日本とインドにおける交通事故トレンドのモデル化とその分析

ANALYSIS AND MODELING OF ROAD ACCIDENT TRENDS IN JAPAN AND INDIA

コリセティ・ヴンカタ・ガネッシュ・バブ*　朝倉康夫**　黒田勝彦**
By Kolisetty. V. Ganesh Babu*, Prof. Yasuo Asakura and Prof. Kuroda Katsuhiko****

1.0 Introduction

Transportation is one of the most important infrastructure requirements, which is essential for the expansion of opportunities and plays an important role in making or breaking the economy. Road traffic accidents and injuries are a major problem globally and road safety plays an important role in any country's development. Apart from having the usual problems resulting from urbanization and tremendous increase in motorized traffic such as congestions, environmental pollution etc, Japan and India, are facing an acute problem of road accidents. The death toll due to road accidents in these countries especially in India has been increasing every year and there appear to be no indication that the situation would change for the better despite numerous efforts geared towards dealing with the problem.

In summary, the present paper aims to discuss the road accident situation in Japan (Developed country) and India (Developing country) and analyse the past and present trends in road accidents, causalities and fatalities. The accident trends are compared with other developed countries like Australia, Canada, European Union, U.K. and U.S.A. to bring a comparative assessment of the gravity of the problem especially faced by India. Attempts are made to explore possible relationships between accident fatalities and accident exposure variables. In this study it is assumed that exposure of road users may be represented as population size and the exposure to the vehicle system is represented by number of registered motor vehicles. Regression analysis is used to get a number of statistically significant accident trend models for accident fatalities based on population size and number of registered vehicles. Two types of data sets are considered for analysis i.e., (a) same years data for Japan and India (1970 to 2000) and (b) different years data for Japan (1951 to 1970) and for India (1981 to 2000). Reasonable estimates and similarities are obtained between these countries with the analysis of data set (b), which resulted in the form of recommendation of safety measures to India with the experience of Japan in reduction of road accident fatalities since 1970.

2.0 Accident trends in Japan

Japan is a small country where over 120 million people live and more than 70 million vehicles travel each day, about one million people are killed or injured in traffic accidents each year. In addition, congestion in various parts of the country due to the increase in vehicle traffic causes a time loss of 5.3 billion hours annually, which corresponds to an economic loss of JPY 12 trillion. Construction of a sufficient road network to accommodate such a large volume of traffic, however, is difficult, because of the geographical restrictions such as the narrow land area and steep terrain and social restrictions such as excessively concentrated land use. Therefore it is necessary to effectively use road resources to resolve the problems like road accidents, congestion and delays, environment. In Japan, in the post-war period, from the early 1950s through to the early 1970s, the annual number of fatalities resulting from road traffic accidents rose steadily. This was due to several factors, including a lack of traffic safety infrastructure and the rapid growth in private motor vehicle ownership. Between 1951 and 1969, annual road fatalities rose from 4429 to 16257, while annual injuries soared from 31274 to 967000. With the application of several traffic safety measures the latest statistics show that annual traffic accident fatalities fell below 10000 in 1996, 9211 in 1998 and further down to 9066 in 2000, despite the unfortunate fact that traffic accident injury rates continue rising as the total number of vehicle owners, driving license holders and vehicle-kilometers traveled increases. In fact, total traffic accident injuries (990675) for 1998 was the worst figure on record. A survey conducted by Ministry estimated an economic loss of 4285 billion yen, which includes loss due human, property, social costs arising from operations of public authorities. Within the situation where motorized traffic increased dramatically it may be too drastic to expect that the actual number of accidents to drop significantly. Although it is quite common to observe the accident trend as indexed to certain exposure variables.

