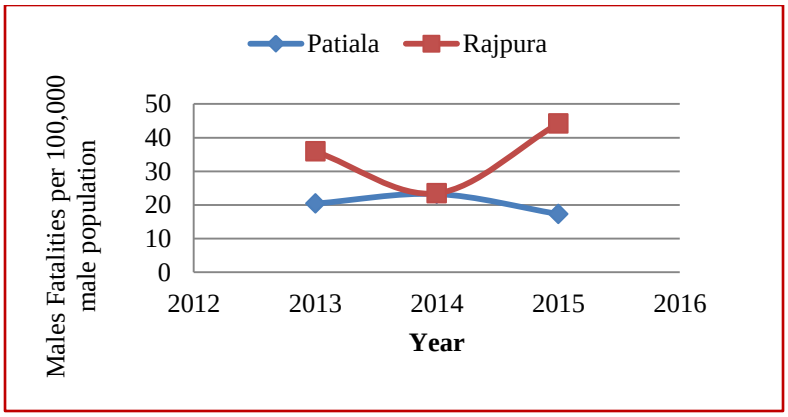

FIGURE 2 Male fatalities per 100,000 male population indices in Patiala and Rajpura in 2013, 2014 and 2015

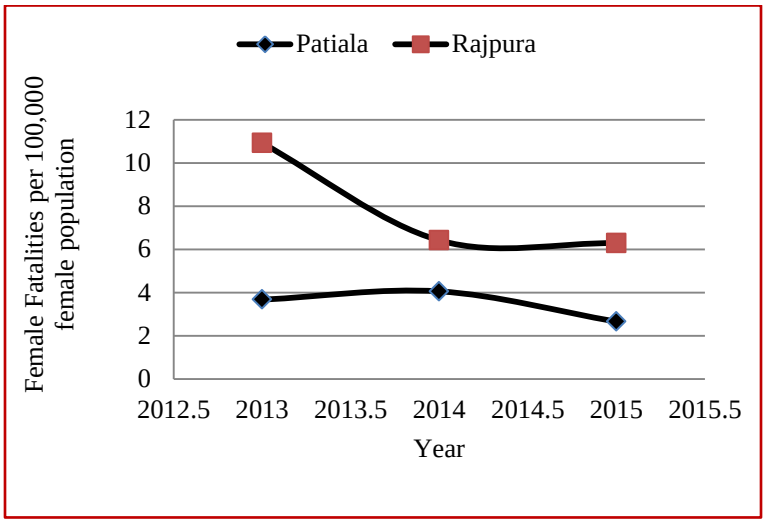

FIGURE 3 Female fatalities per 100,000 female population indices in Patiala and Rajpura in 2013, 2014 and 2015

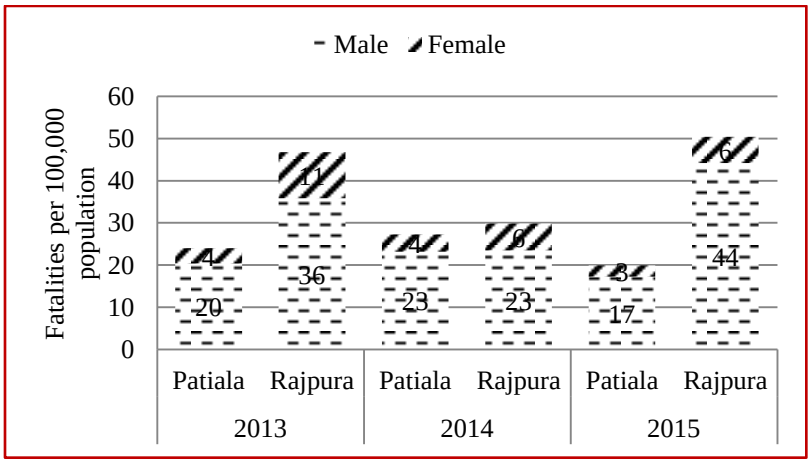

FIGURE 4 Representation of fatalities per 100,000 population category wise in Patiala and Rajpura

