ROAD ACCIDENT MODELS FOR LARGE METROPOLITAN CITIES OF INDIA

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In most of the metropolitan cities in India, the road use patterns are very different from those of developed countries. In Indian cities, roads are shared by non- motorized vehicles in large numbers. The rapid urbanization in India after independence has resulted in the faster development of 23 metropolitan cities as per the 2001 census. While the alarming increase in road accidents has become a major concern in the country, which takes away more than 90,000 lives every year, a significant share of it is from the major cities.

The aim of the present paper is to develop models by analyzing the road accident data at an all India level as well as for major metropolitan cities. The data for the 25 year period from 1977 to 2001 were analyzed to build models to understand the nature and extent of the causes of accidents using the concept of Smeed's formula and Andressen's equations.

On the basis of population and motor vehicle growth rates, which were derived from the empirical formulae, the above models were used for estimating road accidents in seven metropolitan cities for the years 2007 and 2010. As the variation between model and observed values is negligible, models seem to perform well for both equations.

Key Words: Road accidents, Fatalities, Injuries, Regression, India

1. INTRODUCTION

Most of the metropolitan cities in India are witnessing phenomenon of ever increasing growth of vehicular traffic due to population explosion coupled with large-scale socio-economic activities. This has resulted in severe traffic problems on roads in terms of road accidents and deterioration in the eco-friendly environment due to an increase in noise and air pollution.

Rapid growth of road accidents in most of the large metropolitan cities is increasingly becoming a great concern to which takes away as many as 90,000 lives adding to human miseries. Causation of accidents can be well understood with the help of analysis of accident statistics, which can provide clues to many factors of road accidents. Many researchers including Smeed have devoted their research to the area of road accidents and reported pioneering work on the analysis of road accidents. Smeed[1] further investigated the variations in the pattern of accident rates in different countries and their causes. Livneh[2] conducted a detailed case study on road accidents in Israel. Using employment and population data, Partyka[3] developed simple models with a view to understand the various factors affecting the increase in accidents in developing countries. Andreassen[4] investigated the origin of Smeed's formula in detail and concluded that Smeed's formula cannot be applied universally to all countries. Mekky[5] used the time series data for the analysis and studied the effects of a rapid increase in motorization levels on fatality rates in some developing countries. Mohan[6] attempted to understand total crash patterns in Delhi. Jacobs and Cutting[7] attempted further to update the relationship based on earlier studies. The study on the effect of speed limits on road accidents has been carried out by Fieldwick[8]. It was found that speed limits have a considerable effect on safety both in urban and rural areas.

Adams[9] worked on Smeed's law and provided some insights in the analysis. Minter[10] discussed an application of the two models (Wright and Towell) for road safety problems and finally developed a model for estimating the road accidents in U.K. Pramada et al.,[11] investigated the variations in the pattern of road accidents in various States and Union Territories of India. Emanalo et al.[12] established the trend curves for the road accidents, casualties, and other relevant quantities for Zambia.

Pramada et al.,[13] developed a road accident model by using the additional parameter of road length. Ameen and Naji[14] presented a general modeling strategy to fore-

cast road accident fatalities in Yemen.

It is therefore extremely desirable to understand basic factors responsible for causing road accidents. Though analyses of road accidents based on data[15] have been directed towards understanding road accidents at an all India level and large metropolitan cities, author is more emphatic on developing models for metropolitan cities in this paper.

2. GROWTH OF DIFFERENT METROPOLITAN CITIES IN INDIA

Urbanisation in India has been phenomenal since independence resulting in the development of metropolitan cities (one million plus population). With only one metropolitan city, Kolkata in 1901, India has now added another 23 metropolitan cities over a period of 100 years. The number of metropolitan cities during the period 1977-2001 has nearly doubled from 12 to 23. The share of the population in metropolitan cities in the year 2001 constituted about 5.34% of the total population of 1.2 billion. There is a large variation in the sizes from 13.2 million (Mumbai) to 1.62 million population (Ludhiana) in 2001.

3. PATTERN OF ROAD ACCIDENTS IN DIFFERENT CITIES IN INDIA

Of the total of 23, only seven major metropolitan cities have been considered for detailed analysis of road accidents for the period of 25 years, i.e., (1977-2001). Rapid growth of population along with numerous economic activities have acted as the major catalyst for the steady growth of the motor vehicle population and has subsequently resulted in the increase of road accidents. Table 1 presents the growth rates of motor vehicles, population and accidents for selected metropolitan cities in India. It can be seen from the table that the ratio of average annual growth of motor vehicles to population varies from 0.27 to 0.72. Except cities like Mumbai and Chennai, the five metropolitan cities exhibit a positive growth rate of accidents that is a great concern for road safety. Table 2 presents a useful result in terms of rate of changes in road accident indices.