Figure 1 (a) and (b) presents the road accident situation and trends in accident fatality rates in terms of fatalities per 100000population, fatalities per 100 casualties, fatalities per 100 accidents and fatalities per 10000registered motor vehicles. This figure shows downward trend of all parameters with respect to fatalities. Even though there is decrease in number of accident fatalities; number of road accidents and accident injuries, population and registered motor vehicles are increasing steadily. By observing the age wise fatalities, it can be concluded that fatalities are equally distributed in the middle age (20 to 40 years) and in the old age (70 and over). This will also reflect more in number of pedestrian fatalities. From these figures it can also be observed that number of road accidents and number of casualties are increasing

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* Ph.D. Student　** Professor
Urban and Transportation Planning Lab, Department of Civil Engineering, Kobe University, 1-1 Rokkodai, Nada-ku,
KOBE 657-8501 (Tel & Fax: 81- 78- 8036008 / 8036208)
E-mail: 005d908n@y02.kobe-u.ac.jp/ asakura@kobe-u.ac.jp/ kurodak@kobe-u.ac.jp

steadily and it will affect the society of Japan in future by creating more number of health related problems due to accident injuries. Furthermore, Japan is expected to become an unprecedented aged society where the elderly population increases while total population and productive-age population fall. By 2020, the elderly aged 65 years and older will account for 25 percent of the population. An environment that supports greater mobility for the elderly and serves as a foundation for vibrant societies thus needs to be established.

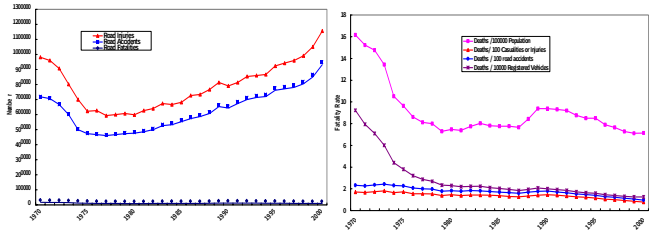

Figure 1(a) and (b) Road Accident Trends in Japan

3.0 Accident trends in India

India with 85000 fatalities and 399300 injuries per annum (in 2000), accounts for about 10% of total world's road fatalities. The share of National and State Highways in the total road network is just 6% but these cater to 70 to 75% of total Indian road traffic. However, the National Highways, which constitute below 2% of the total road network, account for 25% of accidents, 34% of fatalities and 28% of injuries. Accidents, fatalities and causalities have been increasing dramatically in India over last 20 years – about 5% growth rate over last two decades – partly due to exponential growth of vehicles. On Indian roads there is an accident every 90 seconds and every 7 minutes one-person dies. Nearly 60% of the total road accidents take place during night though the night traffic is hardly 15% of the 24-hour volumes, which means that the probability of an accident in India during night is almost 8times higher than in day. Nearly 50% of these accidents take place in 40metropolitan cities in India and the causes of road accidents are several. Road engineering contributes in terms of blind curves, wrong shapes and design of roads, disturbing gradients, and variation in speeds and lack of homogeneity. Traffic engineering contributes in terms of negligence of installation of signs and markings, highway furniture etc. Other reasons include dangerous overtaking, lane cutting, jumping signals, erratic parking and lack of gap. Lane cutting is common in urban areas cutting across lanes in order to find that elusive gap and resulting in terrible situations. Lack of gap when driving too close with the front vehicles will also results accidents when apply sudden brakes. Within the situation where motorized traffic increased dramatically it may be too drastic to expect that the actual number of accidents to drop significantly. Although it is quite common to observe the accident trend as indexed to certain exposure variables.

Figure 2 (a) and (b) presents the road accident situation in India, which shows constant growth rate in fatalities, injuries and accidents and trends in accident fatality rates in terms of fatalities per 100000population, fatalities per 100 casualties, fatalities per 100 accidents and fatalities per 10000registered motor vehicles. In India, most of the times accidents are under reported. Compared to Japan there are less in reported number of accident injuries and road accidents. As per Ministry of Road Transport and Highways, India suffered losses of Rs.7000crores and Rs.9000crores as a result of road accidents in 1995 and 1999. However, if under reporting of road accidents are taken into account, the actual loss amounts to Rs.32000crores (in 1995), and the estimated figure for the year 2001 is as high as Rs.55000crores, which is about 2% of GDP. Pedestrians, bicyclists and motorized two-wheeler riders are the vulnerable road users, which constitute 60-80% of all traffic fatalities in India. In developed countries majority of the fatalities include the occupants of cars, whereas in India the majority of victims are pedestrians, cyclists and two-wheeler riders. This follows logically as this class of road users forms the majority of those on roads. On highways, the proportion of other motor vehicle occupants and vulnerable road users are 32% and 68% respectively. In addition, they sustain relatively more serious injuries even at low velocity crashes, unlike car occupants who are protected by impact absorbing metallic body of the vehicles. Indian roads need constructive safety measures to reduce number of fatalities, injuries and accidents.