4.2 Fatalities Per 10,000 Vehicles Registered Per Three Year

Further using the number of vehicle registered per year data for the two cities, fatalities per 10,000 vehicles registered per three-year has been computed which has been shown in Figure 5. It conveys that the risk motor vehicle occupant involvement in fatal crashes in Patiala is relatively very high as compared to the risk in Rajpura. Thus the relative risk of vehicle involvement in fatal crashes is very large in Patiala relative to Rajpura indicating that the scenario of traffic safety is worse in Patiala with respect to Rajpura in the perspective of vehicles.

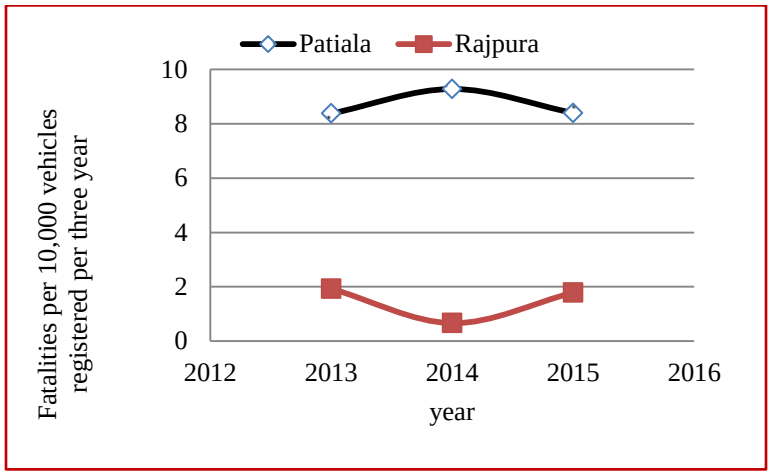

FIGURE 5 Fatalities per 10,000 registered vehicles per three years in Patiala and Rajpura

Figure 6 shows the index of MTW fatalities per 10,000 MTWs registered per three years. It can be observed that the risk of MTW occupant involvement in a fatal crash is much higher in Rajpura than in Patiala. Further Figure 7 shows the index of truck fatalities per 1000 registered trucks per three years in Patiala and Rajpura. It is observed that no truck fatality has been observed in Patiala in the three years however the truck fatalities per 1000 registered trucks per three years in Rajpura are two fatalities per 1000 registered trucks per three years. This could possibly have been because a number of National Highways pass through Rajpura city, which includes NH-01 and NH-64 and the exposure to trucks and freight vehicles are greater in Rajpura.

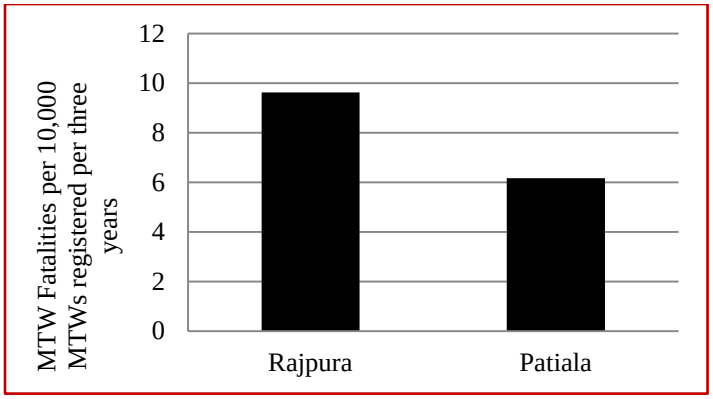

FIGURE 6 MTW fatalities per 10,000 MTWs registered per three years in Patiala and Rajpura

