ROAD ACCIDENTABILITY IN BRAZIL

Antonio Clóvis Pinto Ferraz, Departamento de Transportes, Escola de Engenharia de São Carlos, coca@sc.usp.br

Barbara Stolte Bezerra, Departamento de Transportes, Escola de Engenharia de São Carlos, barbarabezerra@usp.br

Jorge Tiago Bastos, Departamento de Transportes, Escola de Engenharia de São Carlos, jtbastos@usp.br

ABSTRACT

This paper contains an overview of road accidentability in Brazil, by means of total and updated accident indexes, comparisons with values from other countries, and national values evolution over time. A critical analysis of the problem through actions and facts that have occurred or still occur in the country is also presented. Examples of these facts are the mandatory seat belt usage, the advent of the new Brazilian Traffic Code, the "Lei Seca" (zero tolerance for alcohol and driving), and the fleet growth (especially motorcycles). The problem of the main individual transportation modes is analyzed (car and motorcycle). The conclusion is that accidentability in traffic is a serious current problem in Brazil. Therefore, strong actions should be implemented to prevent this problem and avoid additional deteriorations in the future.

Keywords: accidentability, Brazilian traffic, and traffic safety data evolution.

1. INTRODUCTION

In Brazil, based on data from OEI(2007), ABRAMET(2007), and DENATRAN (2005), accident general numbers for the year of 2005 are: 36,000 fatalities, 515,000 injured people (about 1/5 with permanent disabilities), 385,000 accidents with injuries (82% in urban areas and 18% in the highways), 1 million of accidents, 208 accidents with injuries per 100,000 inhabitants, 91 accidents with injuries per 10,000 vehicles, 279 victims per 100,000 inhabitants, 122 victims per 10,000 vehicles, 19 deaths per 100,000 inhabitants, and 85 deaths per 10,000 vehicles.

Comparison with other death causes

Traffic fatality rates for different death causes endorse traffic accidents scene severity in Brazil. According to OEI(2007), traffic accidents occupied the 7th position of the ten major death general causes in 2004, with a rate of 19.6 deaths per 100,000 inhabitants. Thus, above coronary heart disease (17.9), neonatal infections (17.3), and hypertensive diseases (17.2); just below flu/pneumonia (21.0); lower respiratory chronic diseases (21.5) and diabetes mellitus (21.9); and beneath homicides (27.0), ischemic heart diseases (48.5), and brain vascular diseases (50.8). Considering male population, road traffic accidents occupied the 4th position (32.4 deaths per 100,000 inhabitants), only behind homicides (50.5), brain vascular diseases (52.4), and ischemic heart diseases (56.8).

Scenario in relation to other countries

The comparison among Brazil and some more developed countries death rates, according to Table I data, indicates traffic accidents problem severity. The relation between number of fatalities and vehicle fleet is, in Brazil, ten or more times higher than the numbers of Switzerland and Sweden; eight or more times higher than the numbers of Japan, Germany and Great Britain; five or more times higher than the numbers of France and Canada; and four or more times higher than the number of the United States.

Table 1 – Motorization and traffic deaths rates in some countries

Country	**Motorization rate (veh/100 inhabitants)**	**Death rate (deaths/100thosand inhabitants*year)**	**Death rate (deaths/100thosand vehicles*year)**	**Relation between death rate per vehicle in Brazil in comparison with other countries**
Switzerland [a]	68,5	5,0	7,3	11,6
Sweden [a]	57,5	4,9	8,5	10,0
Japan [a]	64,8	5,7	8,8	9,7
Germany [a]	66,6	6,2	9,3	9,1
Great Britain [a]	56,5	5,4	9,6	8,9
France [a]	60,9	7,7	12,6	6,7
Canada [b]	62,4	9,1	14,6	5,8
United States [b]	82,9	14,7	17,7	4,8
Poland [a]	47,3	13,8	29,2	2,9
Hungary [b]	34,2	12,7	37,1	2,3
Brazil [c]	22,8	19,4	85,0	1,0
Kazakhstan [d]	9,4	14,5	154,2	1/1,8
Colombia [d]	6,3	16,8	268,1	1/3,2
Bangladesh [d]	0,22	2,8	1249,3	1/14,7
Ethiopia [d]	0,17	2,6	1553,2	1/18,3

Source: IRTAD (2006), Elvik & Vaa (2004) e ABRAMET(2007)
[a] Data relative to 2006 (IRTAD, 2006).
[b] Data relative to 2005 (IRTAD, 2006).
[c] Data relative to 2005 (ABRAMET, 2007).
[d] Data relative to 1999 (Elvik and Vaa, 2004)

Future predictions

Current traffic accident scene tendency is to become worst if appropriated countermeasures do not be implemented. This prediction is due to the resumption of death and victim number growths since 2001, after the reduction experimented in 1998, 1999 and 2000, as a result of the new Brazilian Traffic Code (CTB, 1997), established in 01-28-1998. What can be seen in Table II.

2. TRAFFIC ACCIDENTS EVOLUTION DATA IN BRAZIL

Table 2 evinces data from 1996 to 2005. This shows traffic accidents evolution.

Table 2 – Data about road accidentability evolution in Brazil

Year	Population (millions of inhabitants)	Vehicle Fleet (millions of vehicles)	Accidents With victims (thousand)	Victims (thousands)	Deaths (thousands)	Hospitalization [a] (thousands)
1996	157,07	27,75	-	-	35,28	-
1997	159,64	28,89	-	-	35,62	-
1998	161,79	30,94	262,37	-	30,89	-
1999	163,95	32,32	376,59	397,65	29,57	-
2000	169,80	29,50	286,99	378,81	27,00	107,97
2001	172,38	31,91	307,29	394,60	30,52	102,22
2002	174,63	34,28	251,88	337,19	32,75	108,36
2003	176,87	36,66	333,69	461,69	33,14	108,75
2004	181,59	39,24	348,58	499,77	35,11	112,50
2005	184,18	42,07	383,37	513,51	35,76	118,12

Source: ABRAMET(2007). [a] Only hospitalization of victims through the public health system (SUS); not considering private insurance coverage.

Graphics representation for population, fleet, deaths, and accidents with victim evolution is shown in Figure I.

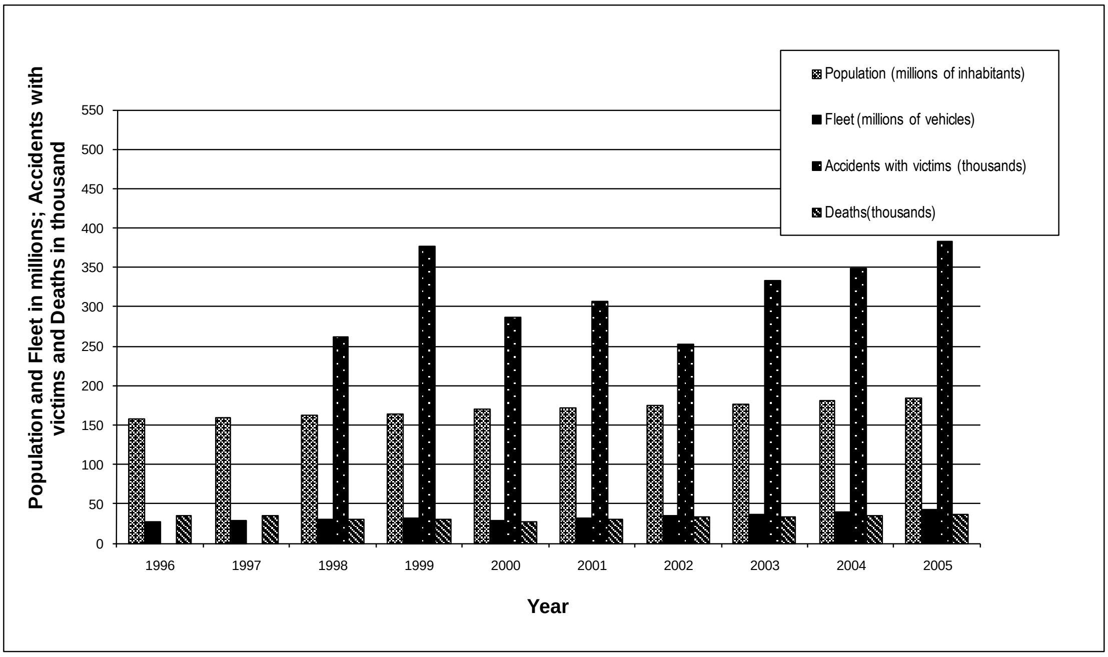

Figure 1 – Evolution of population, vehicle fleet, deaths and accidents with victims.