Over a period of ten years (1990-2000), all the seven cities have experienced a decline in rate of change of road accident indices. As far as the change in the ratio of accidents to population is concerned, cities like Delhi, Hyderabad and Kolkata indicate positive values.

4. ROAD ACCIDENT SITUATION IN INDIA

The magnitude of road accidents in India has gone up to an alarming proportion. About 80,000 persons were killed and 382,700 persons were injured in India in the year 2001. This clearly demonstrates the gravity of road traffic problems in India, which continues to be worse primarily due to the ever-increasing growth of motor vehicles and the inadequacy of the road system to cope with the saturated traffic flow.

The actual trend in the total accidents, fatalities and injuries in India for the period 1970-2001 is illustrated

Table 1 Growth rates of motor vehicles, population and accidents for major metropolitan cities in India from 1990 to 2000

Name of the Metropolitan City	AAGR of Motor Vehicles(N_R)	AAGR of Population(P_R)	AAGR of Total Accidents(C_R)	AAGR of Fatalities(F_R)	AAGR of Injuries(I_R)	C_R/N_R	N_R/P_R
Ahemadabad	1.749	4.8898	0.0100	0.5000	0.1500	0.0064	0.3600
Bangalore	2.468	3.4800	0.3970	0.4600	0.3000	0.1600	0.7100
Chennai	1.315	1.8254	-0.1000	0.7000	0.2000	-0.0600	0.7200
Delhi	1.406	2.7506	0.5200	0.4400	0.3101	0.3700	0.5100
Hyderabad	1.350	2.0851	0.7000	0.3700	1.0530	0.5150	0.6500
Kolkata	0.741	1.6137	0.5577	0.0682	-0.0300	0.7500	0.4600
Mumbai	0.520	3.1678	-0.0100	-0.2900	-0.1800	-0.0100	0.2700

AAGR: Average Annual Growth Rate

in Fig. 1, which clearly reflects the increasing trend of road accidents during this period. The total number of road accidents and fatalities have gone up significantly from 114,000 to 394,000 and from 14,500 to 80,000 resulting in an increase of 3.46 times and 5.51 times respectively over a period of 32 years.

As compared to an all India level, the total road accidents in the seven metropolitan cities namely Ahemedabad, Bangalore, Mumbai, Kolkata, Delhi, Hyderabad and Chennai were about 21.5% of the total accidents during 1977, which marginally came down by 5% to 16.9% in 2001. The fatalities and injuries during this period exhibit a declining trend significantly from 10.52% to 6% and from 23.28% to 8.96% respectively. This decline in most of the selected cities reflects not only the relative expansion of the road-network, but also the extent of safety measures taken by concerned city authorities.

5. DEVELOPMENT OF ACCIDENT MODELS

5.1 Smeed's model

Smeed[16] examined the relationship on a number of road fatalities with those of motor vehicles and the populations of 20 countries in 1938 in the following form:

$$D / N = 0.0003 (N / P)^{-0.67} \quad (1)$$

where D, N, P are deaths, motor vehicles and population respectively.

It was observed that 10 of the values of D calculated by this formula were within 15% of their actual values, 19 were within 40% and one was in error by 67%. The reason for the use of this formula was explained as "a formula is fitted to a set of data to summarize them and make it easier to reflect the properties of the data". There was no suggestion made to use the formula for prediction purposes. Smeed and Jaffocate[17] further attempted

Table 2 Rate of change in road accident indices from 1990 to 2000

Name of the Metro Politan City	C/N	F/N	I/N	C/P	F/P	I/P
Ahemadabad	-0.630	-0.4700	-0.5800	-0.3700	-0.1000	-0.2900
Bangalore	-0.597	-0.5790	-0.6280	-0.0080	0.3700	-0.0800
Chennai	-0.600	-0.2400	-0.4800	-0.2300	0.4600	0.0009
Delhi	-0.370	-0.4000	-0.4600	0.1600	0.0980	-0.0012
Hyderabad	-0.280	-0.4200	-0.1300	0.4000	0.1100	0.6700
Kolkata	-0.110	-0.3900	-0.4400	0.3300	-0.0898	-0.1707
Mumbai	-0.350	-0.5300	-0.4600	-0.1800	-0.4100	-0.3300