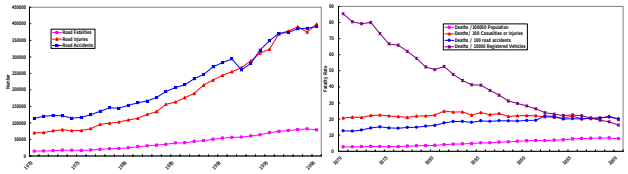

Figure 2(a) and (b) Road Accident Trends in Japan

4.0 Comparison of different parameters between different countries

Data collected from International Road Traffic and Accident Database (IRTAD) and other sources for India, Japan, U.S.A., European Union, U.K., Australia, and Canada. As a developed country, Japan has several advantages compared to India. In population, India is almost ten times bigger than Japan. India having only 66% of vehicular population and ten times more in length of expressways compared to Japan. One of the biggest differences is India didn't have any sophisticated technologies in terms of efficient design of road network and application of Intelligent Transport System (ITS) to reduce delays, congestion, accidents, and environmental pollution. In terms of accident fatalities, India is ten times higher than Japan. This shows more economic and human losses compared to Japan. When compared India with other countries, it was observed that (a) the number of vehicles in Japan, USA and EU are more and varying from 0.5 to 4 times compared to India where as the number of fatalities are less and varying from 2 to 8 times compared to India, (b) high fatality rate per kilometer in India compared to Japan and other countries and is varying from 2 to 3 times (c) high fatality rate per million vehicles in India compared to Japan and other

countries and (d) risk value is measured in terms of killed against 100000 populations and risk value for India is more or less same with Japan and other countries.

5.0 Accident trend models for Japan and India

The collected accident data leads to a closer examination of the accident trend over a period of time, particularly with respect to fatalities. In this analysis it is assumed that exposure of road users may be represented as population size and exposure to the vehicle system is represented by number of registered motor vehicles. Regression analysis is used to get a number of statistically significant accident trend models. Two types of data sets are considered for analysis i.e., (a) same years data for Japan and India (1970 to 2000) and (b) different years data for Japan (1951 to 1970) and for India (1981 to 2000). They provide reasonable estimates and resulted in the form of recommendation of safety measures to India with the experience of Japan in reduction of road accident fatalities. The predicted number of fatalities was then determined using the equations for the same time period and compared with the actual accident fatalities. The deviation between the predicted values and the actual number of fatalities were determined. The percentage of error for the predicted values and the average absolute percentage of error for each of the models are given in Table 1 for year 1971 to 2000 for Japan and India.

From Table 1, it was found that in case of Japan, lot of variation from the predicted values by the four models and the actual accident fatalities with low and equal R^2 values over thirty years period appear to indicate that there is no possible relationship between number of traffic accident fatalities, size of population and number of registered motor vehicles. The reason is with the implication of several safety measures since 1970, fatalities dropped to 8466 in 1979 and 9066 in 2000 with a reduction of fatalities by 45% in 30 years. In case of India it was found that a fairly close relation from the predicted values by the four models and the actual accident fatalities with high and equal R^2 values over the thirty years period appear to indicate that there is a possible meaningful relationship between number of traffic accident fatalities, size of population and number of registered motor vehicles. From the results it was observed that population and registered motor vehicle coefficients having different signs in both cases and shows no relation between these countries.