The main indexes related to traffic accidents in Brazil, from 1996 to 2005, are exposed in Table 3.

Table 3 – Index related to road accidentability evolution in Brazil

Year	Vehicle/ 100 inhabitants	Accident with victims/ 100,000 inh.	Accident with victims/ 10,000 veh.	Victims/ 100,000 inh.	Victims/ 10,000 veh.	Deaths/ 100,000 inhab.	Deaths/ 100,000 Veh.
1996	17,67	-	-	-	-	22,46	127,14
1997	18,10	-	-	-	-	22,31	123,30
1998	19,12	162,17	84,80	-	-	19,09	99,84
1999	19,71	229,70	116,52	242,54	123,04	18,04	91,49
2000	17,37	169,02	97,28	223,09	128,41	15,90	91,53
2001	18,51	178,26	96,30	228,91	123,66	17,71	95,64
2002	19,63	144,23	73,48	193,09	98,36	18,75	95,54
2003	20,73	188,66	91,02	261,03	125,94	18,74	90,40
2004	21,61	191,96	88,83	275,22	127,36	19,33	89,48
2005	22,84	208,15	91,13	278,81	122,06	19,42	85,00

Figure 2 shows the evolution of the following indexes: vehicles per 100 inhabitants, fatalities per 100,000 inhabitants, and fatalities per 10,000 vehicles.

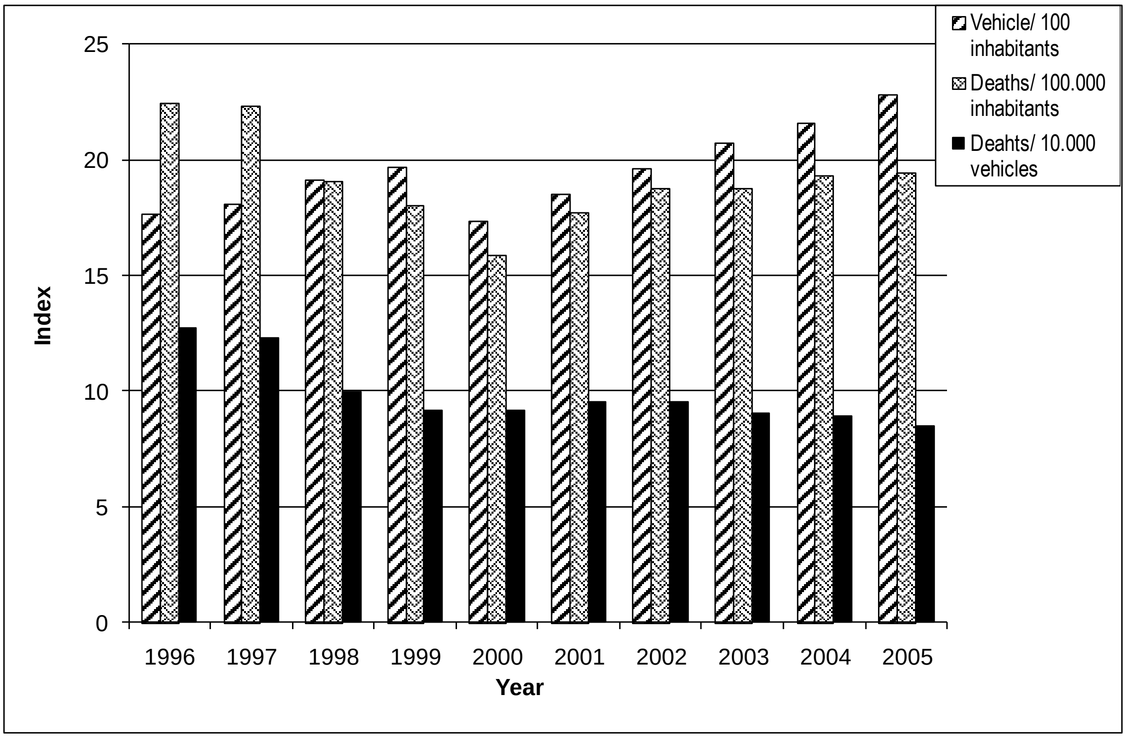

Figure 2 – Evolution of indexes related to road accidentability in Brazil.

Thereby, based on the presented data, some important information is detailed below:

1. The number of deaths decreased significantly in 1998 (because new Brazilian Traffic Code is much stricter than the previous), and continued to decline until 2000, when returned to rise. From 27,000 deaths in 2000, rose to 35,760 in 2005 (a 32.5% increase rate, corresponding to a 6.5% annual growth rate). However, since 2002, this growth rate diminished to 3.1%.

2. . Regarding data about the number of accidents with victims related to 2000 (286,990 crashes) and 2005 (383,370 crashes), the increment was 33.6% increase rate (a 6.7% annual growth rate).

3. Average annual growth rates for deaths and accidents with injuries in the period 2000-2005 are very close: 6.5% and 6.7%, respectively. At the same time, average annual growth rates of population, fleet and motorization index were, respectively, 1.7%, 8.5%, and 6.3%. It demonstrates that deaths and accidents (with injuries) growth rates lie quite above population growth rate, slightly below fleet growth rate, and little above motorization index growth rate. Since the trend is the fleet and motorization index growth continuity, with lifted rates, traffic safety situation tends to deteriorate.

4. Fatalities index, in relation to population decreased significantly in 1998, and persisted to reduce, although slower, until 2000, when returned to inflate. From 15.90 deaths per 100,000 inhabitants in 2000, rose to 19.42 deaths per 100,000 inhabitants in 2005 (a 22.1% addition, corresponding to a 4.4% annual rate). Nevertheless, since 2002, fatalities index growth rate declined, in view of the 1.2% annual rate in the period 2002-2005.

5. Deaths index, in relation to fleet decreased substantially in 1998, and continued to decrease (slowly) until 1999, when had an increase, and returned to decline in 2001. Between 2000 (91,530) and 2005 (85,000) the reduction was 7.1% (-1.4% annual rate). Conversely, since 2002 there was acceleration on this index decrease because the average annual rate, from the beginning of the period until 2005, became -3.7%.

The main reasons for the increment in fatalities and accidents with victim numbers (in the last years) are:

1. Risk exposure level increase, as a result of traffic volume growth. In other words, there was a growth in the amount of vehicle-kilometer and passenger-kilometer travelled, attributed to population and fleet increase and, of course, also to economic development.

2. Substantial increase on motorcycle trips percentage - vehicle much more unsafe than the automobile, bus, or truck.

3. Road users have accustomed to new traffic code higher severity, due to, among other reasons, the fines value stagnation since 2000 and lack of appropriate policy (including financial contribution) directed to traffic education and safety.