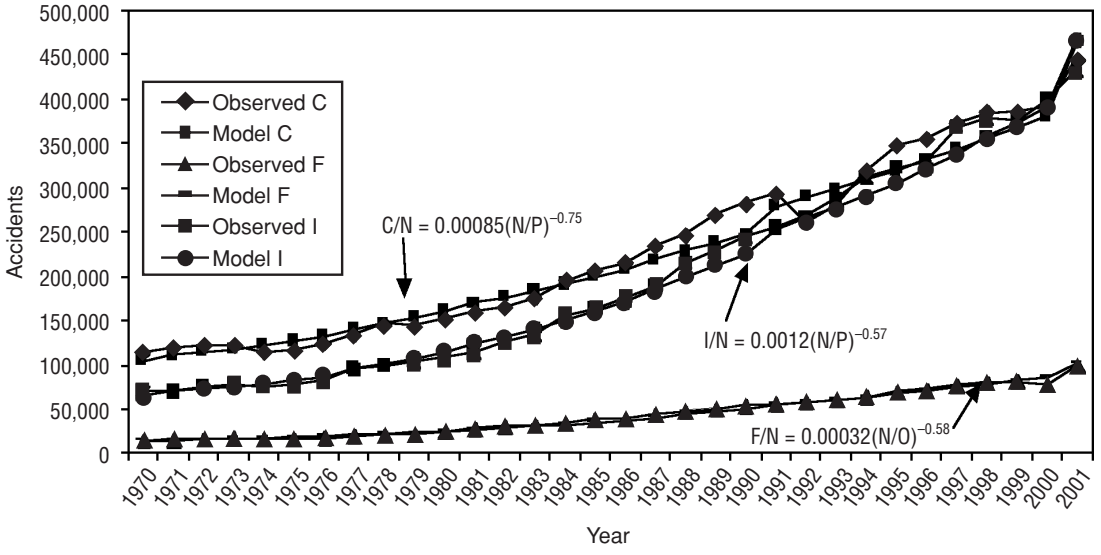

Fig. 1 Comparison of model values with the observed values of road accidents in India

to present the accident figures (1960-1967) of 70 countries, including India, through the above formula. It may be mentioned that except five out of 70 countries namely, Gibraltar, Sarawak, North Borneo, India and South Africa, Smeed's model successfully predicted the number of fatalities. Using the same method as Smeed[18], Jacobs[7] carried out analysis of fatalities in developing countries for different years and established significant relationships between fatality rates and levels of vehicle ownership. The analysis was repeated for the year 1980 using data from 20 developing countries and a relationship was derived which is as follows:

$$D / N = 0.00036 (N / P)^{-0.65} \quad (2)$$

Equation (2) is very similar to that derived by Smeed suggesting that the situation in developed countries in 1938 is similar to that in developing countries in 1980.

Again this analysis of 35 developing countries was carried out for the years (1978-1980). The following equation was derived:

$$D / N = 0.00039 (N / P)^{-0.64} \quad (3)$$

It can be seen that equation (3) was similar to that derived for 1980 and Smeed's equation.

5.2 Andreassen's equation

Smeed's analysis was heavily criticized by Andreassen[19] for model accuracy. He argued that the Smeed's formula cannot be applied universally to all countries. The generalized relationship Andreassen produced in 1985 is of the form:

$$D = \text{const} * (N)^{M_1} * (P)^{M_2} \quad (4)$$

The failure of Smeed's model to predict fatalities in many developed and developing countries (see Jacobs and Cutting[7], Adams[9] and Andreassen[4,19]) motivated the authors to modify the same by including other variables like road length to improve its predictability.

5.3 Road accident models for India

Based on Smeed's formula as described earlier, an attempt has been made to develop relationships among the parameters, namely, road accidents, the number of registered motor vehicles and population. The data on road accidents in terms of total number of accidents (C), fatalities (F), injuries (I) and the number of registered motor vehicles (N) were used from road accidents in India. The model developed by Smeed does not however, explain the discrepancy for the data on India, as the data do not give good fit to the formula.

It is, therefore, proposed to investigate the data and develop appropriate models based on the concept of Smeed's formula and Andreassen's formula.

The models developed by Pramada et al.[13] relating fatalities (F) to vehicles and population in India for the years (1960-1991) is as follows:

$$F / N = 0.00073 (N / P)^{-0.4} \quad (5)$$

The parameter coefficient -0.4 in equation (7) is not the same as the parameter's coefficient in Smeed's formula. The constant term (i.e., 0.00073) also differs with Smeed's formula (i.e., 0.0003).