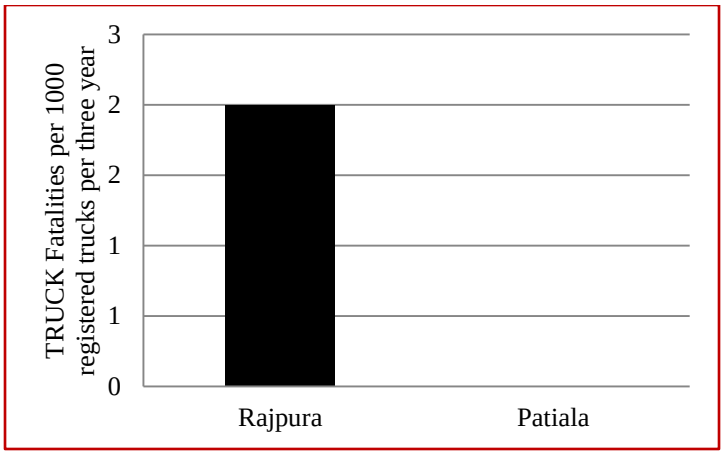

FIGURE 7 Truck fatalities per 1000 registered trucks per three years in Patiala and Rajpura

5. COMPARISON OF TRAFFIC SAFETY SCENARIOS IN SMALL, MEDIUM AND MEGACITIES

Several studies have been previously conducted on mega-sized (12) (13), medium sized (14) and small sized (15) cities of India to understand the traffic scenarios in these cities. This study aims to conduct the traffic safety assessment in small size Indian cities to understand the existing scenarios and to compare the scenario with the larger sized Indian cities. The cities are undergoing rapid urbanization and the small city of today is going to be a large city in the future. Adopting treatment strategies in small cities now will help not alleviate the problem later and hence worsen the situations. Design amendments and adopting treatment measures are relatively easier in small cities before they become more congested and sprawled. India has been witnessing urbanization at a very rapid pace with an absolute increase in the urban population relative to rural population (16). Moreover, it is anticipated that by 2050 nearly 80% of the world's population will be urbanized (17). Also, the smaller cities become more congested and sprawl and will be larger cities in the future. Thus it is important that the issue is figured out at the root level. Figure 8 shows the modal share of road traffic fatalities in small, medium and mega Indian cities. It has been seen that VRU fatalities in all sized Indian cities form the largest proportion of the total road traffic fatalities. They constitute around 83% and 89% of the fatalities in the mega cities of Delhi and Mumbai. Whereas in medium-sized cities the VRU fatalities account for 84% to 93% of the fatalities and in small cities 75% of the fatalities in Rajpura and 87% of the fatalities in Patiala are constituted by the VRUs. These results convey that for all sized Indian cities the most prone road users are pedestrians, bicyclist, and MTWs.

It has been observed that the average pedestrian fatalities in mega-sized Indian cities are 2 times higher than the small sized cities. The average pedestrian fatalities in small, medium and mega-sized cities are 23%, 37%, and 53% respectively. The average MTW fatalities in small, medium and megacities account for 48%, 39% and 28% of the total fatalities respectively. Also, the car occupant fatalities in medium and mega cities range between 2% and 4% whereas in small cities they range between 7% and 14% of all traffic fatalities. Thus with the increasing city size, the relative proportion of pedestrian fatalities keeps increasing and relative proportion of MTW fatalities keeps decreasing. The high proportion of MTW fatalities in small cities is possibly because the proportion of MTW ownership is higher in smaller cities than in megacities (18).