Regarding the motorcycle trips higher risks, a national sampling indicated the following numbers: accident involving risks on a motorcycle trip is three times higher in comparison with an automobile trip (on highways and urban areas), the risk of sustaining an injury is eight times higher on highways and 15 times higher on urban areas, and the death risk is 11 times higher on highways and 28 times on the streets.

Therefore, one of the serious traffic safety problems in Brazil is the motorcycles fleet enormous growth. In 1998, motorcycle fleet was 2.79 million (11.5% of the national vehicle fleet) and with an index of 17.3 motorcycles per 1,000 inhabitant. By contrast, in 2006, motorcycle fleet was 9.45 million (20.8% of the national vehicle fleet) and with an index of 50.6 motorcycles per 1,000 inhabitant. It represented a 238.5% fleet increase in eight years (annual rate of 29.8%). Considering the population related index, motorcycle fleet increased 192.5% above the population growth (annual rate of 24.1%). ABRAMET(2007).

Comments about traffic fatalities data

Information source used in ABRAMET(2007), regarding traffic accidents, are: DENATRAN (2005) (accident with injured people and number of victims) and Ministry of Health (traffic fatalities and hospitalizations).

Available data sources for traffic fatalities are: DENATRAN, Ministry of Health (DATASUS), and FENASEG. DENATRAN's data is based on accident reports from Military Police that register deaths occurred at the accident place and also those occurred just before the report conclusion. Ministry of Health information sources are the Coroner Institutes, where the autopsies for non natural cause of death are made. FENASEG data is related to compensations paid because of death, permanent disability, and medical expenses reimbursement, all covered by the Land Motorized Vehicle Personal Damages Insurance (DPVAT), established by Law Number 6.124, dated of 12-19-1974.

Table 4 indicates traffic accident deaths, from 2002 to 2005, according to the three mentioned data sources (Por Vias Seguras, 2008). It also contains death numbers estimated through the multiplication by the 1.65 factor (as recommended for the international practice).

Table 4– Number of deaths in traffic accidents

Year	2002	2003	2004	2005
FENASEG	42.271	43.185	40.685	39.179
DATASUS*	31.956	32.275	34.247	35.147
DENATRAN	18.877	22.629	25.526	26.409
DENATRAN x 1,65	31.147	37.338	42.118	43.575

Source: Por Vias Seguras[39]

*Values correspondent to 96% of the total deaths in accidents with transports (slight different from the values considered in ABRAMET(2007)[6], that refers to total number of accident in terrestrial transportation)

Figure 3 shows traffic fatalities evolution according to the three data sources mentioned.

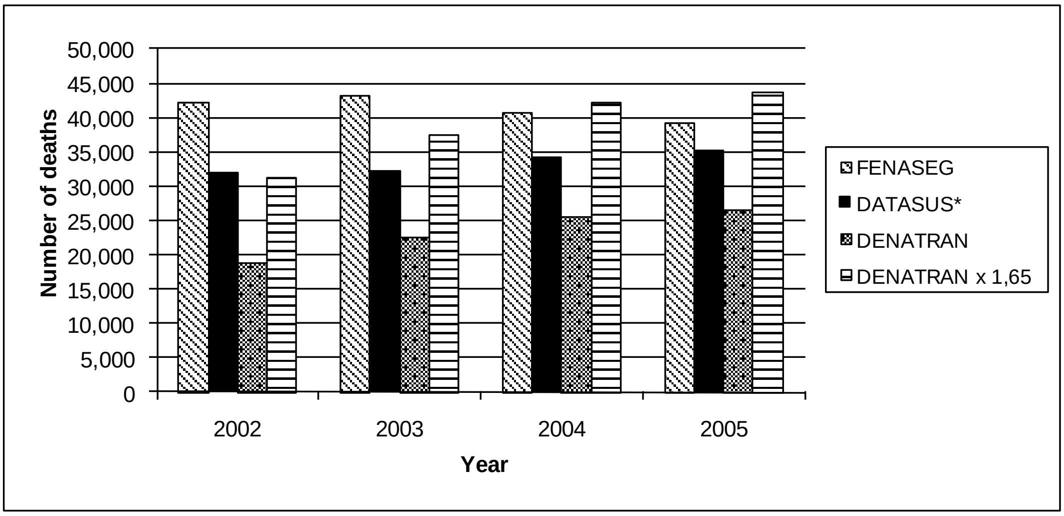

Figure 3 – Evolution of number of deaths accordingly different sources of data.

In this paper it was used fatalities numbers mentioned in ABRAMET(2007) and total numbers of transportation accidents presented by the SUS (Sistema Único de Saúde), both in agreement with the procedure adopted in the most of national technical publications.

Distribution of accident with injury (by type)

Table 5 evinces many types of accidents with injuries, in the period 2001-2005.

Table 5– Distribution of accidents with victims by type of accident

Year	Collision	Roll over and overturn	Run over	Collision with fix object	Other	Ignored
2001	51,9	9,2	21,9	7,1	5,0	4,9
2002	53,6	9,1	21,1	8,0	5,9	2,3
2003	53,0	10,4	18,7	8,1	6,5	3,3
2004	52,2	10,2	18,7	7,8	6,7	4,4
2005	53,5	10,4	17,5	8,2	7,8	2,7

Source: ABRAMET(2007).

Initially, percentages of each accident type are very close during the considered period. However, run over proportions decreased 20.1% from 2001 to 2005. It can be considered a positive aspect, whereas this is the accident type with higher fatality rate.

Slightly more than a half of the crashes were result of the interaction between two vehicles (collision). Accidents resultants of vehicle run offs (overturn, roll over and collision with fixed object) and run over are responsible for almost 20% of accidents with injuries.

Accidents with injury distribution by period of the day

According to ABRAMET(2007), in 2005, the accident with injury percentages associated to the period of the day are as following: daylight = 57.0%; night = 40.3%; and not declared = 2.7%.

Although risk exposure levels are unknown in both periods, the number of trips during daylight is much superior to the night ones. Therefore, even if the daylight accidents percentage is larger, is not sure state that is more risk travelling at daylight.

Accidents with injury according to occurrence area

ABRAMET (2007) data indicates that 81.7% of the accidents with injuries occurred in urban areas, 16.4% in rural areas, and 1.9% in not declared places. Probably, the intense risk exposure level in the urban environment explains these data.

Traffic fatalities by gender

Table 6 contains data regarding traffic fatalities by gender in relation to general population and licensed drivers for the year 2005.

Table 6 – Number of traffic fatalities by gender for the year 2005

Parameter	**Male** *	**Female** *	**Relation Male/Female**
Number of fatalities	29.098	6.658	4,37
Distribution of number of deaths (%)	81,4	18,6	-
Death rate per 100.000 persons of same gender	32,2	7,1	4,53
Number of drivers (millions)	28,64	11,42	2,51
Distribution of number of drivers (%)	71,5	28,5	-
Death rate per 100.000 drivers of same gender	101,6	58,3	1,74

Source: ABRAMET(2007)*

Traffic accidents killed men 4.37 times more than women. Since female population is slightly superior, considering the fatality rate per gender, the relation male/female increases to 4.53 times. Additionally, the number of male drivers is 2.51 times higher than the number of female drivers, which diminish this relation to 1.74.

Nonetheless, as a result of the absence of information on exposure by gender, no conclusions can be achieved about differences between men and women risk of involvement in fatal accidents.

Traffic accident death by age

Table 7 illustrates the traffic deaths distribution by age and respective rates per 100,000 inhabitants for 2004.

Table 7 – Traffic deaths distribution by age group in the year of 2004.