In the present paper the regression analysis was carried out using Smeed's model for the years (1970-2001) for India and the following equations are derived:

$$C / N = 0.0008 (N / P)^{-0.75} \quad (6)$$

$$F / N = 0.0003 (N / P)^{-0.58} \quad (7)$$

$$I / N = 0.0014 (N / P)^{-0.57} \quad (8)$$

The constant term (i.e., 0.0003) in equation (7) is exactly the same as the constant term in Smeed's formula in equation (1). Whereas, using Andreassen's approach for accident data on India, the following equations were derived for the above period:

$$C = e^{21.26} * N^{0.495} * P^{-0.83} \quad (9)$$

$$F = e^{13.47} * N^{0.613} * P^{-0.63} \quad (10)$$

$$I = e^{13.47} * N^{0.604} * P^{-0.54} \quad (11)$$

A comparison of observed and model values using the above two approaches as presented in Table 3, reveals that the observed values compare quite favorably with those of Smeed's and Andreassen's equations. A good comparison of values from Smeed's model with observed values in terms of total accidents, fatalities and injuries is shown in Fig. 1. The model seems to fit very well until 1985. Due to a sudden spurt in two wheelers and four wheelers the variation took place in urban India as shown in Fig. 1.

5.4 Road accident models for selected metropolitan cities of India

That the accident characteristics in metropolitan cities of India varies in these cities is evident from the analysis.

The mathematical form of the model is as follows:

$$A / N = B_1 (N / P)^{B} \quad (12)$$

Where

A / N = Accidents per 1000 motor vehicles;

N / P = Motor vehicles per 1000 population;

B and B_1 are model parameters.

Table 4 presents the models for total accidents, fatalities and injuries for selected cities. Model values on road accidents obtained from equation (12) and observed values for three cities Bangalore, Kolkata and Mumbai are shown in Figs 2-4. Table 5 demonstrates the sensi-

Table 3 Comparison of Smeed's and Andreassen's Equation values of accidents for India from 1970 to 2001

Year	Total Accidents					Fatalities					Injuries				
	Smeed's Model			Andreassen's Equation		Smeed's Model			Andreassen's Equation		Smeed's Model			Andreassen's Equation	
	Actual	Predicted	% PD	Predicted	% PD	Actual	Predicted	% PD	Predicted	% PD	Actual	Predicted	% PD	Predicted	% PD
1970	114,000	105,138	-7.77	109,929	-3.57	14,500	14,372	-0.88	14,867	2.53	70,100	64,598	-7.85	66,618	-4.97
1971	120,200	110,681	-7.92	115,707	-3.74	15,000	15,454	3.03	15,984	6.56	70,700	69,497	-1.70	71,667	1.37
1972	122,300	115,139	-5.86	118,877	-2.80	16,100	16,278	1.11	16,678	3.59	76,400	73,227	-4.15	74,859	-2.02
1973	121,600	117,982	-2.98	118,485	-2.56	17,600	16,706	-5.08	16,760	-4.77	79,300	75,152	-5.23	75,350	-4.98
1974	114,300	122,922	7.54	122,108	6.83	17,300	17,643	1.98	17,554	1.47	76,700	79,397	3.52	79,003	3.00
1975	116,800	126,881	8.63	123,500	5.74	16,900	18,336	8.50	17,964	6.29	77,000	82,529	7.18	80,956	5.14
1976	124,700	131,862	5.74	126,641	1.56	17,800	19,281	8.32	18,699	5.05	82,500	86,811	5.23	84,363	2.26
1977	135,400	140,463	3.74	136,464	0.79	20,100	21,157	5.26	20,699	2.98	95,600	95,331	-0.28	93,402	-2.30
1978	146,300	146,515	0.15	140,965	-3.65	21,800	22,390	2.70	21,743	-0.26	99,500	100,920	1.43	98,210	-1.30
1979	144,400	153,317	6.17	146,559	1.49	22,600	23,825	5.42	23,024	1.87	102,900	107,435	4.41	104,082	1.15
1980	153,200	160,106	4.51	151,747	-0.95	24,600	25,263	2.69	24,255	-1.40	109,100	113,964	4.46	109,751	0.60
1981	161,200	170,027	5.48	162,511	0.81	28,400	27,575	-2.91	26,645	-6.18	114,000	124,480	9.19	120,598	5.79
1982	166,200	176,156	5.99	170,833	2.79	30,700	29,120	-5.15	28,450	-7.33	126,000	131,521	4.38	128,731	2.17
1983	177,000	183,631	3.75	181,817	2.72	32,800	31,081	-5.24	30,848	-5.95	134,100	140,460	4.74	139,505	4.03
1984	195,000	190,947	-2.08	192,537	-1.26	35,100	33,030	-5.90	33,239	-5.30	156,200	149,354	-4.38	150,256	-3.81
1985	207,000	199,135	-3.80	205,093	-0.92	39,200	35,280	-10.00	36,079	-7.96	163,400	159,623	-2.31	163,001	-0.24
1986	215,500	207,667	-3.64	218,451	1.37	40,000	37,680	-5.80	39,157	-2.11	176,400	170,588	-3.29	176,812	0.23
1987	234,000	218,367	-6.68	236,593	1.11	44,400	40,824	-8.05	43,386	-2.28	189,000	184,961	-2.14	195,739	3.57
1988	246,700	228,731	-7.28	254,255	3.06	46,600	43,935	-5.72	47,610	2.17	214,800	199,197	-7.26	214,642	-0.07
1989	270,000	237,940	-11.87	269,466	-0.2	50,700	46,724	-7.84	51,353	1.29	229,700	211,960	-7.72	231,414	0.75
1990	282,600	246,987	-12.60	284,354	0.621	54,100	49,505	-8.49	55,094	1.84	244,100	224,697	-7.95	248,181	1.67
1991	293,400	279,290	-4.81	270,068	-7.95	56,300	55,806	-0.88	54,402	-3.37	255,000	253,274	-0.68	247,529	-2.93
1992	260,300	289,268	11.13	279,453	7.358	57,200	58,627	2.50	57,112	-0.15	267,100	266,175	-0.35	259,975	-2.67
1993	280,100	298,605	6.61	287,232	2.546	60,700	61,238	0.89	59,460	-2.04	287,900	278,111	-3.40	270,822	-5.93
1994	320,400	308,209	-3.80	295,160	-7.88	64,000	63,952	-0.07	61,887	-3.30	310,800	290,525	-6.52	282,043	-9.25
1995	348,900	318,896	-8.60	304,794	-12.6	70,700	67,068	-5.14	64,805	-8.34	322,900	304,783	-5.61	295,487	-8.49
1996	355,100	331,416	-6.67	317,555	-10.6	71,900	70,874	-1.43	68,613	-4.63	330,000	322,217	-2.36	312,954	-5.17
1997	290,400	343,430	18.26	328,926	13.26	61,000	74,522	22.17	72,121	18.23	290,800	338,929	16.55	329,100	13.17
1998	298,100	351,320	17.85	331,979	11.38	62,700	76,633	22.22	73,410	17.04	296,700	348,578	17.48	335,290	13.01
1999	386,425	368,089	-4.745	351,574	-9.02	82,045	82,125	0.10	79,313	-3.28	375,000	373,772	-0.33	362,261	-3.40
2000	391,463	380,292	-2.854	361,976	-7.53	78,955	85,907	8.80	82,748	4.88	399,300	391,111	-2.05	378,161	-5.29
2001	445,221	461,356	3.6241	320,193	-18.9	99,456	102,385	2.95	77,594	-3.04	432,555	465,920	7.71	360,962	-5.6801