Other than above statistical models, from the accident data it was also observed that fatalities were increased linearly for Japan since 1951 to 1970 where as for India since 1981 to 2000. By considering Y as fatalities and X as years, with the linear regression analysis, the coefficient of correlation, R^2 with equations are presented in Table 2. Based on this, it was found that both countries have fairly close and meaningful relation from the predicted accident fatality values by model and the actual accident fatalities over twenty years period between Japan and India. With the same data sets, relation between accident fatalities, size of population and number of registered motor vehicles has been found using regression analysis and presented in Table 3. It was observed that, population and registered motor vehicle coefficients are having same sign (except Model 1) and shows positive relation between these countries. The variation in R^2 value represents that fatalities in India is more linear compared to Japan. If India adopts road safety measures adopted by Japan since 1970 to reduce fatalities, then approximate reduction of fatalities may be expected by 45% over 10years. The implemented safety measures since 1970 in Japan are discussed in the following section. These models can be used as a prediction tools for any base case forecasting of future traffic accident fatalities. However, there are numerous factors contributing to traffic accidents and fatalities and as such these prediction models need to be further refined and only used as a rough guide.

Table 1. Statistical Significance of Trend Models for Japan and India (1971-2000)

Model	Equation	R^2	% of error range	Avg. abs. % of error
Japan (1971-2000)				
1	$F= 8.28\ e^{130}\ V^{2.31}\ P^{-17.90}$	0.351	5.97 to –27.10	12.20
2	$F = 7889.35\ (V/P)^{-0.2865}$	0.355	28.99 to –23.24	13.42
3	$F = 5.80\ e^{8}\ (VP^{2})^{-0.199}$	0.392	24.53 to –24.70	13.12
4	$F = 3.24\ e^{7}\ (VP)^{-0.222}$	0.381	23.48 to –26.94	13.23
India (1971-2000)				
1	$F= 821.39\ V^{0.575}\ P^{-0.267}$	0.984	8.25 to –20.06	3.77
2	$F = 591253\ (V/P)^{0.640}$	0.983	20.56 to –8.16	3.70
3	$F = 7.2e^{-6}\ (VP^{2})^{0.392}$	0.983	17.16 to –10.30	4.98
4	$F = 0.00263\ (VP)^{0.45}$	0.982	9.43 to –18.23	4.37

Table 2. Linear Model for Fatalities in Japan (1951-1970) and India (1981-2000)

Country	Data Years	Model	R^2	% of error range	Avg. abs. % of error
Japan	1951-1970	Y = 655.9 X + 3874.2	0.958	–12.02 to 19.04	5.74
India	1981-2000	Y = 2990.3 X + 23767	0.988	–5.59 to 6.13	2.56

Table 3. Statistical Significance of Trend Models for Japan (1951-1970) and India (1981-2000)

Model	Equation	R^2	% of error range	Average abs. % of error
Japan (1951-1970)				
1	$F= 4.9\ e^{-83}\ V^{-0.232}\ P^{11.010}$	0.887	25.95 to –13.57	9.98
2	$F = 34234.8\ (V/P)^{0.358}$	0.880	36.42 to –17.29	9.83
3	$F = 0.001258\ (VP^{2})^{0.308}$	0.881	16.20 to –35.56	9.76
4	$F = 0.218\ (VP)^{0.320}$	0.879	17.00 to –35.04	9.86
India (1981-2000)				
1	$F= 0.55\ V^{0.466}\ P^{0.177}$	0.990	5.18 to –7.16	2.22
2	$F = 525082\ (V/P)^{0.600}$	0.990	5.67 to –5.91	2.42
3	$F = 0.000029\ (VP^{2})^{0.368}$	0.989	8.02 to –4.15	2.28
4	$F = 0.0073\ (VP)^{0.423}$	0.989	7.55 to –5.02	2.23

6.0 Safety measures adopted by Japan

Japan has implemented different safety measures in several fundamental traffic safety programs. With the implementation of six fundamental traffic safety programs since 1971- 2000, the number of accidents was successfully brought down to 9066. The program sets out to do this by aggressively promoting appropriate and effective traffic safety measures that fully address traffic accident realities. Various safety programs implemented during the fundamental safety programs are explained hereunder.