Age group (years)	Number of deaths	Distribution %	Amount of people in the age group in millions	Rate (death/100.000 inhab. by age group)
0-10	1,448	4.1	32.48	4.5
10-20	3,976	11.3	36.95	10.8
20-30	8,938	25.5	31.91	28,0
30-40	6,555	18.7	27.71	23.7
40-50	5,546	15.8	21.98	25.2
50-60	3,765	10.7	14.09	26.7
60-70	2,435	6.9	9.09	26.8
70-80	1,548	4.4	5.3	29.4
> 80	680	1.9	2.1	32.1
Ignored	214	0.7	-	-

Source: ABRAMET(2007).

Based on the presented data, some observations are important to be stated. Fatality rates until the age of 20 years old are smaller due to children and teenagers travel less frequently than adults. This reduces the risk exposure level of the 0-20 year old group.

Oppositely, the group of 20-30 years old has great rates, probably for the following reasons: the number of trips per person is high, young drivers are more prone to risky behavior while driving (as drinking alcohol), and the motorcycle (more risky vehicle) usage index is also higher among this age group.

Between ages 30 to 70 years old, the fatality rate seen to have a constant increasing growth (from 23.7 to 29.4). This is attributed to mental and physical reduced agility which compromises the driver's or even pedestrian's performances.

Traffic fatalities by transportation mode

In figures 4 and 5 are shown the time series evolution of percentages and traffic fatality rates for the main transportation modes, respectively.

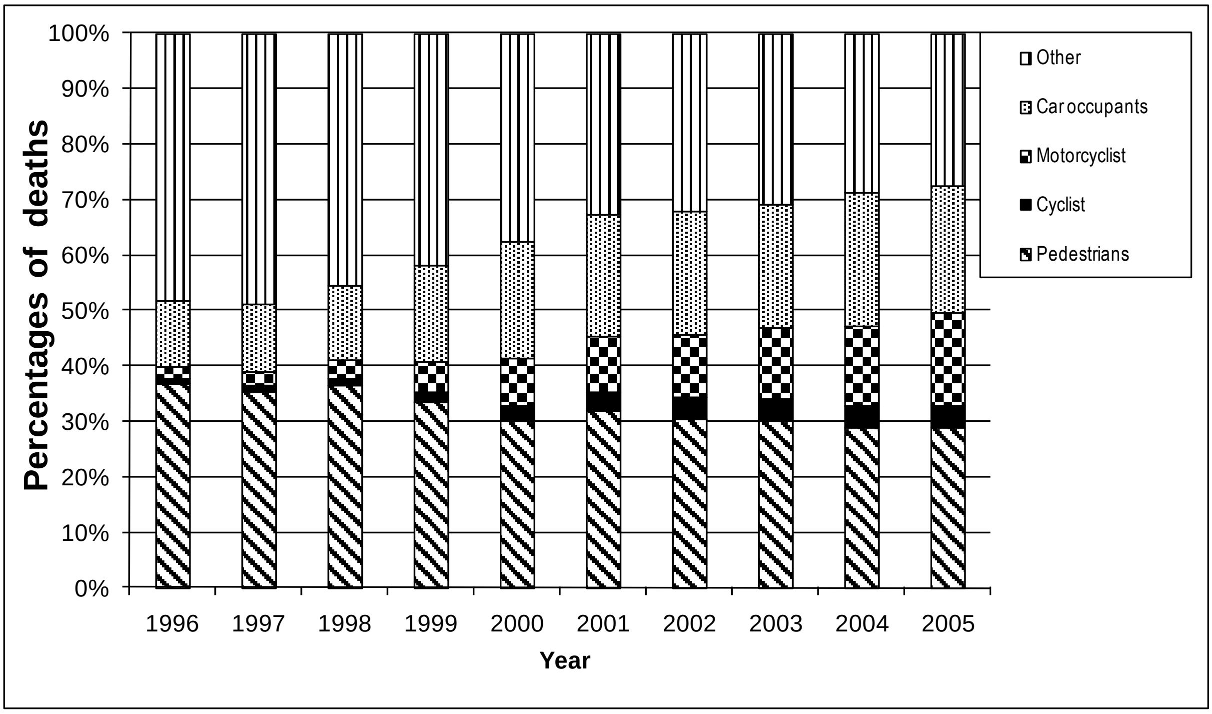

Figure 4 - Time series of percentages of deaths in traffic by different mode of transports. Source: ABRAMET(2007).

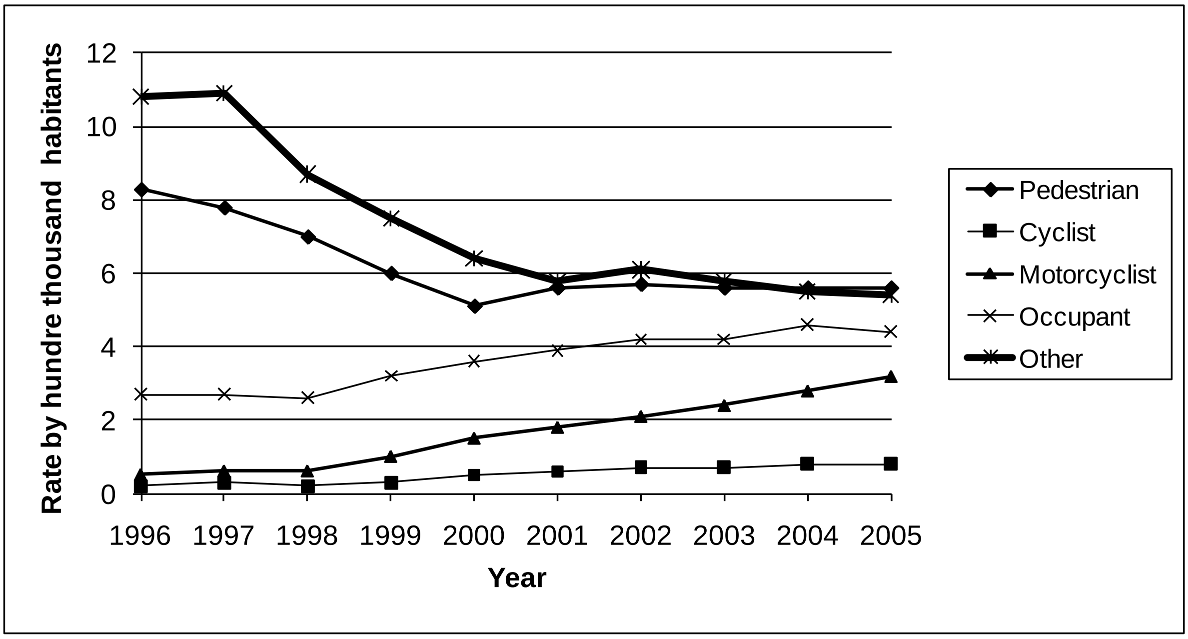

Figure 5 – Time series for death rates regarding per population by different mode of transports. Source: ABRAMET(2007).

Considering transportation mode, death distribution of 2005 is shown on Table 8

Table 8 – Deaths in traffic x mode of transport in Brazil

Mode	Percentage (%)
Car, bus and trucks	22,9
Motorcycle	16,6
Bicycle	4,2
Pedestrians	28,7
Ignored and other	27,6

Source: ABRAMET(2007).

Traffic fatality rate and percentage of the accidents classified as others/unknown is decreasing through the years, leading to the belief of an improvement in the accident data collection and processing.

Pedestrian's fatality rate reduced substantially in the period 1996-2000. It experienced a small increase in 2001 and, from then, remained practically constant. By the other hand, fatality accident rates involving motorcycles, automobiles, trucks, buses or bicycles are inflating through recent years. This increment is very high for motorcycles, a few smaller for the group automobile/truck/bus, and much smaller for bicycles, in a reasonable correlation with each transportation mode usage growth.