Table 4 Road accident models for metropolitan cities of India

METROPOLITAN CITY	TOTAL ACCIDENTS	FATALITIES	INJURIES
Ahemadabad	$C/N = 0.000248(N/P)^{-1.29}$	$F/N = 0.002603(N/P)^{-0.02}$	$I/N = 0.0002651(N/P)^{-1.24}$
Bangalore	$C/N = 0.001364(N/P)^{-1.01}$	$F/N = 0.000119(N/P)^{-0.98}$	$I/N = 0.0009539(N/P)^{-1.08}$
Chennai	$C/N = 0.000408(N/P)^{-1.31}$	$F/N = 0.000134(N/P)^{-0.82}$	$I/N = 0.0006257(N/P)^{-1.07}$
Delhi	$C/N = 0.0004288(N/P)^{-0.65}$	$F/N = 0.0009(N/P)^{-0.58}$	$I/N = 0.0041983(N/P)^{-0.64}$
Hyderabad	$C/N = 0.001022(N/P)^{-0.84}$	$F/N = 0.00191(N/P)^{-0.87}$	$I/N = 0.0007624(N/P)^{-0.84}$
Kolkata	$C/N = 0.004391(N/P)^{-0.96}$	$F/N = 0.000292(N/P)^{-0.83}$	$I/N = 0.0009733(N/P)^{-1.20}$
Mumbai	$C/N = 0.000572(N/P)^{-1.50}$	$F/N = 1.57E\text{-}07(N/P)^{-2.91}$	$I/N = 4.006E\text{-}05(N/P)^{-1.97}$
ALL INDIA	$C/N = 0.000817(N/P)^{-0.75}$	$F/N = 0.000315(N/P)^{-0.58}$	$I/N = 0.001453(N/P)^{-0.57}$

tivity of the model during the years between 1995 and 2000 for seven major metropolitan cities of India wherein the percentage difference between model and observed values is quite high for Kolkata and Hyderabad, in terms of total accidents and injuries in the year 2001. Fatalities and injuries models have fitted well with the data for Delhi and Mumbai. But, only the fatalities model is performing well with respect to four Indian cities i.e.