Traffic regulations for road safety have been consistently strengthened. Speed limits in Japan are among the severest. Passing is prohibited on virtually on all roads even in rural areas. Other regulations such as elevated freeways/ expressways, no U-turns, no right-turns, one-way streets and no-lane changing are also extensively used. Intensive efforts to expand *road safety facilities* during last decades. Road safety facilities include installation of traffic signals, regulatory and warning signs, zebra crossings, lane markings, sidewalks, bicycle lanes, street lighting, guard fences etc. Many measures other than these include channelization of intersections, anti-skid resurfacing, improvement in road designs etc. These improvements are regarded to have been highly effective in the prevention of accidents. *Enforcement and Penalties* has been strengthened and includes speeding violations; parking violations, stop violations, no-passing violations, alcohol affected driving plus drunk driving etc. Penalties consist of fines and points or bad marks. These will be recorded in the driver's record and licenses are suspended if one accumulates certain points for a period of time.

Driver Administration and control administered by National Police Agency maintains a file of all licensed drivers in Japan which notifies those drivers whose points have reached close to the level of license suspension or revocation to remind them to drive more carefully, issuing driving record certificates and accident analysis. *Safety Education for Children* taught how to safely walk and ride bicycles from kindergarten. Primary school children are usually grouped and are shown designated commuting routes. This will help more exposure to children how to work on the road network. *Vehicles inspection* of old cars or commercial vehicles is required to be inspected every two years. If these are more than ten years inspections will be held every year. This will result to maintain the cars and commercial vehicles in proper condition. Other way to maintain old cars is essential to spend relatively high cost in order to pass the inspection, people tend not to own cards older than ten years and this will indirectly contribute to reduction of road accidents and fatalities.

Nationwide safety campaigns includes traffic improvement measure periodically organizes the nation-wide safety campaigns which are held several times in a year. During these campaigns, fatalities and accidents are reduced approximately 10%. *Improvement of drivers safety concern* includes revision of driver education policy, traffic regulations and the manner in which enforcement is implemented. Amendment of seat belt usage would decrease the total number of deaths in vehicle occupants by one-third. Application of *Intelligent Transport System (ITS)* on road network which also reduced number of accidents, delays, congestion and environmental pollution.

7.0 Safety measures recommended to India

Traffic pattern on Indian roads is highly heterogeneous in nature. Current road system technology is impersonal and manual in most of the areas. Each vehicle, each driver and each passenger is treated equally and the way that the system is presented and responds is the same for every user. Current system also appears to operate on a small local area and cannot control entire network or state by state. The safety measures recommended to reduce accident fatalities includes (1) bringing driver-licensing system under one umbrella so that in any corner driver makes any violation can reflect in to his driving records, (2) improvement of traffic regulations and road safety facilities will help directly to reduce accident fatalities and create aesthetic appearance to road network, (3) improvement of road designs to avoid conflict points, turning points, sharp curves etc., (4) road safety education for children and aged groups, (5) nation wide road safety campaigns and (6) application of ITS to at least to National and State Highways.

8.0 Conclusions and Recommendations

The road accident situation in Japan and India has been discussed and analysis of the road accident trends presented. The accident trends are compared with other countries like U.S.A., U.K., Australia, European Union and Canada to bring a comparative assessment of the gravity of the problem especially faced by India. Attempts were made to investigate possible relationships between accidents fatalities and exposure variables like population and number of registered motor vehicles. Using regression analysis, four statistically significant models developed for Japan and India with same and different data sets. The models developed for Japan as well as India not only provide a possible explanation to the trends observed but also could be used as a base case prediction tool especially for India. If India adopts the recommended safety measures based on Japanese experience, approximately accidents may be reduced by 45% in next 10 years. It is recommended that before taking a final decision on implementation of safety measures on Indian road network, a detailed study should be carried out.

References

1.En Route (2002), Towards Safer Roads, Jan-Mar, 10-13.

2.IATSS, Tokyo, Japan (2000), White paper on Traffic Safety 2002 in Japan, Abridged Edition.

3.IATSS, Tokyo, Japan (2001), White paper on Traffic Safety 2002 in Japan, Abridged Edition.

4.Ministry of Road Transport and Highways, Government of India website pages http://morth.nic.in/mts.htm and http://morth.nic.in/motorstat/mt3.pdf

5.National Police Agency, Japan website page http://www.npa.go.jp/toukei/koutuu1/homee.htm