Traffic fatalities: age and transportation mode association

Figures 6 to 9 indicate traffic fatality rates per 100,000 inhabitants for each transportation mode and age group.

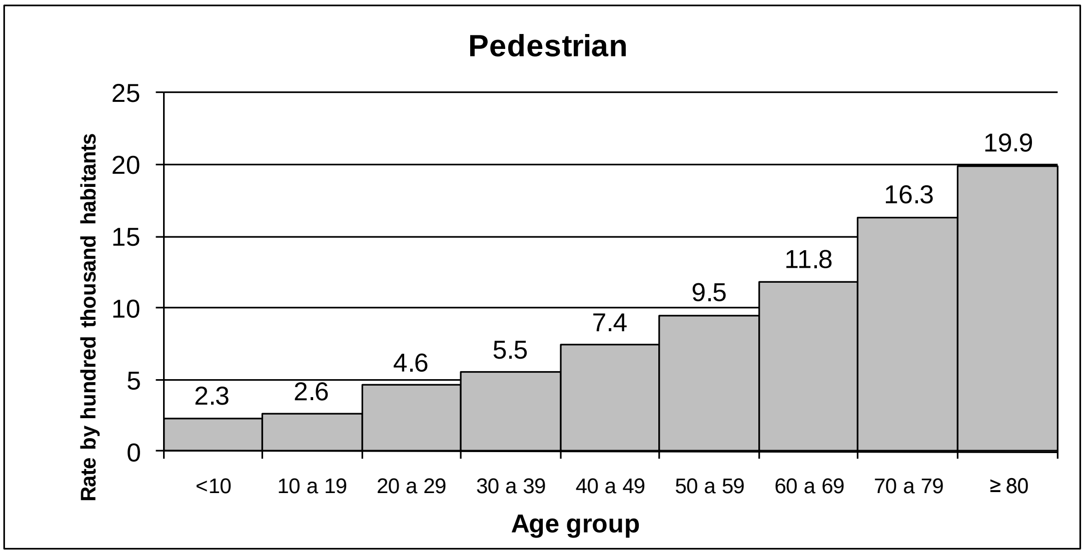

Figure 6 - Pedestrian fatality rates per 100,000 inhabitants and age group. Source: ABRAMET(2007).

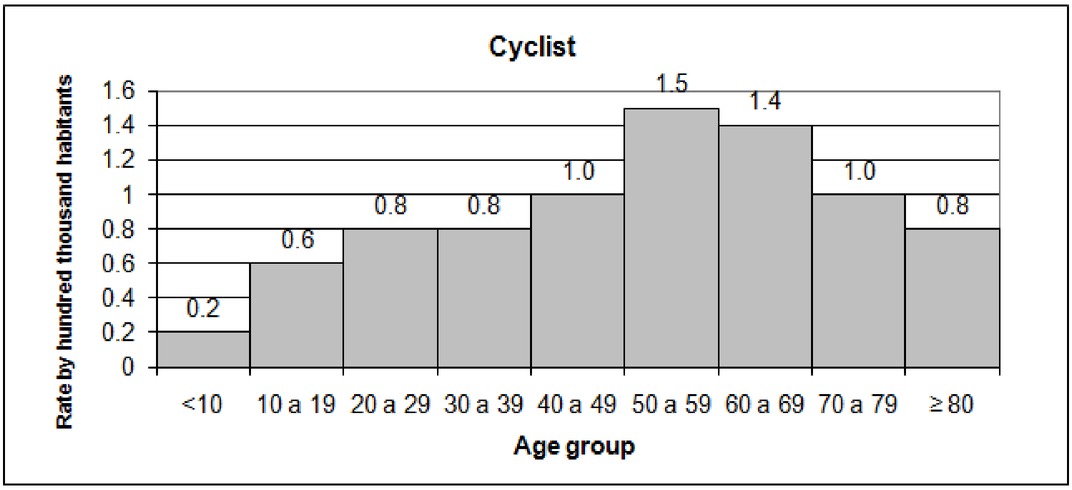

Figure 7 - Cyclist fatality rates per 100,000 inhabitants and age group. Source: ABRAMET(2007).

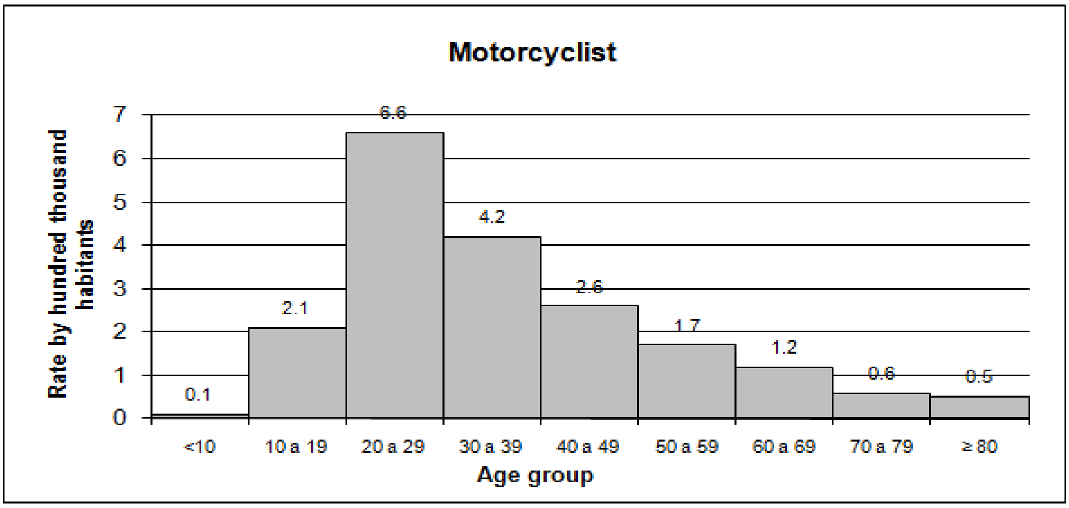

Figure 8 - Motorcyclist fatality rates per 100,000 inhabitants and age group. Source: ABRAMET(2007).

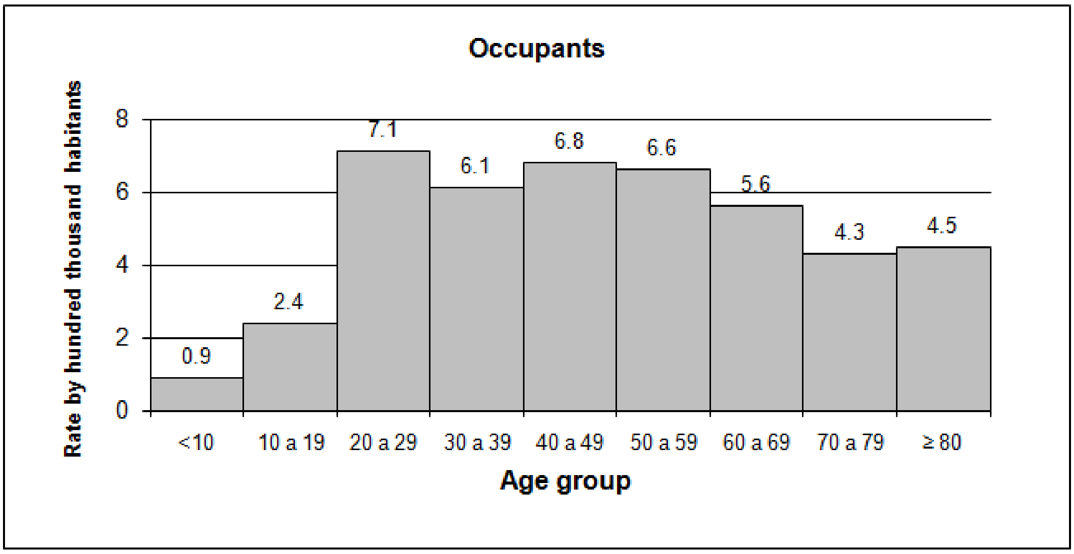

Figure 9 – Occupants fatality rates per 100,000 inhabitants and age group. Source: ABRAMET(2007).