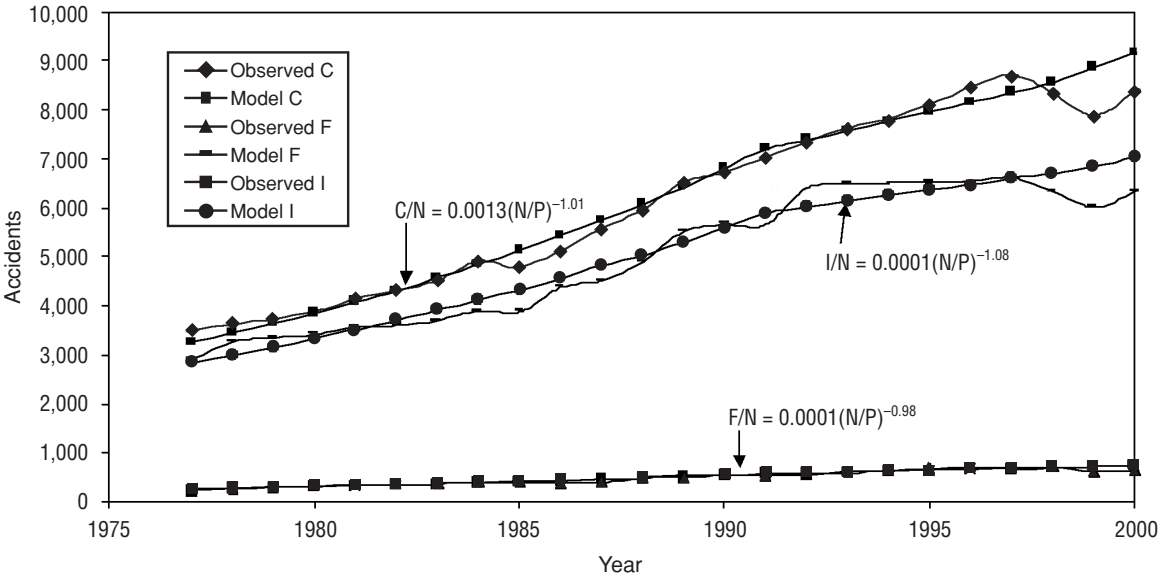

Fig. 2 Model and observed values of road accidents in Bangalore

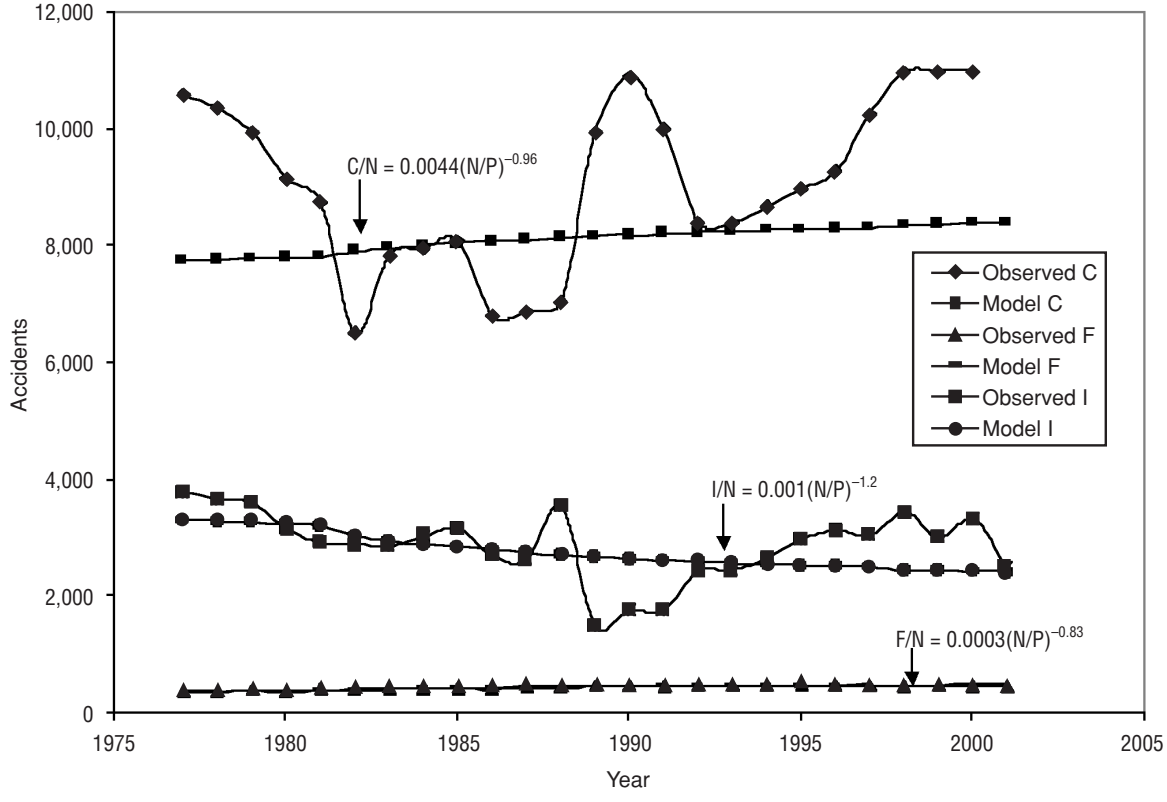

Fig. 3 Model and observed values of road accidents in Kolkata

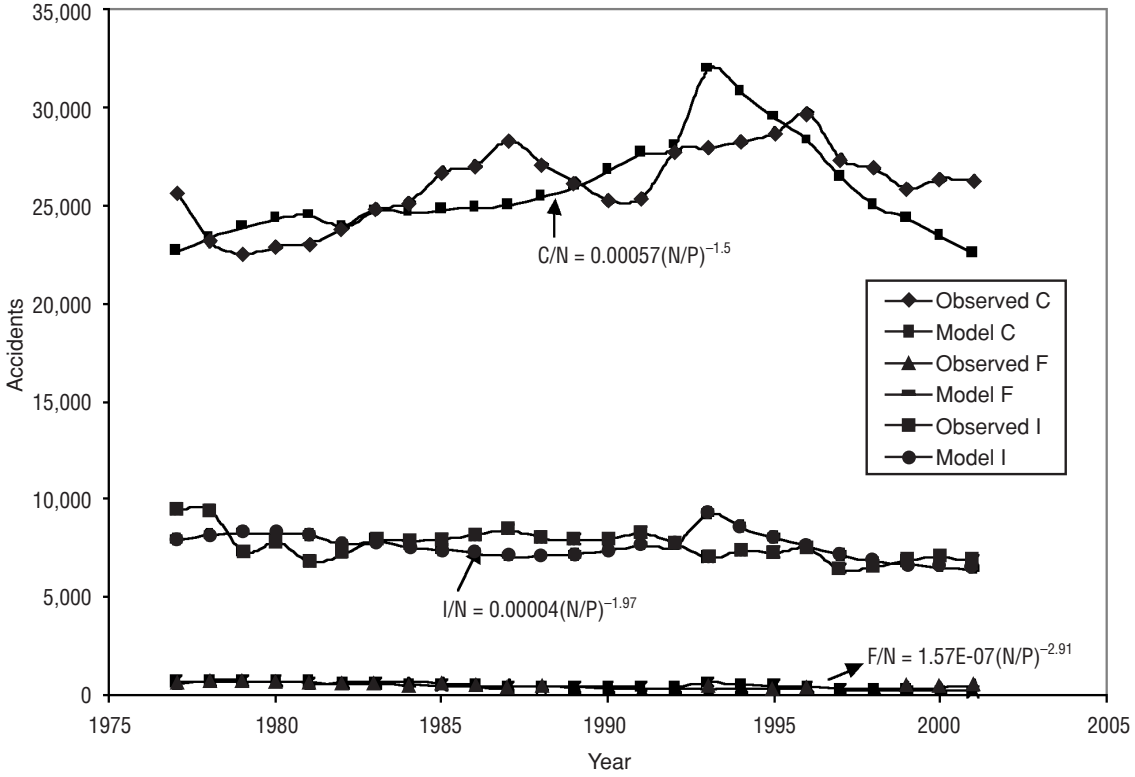

Fig. 4 Model and observed values of road accidents in Mumbai

Table 5 Comparison of actual and predicted road accidents of metropolitan cities in India for the year 1995 and 2000

Name of the Metropolitan City	Year	Total Accidents			Fatalities			Injuries		
		Actual	Predicted	% PD	Actual	Predicted	% PD	Actual	Predicted	% PD
Ahemadabad	1995	2,354	2,936	24.73	189	200	6.04	2,670	2,781	4.16
	2000	3,014	3,168	5.11	223	206	-7.76	2,905	3,056	5.21
Bangalore	1995	8,127	7,963	-2.02	690	657	-4.77	6,545	6,386	-2.43
	2000	8,391	9,174	9.33	659	757	14.91	6,347	7,042	10.96
Chennai	1995	4,987	4,750	-4.75	598	564	-5.65	4,987	4,395	-11.86
	2000	4,878	4,567	-6.37	692	640	-7.58	4,496	4,581	1.89
Delhi	1995	10,138	9,317	-8.10	1,981	1,963	-0.91	7,643	7,279	-4.76
	2000	10,245	11,773	-14.91	1,918	2,532	32.04	7,683	9,248	20.37
Hyderabad	1995	1,901	1,665	-12.41	350	324	-7.47	1,892	1,254	-33.70
	2000	2,492	1,819	-26.99	425	348	-18.20	2,357	1,365	-42.09
Kolkata	1995	899	8,286	-7.83	476	470	-1.35	2,980	2,529	-15.13
	2000	10,999	8,385	-23.77	452	488	8.02	3,316	2,425	-26.88
Mumbai	1995	28,765	29,567	2.39	391	481	22.92	7,321	8,099	10.63
	2000	26,450	23,473	-11.26	449	217	-51.65	7,122	6,586	-7.52