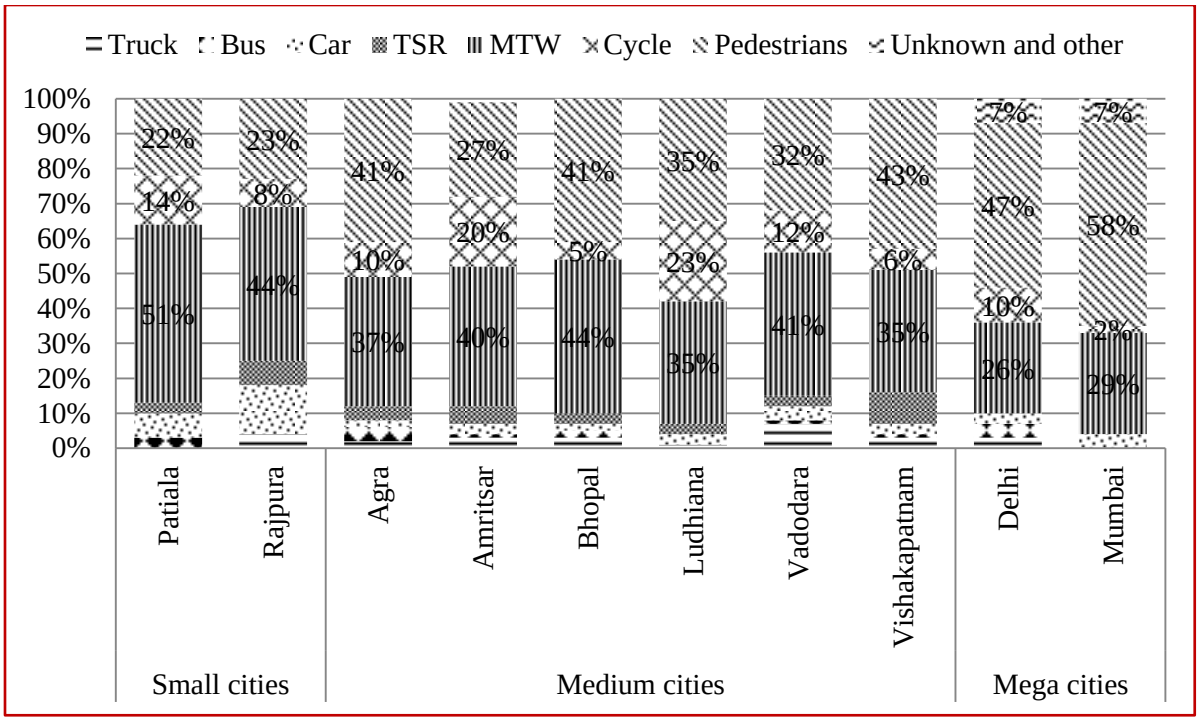

FIGURE 8 Modal share of road traffic fatalities in small, medium and mega cities

In the vehicle occupant fatalities, MTWs have the highest share of fatalities for all sized Indian cities. The MTW fatalities range between 35% and 44% of the total fatalities in medium sized Indian cities, 44% and 51% in small sized Indian cities and 26% and 29% in mega-sized Indian cities.

6. CONCLUSION

The study investigates the seriousness of the problem of road safety in the two small sized cities of Patiala and Rajpura using fatal crash records, population, and vehicle registration data for a period of 3 years from 2013-2015 by computing road safety indices. Further, it compares the traffic safety scenario in small, medium and mega-sized Indian cities to understand the prevalent traffic safety scenarios and associated problems.

It has been found that the males are prone to greater risk of getting road traffic fatalities relative to females in small cities. Also, the individual risk on the personal safety of a population of getting involved in road traffic crash is greater in Rajpura as compared to Patiala. However, the risk of vehicle occupant fatality is larger in Patiala indicating that the scenario of traffic safety is worse in Patiala with respect to Rajpura. The risk of MTW occupant involvement in a fatal crash in Rajpura is higher than in Patiala as the index of MTW fatalities per 10,000 MTWs registered in Rajpura has a higher value than in Patiala. However, the risk of truck occupant fatality is higher in Rajpura. This could be possibly because NH-01 and NH-64 pass through Rajpura.