There are presented below some comments based on Figures 6 to 9 data:

1. Pedestrians – fatality rate increases with age, which indicates a relation with the smaller mobility rate of children and teenagers and also the mental/physical abilities reduction for the elderly.

2. Cyclists – rates are reduced for younger than 20 years old and elevated for the age between 50 and 70 years old. Probably, this is the result of a smaller mobility rate for children and teenagers and a more intense bicycle usage among this intermediate age group.

3. Motorcyclists – rates are low for younger than 20 and older than 50 years old. Oppositely, rates are high for 20-40 years old group. Maybe it is due to the non-use of motorcycle for younger than 18 years old and a reduced usage by the elderly, in association with a more risky behavior of the 20-30 years old parcel.

4. Passengers – rates are low for younger than 20, high for the 20-70 and median over the 70 years old, probably, influenced by a smaller mobility rate for children, teenagers, and elderly.

3. TRAFFIC ACCIDENT DATA IN URBAN AND RURAL STREETS

Rural streets (highways)

Distribution values of highways accidents and fatalities percentage (per type) are shown in Table VIII, in three different ways:

1. Federal highways, involving two-lane and multilane, in 2004 (IPEA, 2006).

2. Two-lane highways segments of São Paulo State (about 640km), in 2006.

3. Multilane highways segments of São Paulo State (about 765km), in 2006.

Table 10 exposes the fatality rate by accident type for the three mentioned cases. Table 11 points the main indexes that characterize the traffic accidents for the three cases.

Table 9 – Death and type of accidents in some Brazilian roads.

Type of accident	Accidents			Deaths		
	Federal Roads	Two-lane	Multilane	Federal Roads	Two-lane	Multilane
Rear collision	24,1	14,0	15,7	9,0	11,9	30,7
Head on collision	4,0	2,7	0,7	24,6	21,4	3,4
Transversal collision	7,1	8,1	2,0	7,7	11,9	9,1
Lateral collision	17,0 (52,2)	9,9 (34,7)	5,6 (24)	9,8	7,1	1,1
Collision with fix object [a]	22,3	31,1	44,9	12,9	14,3	11,3
Pedestrian run over	3,6	2,2	2,2	19,1	12,1	30,7
Animal run over	3,1	8,0	5,8	0,9	0,0	1,1
Overturn	5,7	10,2	9,5	2,6	4,8	2,3
Roll over	6,5 (12, 2)	8,6	6,4	7,3	11,7	4,5
Pile-up	1,0	0,2	0,4	0,5	0,0	0,0
Other [b]	5,6	5,0	6,8	5,5	4,8	5,8
Total	100,0	100,0	100,0	100,0	100,0	100,0

[a] Included the accident of runoff, because is imply that, only in rarely exception, always exist a collision with a fix object. [b] Fall, fire, without information, etc.

Table 10 – Taxa de mortalidade (mortes/100 acidentes) por tipo de acidente

Type of accident	Federal Roads	Two-lane	Multilane
Rear collision	2,0	3,1	4,9
Head on collision	33,2	29,0	13,0
Transversal collision	5,9	5,4	11,1
Lateral collision	3,1	2,7	0,5
Collision with fix object [a]	6,2	1,7	0,6
Pedestrian run over	29,3	20,0	34,2
Animal run over	1,6	0,0	0,5
Overturn	2,5	1,7	0,6
Roll over	6,1	5,1	1,8
Pile-up	2,7	0,0	0,0
Other [b]	5,3	0,4	2,1
Total	5,4	3,7	2,5

[a] Included the accident of runoff, because is imply that, only in rarely exception, always exist a collision with a fix object. [b] Fall, fire, without information, etc.

Table 11 – Main indexes that characterized road accidentability.

Type of accident	Federal Roads	Two-lane	Multilane
Deaths in the spot/ 1,000 accident	54,4	24,9	36,8
Accidents/Year/ km of road	4,84 – 8,34 [a]	5,54	1,49
Deaths in the spot/Year/ 100 km of road via	-	13,8	5,5

[a] Range of values for the five roads with high accidents rates, based on IPEA(2006).

From Tables 9-11 some comments are worthy:

1. The lower accident and death per kilometer indexes obtained in two-lane segments of São Paulo State, in relation to federal highways (including two-lane and multilane segments) are probably a result of a superior design standard (geometry, signing, drainage, and pavement), maintaining, enforcement, and victims assistance.

2. In multilane roads, the accident per kilometer index was 3.7 times lower than the one for two-lane, and the deaths (on the accident place) 2.5 times lower. It is attributed to the better operating condition of multilane highways, especially considering overtaking.

3. In both two-lane and multilane highways, the most common accident types are collision with fixed object and rear end collision, respectively. In federal highways (including two-lanes and multilane), the two mentioned types are also the most common, however in oppose ordination.

4. In multilane highways, the most fatal accidents are equally rear end collision and pedestrian run over. In two-lane roads, head-on collision is in first place, followed by collision with fixed object. In federal highways, at first is head-on collision, and secondly the pedestrian run over. This is logical if considering the simultaneous two-lane and multilane highways presence.

5. In multilane roads, the pedestrian run over is the type that presents the highest deaths per accident rate. In second place is the head-on collision (which is rare, but lethal). In two-lane roads, at first is head-on collision, followed by pedestrian run over. The lower speeds on two-lane highways perhaps explain the reduced lethality in run over.

Based on data of the same 1,405km of highways (640km of two-lane and 765km of multilane), the accidentality estimation, per person travelling in distinct vehicle types (except buses), presented the values exposed in Table 12. This consists, approximately, on the risk of a person to have an accident travelling on the analyzed highways by the different vehicles considered.

Table 12 – Accidentability per person travelling in different vehicles types [a]

Vehicle type	Accident	Injured	Death
Car	1	1	1
Trucks	1	0,6	0,5
Motocycle	3	8	11

[a] The available data did not allowed to make reliable estimative to bus.

The highest risk associated to motorcyclists is presumably accredited to the following factors: young drivers' abuses on speeding and on taking dangerous manoeuvres, lack of conspicuity, and ease of loosing balance while riding (arousing the vehicle fall). Likewise, the higher risk of sustaining an injury using a motorcycle is a result of the protective frame and the seat belt performance in trucks and cars. In the case of trucks, the frame is more resistant than the one for cars, besides, driver and passengers are in a highest position (an advantage in many accidents), which ensure a risk two times lower compared with the automobile's risk.
Other relevant data from IPEA (2006) researches are:

1. 4.4% of the accidents occurred in highways were fatal, 31.9% presented injured victims, and 63.8% did not have any injury sustained (values referring to the situation at the accident place, as reported by the Federal Highway Police).

2. For each 1,000 accidents, there were 94.9 fatalities, 772.9 injured people (values corresponding to a 30 days period after the accident occurrence).

3. 61% of the fatalities occurred at the accident place and 39% not. The number of posterior deaths represents 65% of the deaths occurred at the accident place, the same percentage internationally adopted for the 30 days after period.