Ahemadabad, Chennai, Hyderabad and Kolkata. However, some variations in model values are observed in these cities as shown in the figures concerned. Bangalore is the only city where accident models have fitted well with the data.

A further attempt was made for prediction of road accidents for seven metropolitan cities for the years of 2007 and 2010 as presented in Table 6. The summary of the statistical tests for the regression equations is presented in Table 7.

6. CONCLUSIONS

The data collected for selected metropolitan cities could not be fitted collectively to express the accident model properly. Hence, different models were developed for different cities depending upon the data trends of each city. However, the fatalities model accuracy is acceptable for all cities.

The above models have been used to predict road accidents for the years 2007 and 2010. In order to minimize accidents, major policy may be evolved to reduce the growth of personalized vehicles and simultaneously to encourage the use of public transport vehicles. Due to data limitations, other metropolitan cities could not be considered.

Though a limited study has been reported so far in the area of road accidents, it is desirable to look into the causes and effects of road accidents to be carried out not only at a macro-level but also at a micro-level.

Table 6 Estimates of road accidents, population and motor vehicles of metropolitan cities in India for the Year 2007 and 2010

Name of the Metropolitan City/Year	Population in 1000		Motor Vehicles		Total Accidents		Fatalities		Injuries	
	2007	2010	2007	2010	2007	2010	2007	2010	2007	2010
Ahemadabad	8,718	9,386	1,114,515	1,269,082	3,534	3,723	223	232	3,447	3,645
Bangalore	8,302	9,200	1,897,884	2,041,953	11,657	12,918	962	1,066	8,976	9,972
Chennai	7,107	7,389	1,627,153	1,815,221	4,624	4,705	733	772	4,929	5,100
Delhi	13,872	14,446	4,262,188	4,656,458	11,726	12,220	2,690	2,845	9,370	9,862
Hyderabad	4,513	4,719	1,212,191	1,459,282	1,915	1,951	362	368	1,433	1,460
Kolkata	14,366	14,871	824,597	886,338	8,475	8,512	503	511	2,352	2,320
Mumbai	14,873	15,762	14,872,956	15,765,530	22,470	22,401	158	144	6,722	6,881
INDIA	1,324,815	1,387,958	73,629,596	84,212,864	531,756	569,255	122,272	132,962	556,925	605,857

Table 7 Summary of the statistical tests for the regression equations

Name of the Metropolitan City	Parameter values for Total Accidents (C)					Parameter values for Fatalities (F)					Parameter values for Injuries (I)				
	A	B	R^2	Std. Error	F-value	A	B	R^2	Std. Error	F-value	A	B	R^2	Std. Error	F-value
Ahemadabad	7.545	-1.2943	0.94	0.15	288	1.141	-0.0228	0.90	0.20	174	7.262	-1.2436	0.96	0.11	501
Bangalore	7.314	-1.0139	0.99	0.03	3,512	4.685	-0.9860	0.98	0.06	999	7.447	-1.0849	0.99	0.05	1,789
Chennai	8.156	-1.3080	0.97	0.15	867	3.669	-0.8220	0.95	0.13	484	6.922	-1.0700	0.97	0.13	767
Delhi	5.965	-0.6529	0.97	0.10	683	3.927	-0.5838	0.95	0.11	406	5.896	-0.6458	0.96	0.11	583
Hyderabad	5.836	-0.8419	0.98	0.15	1,466	4.381	-0.8741	0.98	0.14	1,733	5.596	-0.8493	0.92	0.38	237
Kolkata	8.086	-0.9565	0.70	0.31	48	4.499	-0.8294	0.99	0.04	2,674	8.319	-1.2082	0.88	0.22	150
Mumbai	9.818	-1.5022	0.96	0.06	503	11.352	-2.9114	0.89	0.21	173	10.450	-1.9780	0.92	0.12	234
INDIA	9.045	-0.7540	0.99	0.08	1,824	6.4470	-0.5754	0.98	0.08	1,228	7.93	-0.57	0.98	0.07	1,590

A, B & R are the regression constant, regression coefficient and correlation coefficient

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