Comparing the traffic safety scenario in all sized Indian cities it has been found that the pedestrian fatalities increases and MTW fatalities decrease with the increase in city size. It has been observed that the average pedestrian fatalities in mega-sized Indian cities are 2 times higher than the small sized cities. The average MTW fatalities in small, medium and megacities account for 48%, 39% and 28% of the total fatalities respectively. The high proportion of MTW fatalities

in small cities is possibly because the proportion of MTW ownership is higher in smaller cities than in megacities. Also, the car occupant fatalities are 3 times higher in small cities relative to medium and mega cities. The underlying reasons for such trends require further research.

REFERENCES

(1) Elvik R. An analysis of official economic valuations of traffic accident fatalities in 20 motorized countries. *Accident analysis & prevention* 27, No. 2, 1995, pp. 237-247.

(2) Wyatt JP, Beard D, Gray A, Busuttil A, Robertson CE. Rate, causes and prevention of deaths from injuries in south-east Scotland. *Injury* 27, No. 5, 1996, pp. 337-340.

(3) DiGuiseppi C, Roberts I and Li L. Influence of changing travel patterns on child death rates from injury: trend analysis. *BMJ* 314, No. 7082 ,1997, pp. 710.

(4) Robertson LS. Reducing death on the road: the effects of minimum safety standards, publicized crash tests, seat belts, and alcohol. *American Journal of Public Health* 86, No. 1, 1996, pp. 31-34.

(5) NCRB (2012). Accidental deaths and suicides in India 2011. National Crime Records Bureau, Ministry of Home Affairs, New Delhi (2011).

(6) Garg N, Hyder AA. Exploring the relationship between development and road traffic injuries: a case study from India. *The European Journal of Public Health* 16, No. 5. 2006, pp, 487-491.

(7) Planning Commision. Tenth Five Year Plan 2002-2007, *Sectoral Policies and Programmes*, Volume 2, Planning Commission, Government of India, New Delhi, 2009. Retrieved 23 September 2016 http://planningcommission.gov.in/plans/planrel/fiveyr/10th/volume2/10th_vol2.pdf

(8) Pucher, J., Peng, Z.R., Mittal, N., Zhu, Y. and Korattyswaroopam, N., 2007. Urban transport trends and policies in China and India: impacts of rapid economic growth. *Transport Reviews*, *27*(4), pp.379-410.

(9) MORTH, Road Transport Year Book (2011-2012). Transport Research Wing, Ministry of Road Tranport and Highways, Government of India, New Delhi, 2012.

(10) Mohan, D., Tiwari, G., Bhalla, K, *Road safety in India status report- 2015*, Transportation Research and Injury Prevention Programme, Indian Institute of Technology Delhi, 2015.

(11) Census of India, 2011. The Registrar General & Census Commissioner, India, New Delhi, Ministry of Home Affairs, Government of India. Retrieved 16 February 2017 **http://censusindia.gov.in/pca/cdb_pca_census/Houselisting-housing-PUNJAB.html**

(12) Delhi traffic police, Road accidents in Delhi – 2013. Accident Research Cell Delhi Police, New Delhi, 2014.

(13) Mani. A, Tagat. A. Safety Assessment of Auto-rickshaws in Mumbai, *Embarq India*, Mumbai, 2013, pp. 1-13.

(14) Mohan D, Tiwari G, Mukherjee S. Urban traffic safety assessment: a case study of six Indian cities. *IATSS research* 39, No. 2, 2016, pp. 95-101.

(15) Dhanoa, K. K., Tiwari, G., Malayath, M.. Method to identify blackspots with minimal available police data. *Eastern Asian Society for Transportation Studies,* in press.

(16) Bhagat, R.B.. Emerging pattern of urbanisation in India. *Economic and Political Weekly 46, No.* 34, 2011, pp.10-12.

(17) Bettencourt L, West G. A unified theory of urban living. *Nature* 467, No. 7318, 2010, pp, 912-913.

(18) Mohan, D., Tsimhoni, O., Sivak, M. and Flannagan, M.J., 2009. Road safety in India: challenges and opportunities. *University of Michigan, US*.