4. 73% of the injured people exhibited symptoms at the place and 27% after leaving the place – a part of the two groups has evolved to death.

5. 6.7% of participants considered not injured revelled injured afterwards and 6.2% of the injured people at the place died, according to the Federal Highway Police.

6. For each 11 accidents there is a fatality (at the accident place or not) and for each 1.3 accident there is an injured person.

Research performed by the Institute of Post Graduation and Administration Research of the Federal University of Rio de Janeiro (COPPEAD, 2008), indicated that, taking into account only the deaths on policed federal highways, the fatality rate per 1,000 kilometres is 106.8 in Brazil. In other countries, this rate has the following values: Germany = 10.5 (10.2 times lower); Italy = 10.1 (10.6 times lower); United States = 6.6 (16.2 times lower); Canada = 3.3 (32.4 times lower). In American highways, for each 10,000 accidents group, 65 people die; in Brazil, 544 (8.4 times more) considering only federal policed highways, and 909 (14 times more) considering all highways.

Urban streets

Table 13 exposes accident and fatalities distribution values by accident type in four cities located at Southern Brazil:

1. City A - population about 100,000 inhabitants;

2. City B - population about 200,000 inhabitants;

3. City C - population about 400,000 inhabitants;

4. City D - population about 1.5 million inhabitants.

Table 13 - Distribuição dos acidentes e das mortes por tipo de acidente em cidades.

Accident type	Accidents				Deaths			
	A	B	C	D	A	B	C	D
Rear and Head on collision	21,7	25,6	24,8	34,2	30,0	50,0	14,5	11,2
Transversal and Lateral collision	44,7	46,6	33,3	46,0	20,0	12,5	14,5	19,7
Collision with fix object	27,6	20,1	12,1	11,2	30,0	31,2	22,6	23,0
Pedestrian run over	3,4	2,9	8,0	5,9	10,0	6,3	25,8	42,1
Animal run over	0,3	0,4	0,8	0,0	10,0	-	3,2	-
Overturn	0,4	0,6	2,2	0,2	-	-	3,2	-
Roll over	0,3	0,6	1,2	0,4	-	-	3,2	1,3
Pile-up	0,4	1,1	0,6	0,0	-	-	-	-
Other [a]	1,2	2,1	17,0	2,1	-	-	13,0	-
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

[a]Fall, fire, without information, etc.

Table 14 presents the mains indexes related to traffic accidents in the four cities.

Table 14 - Main indexes that characterized road accidentability

Type of accident	A	B	C	D
Motorization rate (vehicle /100 inhabitants)	45,60	47,50	49,52	39,83
Accident/thousand vehicle	35,79	33,51	35,81	36,96
Accident/thousand inhabitants	16,32	15,92	17,73	14,72
Deaths in spot/100.000 vehicle	10,52	16,84	15,05	27,35
Deaths in spot/100.000 inhabitants	4,80	8,00	7,45	10,90
Deaths in spot/1.000 accidents	2,94	5,03	4,20	7,40

Some comments are important based on Tables 13 and 14 data:

1. Fleet and population related accident rates are similar, not presenting substantial differences for cities with distinct sizes.

2. Local deaths indexes, in relation to fleet or population, pointed a growth tendency with the city enlargement. Possibly, one of the reasons is the existence of streets with higher speed limits in larger cities.

3. Side and lateral (in the same or opposite way) are the most common accident types, followed by rear and head-on collisions.

4. According to lethality, the ordination is rear/head-on collisions and collision with fixed object in the smaller cities; and pedestrian run over and collision with fixed object in the larger ones. Also here, the higher speed limits may have an important part on these numbers.

Accidents estimative per passenger travelling in a car and a motorcycle for the analyzed cities are shown in Table 15. These values express, approximately, the relative risk of a person in the studied cities, by car/motorcycle.

Table 15 – Relative risk of a person in different vehicles type

Vehicle type	Accident	Injured	Death
Car	1	1	1
Motorcycle	3	15	28

The comparison between these data and the obtained information for highways provides some comments:

1. Motorcyclists' higher risk of involvement in accident compared with the car is very close in both cases (urban and rural streets), being almost three.

2. Motorcyclists' higher risk of involvement in accident with injury in relation to a car accident is about two times higher in the urban environment than in the highways (15 against 8). This is attributed to the efficiency reduction of seat belts and automobile's protective frame caused by higher speeds.

3. Death risk in a motorcycle is about 2.5 times higher compared with the car in urban streets (28 against 11 in rural streets). Certainly because of the same reason mentioned in the item before.

Other relevant data contained in IPEA (2003) research, related to urban areas are:

1. Accidents with victims correspond to 14% of the occurred accidents. Opposing, the accident with no injuries are 86% of the total number.

2. 7% of the car accidents had victims, while for motorcycle this proportion was 71%.

3. Number of falls of people, without any vehicle participation, is 9 per each 1,000 people group.

4. ENFORCEMENT SCENARIO IN BRAZIL

Specialists' opinion is, generally, in favour of the national traffic legislation. These laws are established by the Federal Constitution (which specifies general recommendations), the Brazilian Traffic Code (main document), resolutions of Traffic National Council (CONTRAN), ordinance of the Traffic National Bureau (DENATRAN), statutes, and specific laws.

However, there are two negative aspects in the last years. The fines' value is unchanged since 2000. Therefore, the fines' price, that at the beginning of the new code implementation, were substantially expensive (inhibiting illegal actions), are now acceptable for most part of drivers. The subsidence of fines' value for speeding and other penalties (established by the Federal Law number 11.334 of 6-25-2006) also deserves criticism.

Until this law implementation, the following criterion was in force:

1. Serious infraction (5 points = R$127,69 fine) – for speed superior until 20% of the legal limit on highways, rapid traffic streets, and arterials; and until 50% of the legal limit excess for the rest.

2. Very serious infraction (7 points = R$574,72 fine, suspension of the right to drive through license seizure) – for speed superior over 20% of the legal limit on highways, rapid traffic streets, and arterials; and over 50% of the legal limit excess for the rest.

The new law, a criterion for all streets was established:

1. Median infraction (4 points = R$85,13 fine) – for speed superior until 20% of the legal limit.

2. Serious infraction (5 points = R$127,69 fine) – for speed superior over 20-50% of the legal limit.

3. Very serious infraction (7 points = R$574,72 fine, suspension of the right to drive through license seizure) – for speed superior over 50% of the legal limit.

After all, the speed penalties subsidence certainly contributed to the increase in numbers of accidents in 2007. In federal highways, for instance, fatalities at accident place increased from 6.168 in 2006, to 6.840 in 2007 (a 10.9% increment).

In spite of that, some recent actions are very positive for the traffic legislation, which are commented in the next paragraphs.

The CONTRAN number 267 resolution (from 2-15-2008) requires the sleep disorders evaluation for the candidates to addition, renewal, or change to C (truck), D (bus) or E (cart) license category. Candidates should be evaluated in relation to the Syndrome of Obstructive Sleep. Objective parameters are verified, as hypertension and Malampaatti Classification; and also subjective parameters that revel excessive drowsiness are measured according to Epworth Sleepiness Scale.

Subsequently, other CONTRAN resolution (number 277 from 5-28-2008) establishes patterns for the shape and usage of the devices for children transportation in automobiles (with obligation predicted for 2010). According to this resolution, younger than 10 years old should be transported on the rear seat, with the individual seat belt usage or a similar retention system, as follows:

1. Child restraint system for children younger than 1 year old;

2. Little chair for children between 1-4 years old;

3. Lifted seat for children between 7.5-10 years old;

4. Seat belt on the rear seat for children between 7.5-10 years old.

In order that, the amount of dead/injured children in traffic accidents certainly will decrease thanks to the proper protection devices.

The helmet usage, for motorcycle riders or passengers, covered by CONTRAN resolution number 203 from 9-29-2006, also defines new specifications for the helmets conception, resistance, retroreflective material, and etc. This is a very important action because the proper helmet usage is fundamental for motorcycle users' protection.

CONTRAN resolution number 219 from 1-11-2007 establishes the safety requirements for private cargo transportation by motorcycles and scooters, as maximum cargo compartment dimension and other aspects as cargo weight, dimensions, position, and etc. Retroreflective material used in cargo compartment, in helmets, and in vests is also referred in this resolution.

But the most relevant change in traffic legislation is the law number 11.705 from 6-19-2008, which modifies the law number 9.503 from 9-23-1997. It establishes zero tolerance to alcohol and more severe penalties for the driver caught driving under alcohol influence. Since the new traffic code implementation, the limit was 6 decigrams of alcohol per litter of blood concentration, approximately equivalent to three beer glasses. In fact, the tolerance levels of the Decree 6.488 from 8-19-2008, the limit is 0.1 milligram of alcohol per litter of air expelled from the lungs (measured through the breathalyzer), or 2 decigrams of alcohol content per litter of blood (measured in a blood exam). An abstract of the new law penalties is presented below:

1. Between 0.1 mg/l and 0.29 mg/l (or between 2 dg/l and 5.99 dg/l) of alcohol – very serious infraction, 7 points, R$957,50, license seizure and vehicle apprehension during a year;

2. Over 3 mg/l (or 6 dg/l) of alcohol – all the prior item penalties, added of driver flagrant arrestment for a variable 0.5-3.0 years period (being the crime without surety).

If the driver refuses to take the exams, the traffic agent can identify the infraction through evident drunkenness signs, excitation or numbness presented by the driver. In this case, the same mentioned penalties are applied.

Other important action introduced by the law number 11.705 was the change on manslaughter offense to intentional crimes for the traffic injuries caused by alcoholised drivers.

Undoubtedly, this was one of the most effective measures to improve traffic safety in Brazil, since researches show that about a half of the accidents with injured people involved someone drunk.

Still on enforcement issue, a unanimous critic among specialists is the lack of supervision. Proper legislation does not work in the sense of reducing accidents without proper supervision on streets. Furthermore, other enforcement fault is the absence of legal obligation for periodic vehicle inspection, since almost in 30% of Brazil's traffic accidents some vehicle failure is present.

In agreement with the exposed facts, the following main actions can be pointed to improve the enforcement in the country:

1. Traffic fines' value update.

2. Hardening on penalties for speeding, but establishing proper legal limits. Limits under the technically acceptable generally lead to excessive numbers of fines without effects on accidents reduction.

3. Periodic vehicle inspection system implementation.

4. Supervision intensification, through action like agents' training, increase of agent's staff, fleet and equipment enlargement (radar guns, breathalyzers, and etc.), and electronic supervision extension. It is also included the special attention to infraction related to alcohol and speeding, since they present a high correlation with the traffic accidents amount and severity.

5. Obligation of vehicles with third break light production.

6. Daytime running lights obligation.

5. EDUCATION ORIENTED FOR TRAFFIC IN BRAZIL

According to specialists, the rules on education oriented for traffic are properly established in Federal Constitution, National Traffic Code, and in resolutions of CONTRAN. However, these practices implementation is not satisfactory. Traffic education in schools is very incipient. Methods and teaching programs are not defined in the three levels (elementary/high school and colleges). Further, the number of institutions that systematically adopts traffic education is much reduced.

6. VEHICLES AND SAFETY DEVICES

Lately, there were substantial advances on Brazilian vehicles safety, following the international tendency. The national economic growth has also contributed for these improvements.

In a general view, the two main fleet related safety problems in Brazil are the lack of proper maintenance and the motorcycles (or similar vehicles) usage spread. The first is evident because of the great percentage vehicle failure presence as one of the accidents contributing factors. In the country, this value reaches 30%, while in developed countries is 10%. The second is expressed by the 29% growth of the motorcycle fleet in the period 1998-2005, with a population related index (motorcycles per 1,000 inhabitants) annual growth rate of 24.1%. Finally, the death risk associated to this mode is 28 times higher compared with an automobile.

Some action can be pointed to improve the safety on vehicle related issue:

1. Obligation of the production of automobiles with the third brake light.
2. Obligation of low beam lights usage for all vehicles during the day on the roads.
3. Obligation of the production of automobiles with airbags to protect front seats occupants.
4. Usage of speed limitation devices on all vehicles (especially on motorcycles).
5. Reduction of motorcycles’ power.
6. Obligation of periodic vehicle inspection.

7. FINAL CONSIDERATIONS

In parallel with national economic growth, Brazilian road system (rural and urban streets) is receiving safety improvements, through the construction of new safer roads and adequacy of the existing ones. Although, there is still a long way to Brazilian l roads reach developed countries in terms of safety road traffic.

Briefly, the following measures can be listed for the country road system improvement:

1. Elaboration of new road projects, with a greater emphasis on safety (safety audits can contribute in this sense).
2. Adequacy of the existing roads so they can became safer: geometry faults corrections, third lane implementation in two-lane highways, shoulders enlargement and paving, elements of lateral restraint installation, rigid lateral barriers elimination, pedestrian builds construction, reconstruction changes of opened intersection (with direct passing) to roundabouts (forcing vehicles to bypass), close curb radius enlargement, sight distance enlargement, super elevation and pavement widening on curves problems correction, readability of the tracks improvement (making the path clear for drivers), elimination of entries/exits in improper points, and etc.
3. Promotion of road and signing conservation.
4. Intensification of actions directed for black spots treatment, by correcting infrastructural/operational problems, installing speed control devices, improving lighting, and etc.
5. Modern signing implementation, including reflective demarcation elements use (to improve visibility at night or under adverse weather), and dashboards with real time information (online).

6. Usage of proper signing on intersections.

7. Establishment of signals operational conditions (location and model of the signal, visibility on the approaches, allowed/protected conversion maneuvers, times duration, phase sequence, and etc.), always in favor of safety.

REFERENCES

WHO (2004). World report on road traffic injury prevention. World Health Organization Geneva.

OEI (2007). Mapa da violência dos municípios brasileiros. Organização dos Estados Ibero-americanos para a educação, a ciência e a cultura. Julio Jacobo Waiselfisz. Brasil.

ABRAMET(2007). Acidentes de trânsito no Brasil: Um atlas de sua distribuição. Associação Brasileira de Medicina de Tráfego. São Paulo.

DENATRAN (2005) Anuário Estatístico 2005. Departamento Nacional de Trânsito. Brasil. Accessed in December of 2008. <http://www.denatran.gov.br>.

IRTAD (2006). International Road Traffic and Accident Database. Accessed in December of 2008 <http://www.irtad.net>.

Elvik, R. and Vaa, T. (2004). The handbook of road safety measures. ELSEVIER.

IPEA (2003). Impactos sociais e econômicos dos acidentes de trânsito nas aglomerações urbanas. Instituto de Pesquisas Econômicas Aplicadas Brasília.

IPEA (2006). Impactos sociais e econômicos dos acidentes de trânsito nas rodovias brasileiras. Instituto de Pesquisas Econômicas Aplicadas. Brasília.

Por Vias Seguras (2008) – Associação Brasileira de Prevenção dos Acidentes de Trânsito. Accessed in December of 2008 http://www.vias-seguras.com/>.

COPPEAD (2008). Notícias sobre acidentes. Accessed in December of 2008 <http://www.centrodelogistica.com.br/new/fs-pesquisa.htm>.