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ROAD SAFETY IN BRAZIL: CHALLENGES AND OPPORTUNITIES

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16. Abstract

This report was designed to analyze the traffic-safety situation in Brazil, and to identify countermeasures for areas in which the total harm caused by crashes can be substantially and readily reduced. The report focuses on two aspects of traffic safety in Brazil: challenges and opportunities. The first part of the report provides a comprehensive analysis of the current traffic-safety situation in Brazil. Based on this analysis, the following four areas are identified as having potential for substantially reducing fatalities in Brazil: (1) pedestrian crashes, (2) motorcycle crashes, (3) nighttime crashes, and (4) crashes on two-lane roads. The second part of the report outlines several promising countermeasures for each of these four areas.

The discussion of the current traffic-safety situation and the proposed countermeasures were based on the available data that, in many respects, are not comprehensive and uniform. Consequently, it is recommended that a uniform, detailed reporting system on all fatal crashes in the country be instituted.

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CONTENTS

INTRODUCTION

This report is the third in our series that examines road safety challenges and opportunities in developing countries. The earlier reports examined the situation in China (Zhang, Tsimhoni, Sivak, and Flannagan, 2008) and India (Mohan, Tsimhoni, Sivak, and Flannagan, 2009).

CHALLENGES: ROAD SAFETY IN BRAZIL

Geographical and institutional aspects

Brazil has an area of 8.5 million km^2, with an estimated population in 2008 of 191 million people (IBGE, 2009). The country has 27 states and about 5,600 cities, with urban populations that vary from a few hundred people up to 11 million in the city of São Paulo. In the last five decades, there has been an intense process of urbanization and today about 90% of people live in urban areas.

At the national level, transportation infrastructure issues (federal roads, waterways, ports, airports) lie within the powers of the Ministry of Transport, while traffic issues are a responsibility of two councils – the CONTRAN (National Traffic Council) and the DENATRAN, its executive branch. With traffic enforcement, the federal government controls the Federal Roadway Police, a civilian enforcement corps operating across the federal roadway system.

States have their own Departments of Transport, responsible for implementing and operating state roads, and their own Traffic Departments (Detrans), responsible for issuing driver licenses and vehicle licenses and implementing state-level traffic education programs. Traffic enforcement is performed by the Military Traffic Police, working both in rural and urban areas, in most cases attached to the state Department of Security Issues. Few states, such as São Paulo, have their own civil roadway patrol, working on the state roadway system.

Cities are responsible for planning, implementing, and controlling their local roads. After the approval of the new Brazilian Traffic Code (CTB) in 1998 cities were allowed to plan and operate their local traffic (which had been a state responsibility until then), and organize local civilian traffic police corps and local traffic safety programs.

Definition of traffic legislation and of vehicle characteristics is the exclusive right of the federal government, as defined by the 1998 Brazilian Traffic Code. Therefore, any general traffic-safety decision related to signs, roads, or vehicles has to be made and approved by the federal authorities.

Roadway network

Intercity and municipal roads

In 2007, the Brazilian paved roadway system was comprised of 212,679 km (Table 1). Most of the roads were state roads (50%), although the federal roadway system was an important part (29%). At the municipal level, only the official roads were included.

There are large differences among regions and states, in terms of the geographical distribution of inhabitants and their activities, and the characteristics of the economy. São Paulo, a relatively small state in area has the largest road network because of its geographical position and the strength of its economy (the wealthiest state in the country). A similar pattern occurs in other states in the Southeast and South regions, where most of the country's economic activities occur. The states in the North have small road networks because of their large forest areas (especially in the Amazon region), while the states in the Northeast have relatively small networks because of their small size and the relatively lower economic activity and average income. The road density (km of roads per square km) varies from about 1 in the State of Amazonas to 170 in Rio de Janeiro. The national average is 25 (see Figure 1).

Table 1
Paved roadway system in Brazil, 2007 (ANTT, 2007).

Region and state	Federal	State 1	State 2	Local	*Total*	km road per km^2 area
NORTH	**7,172**	**174**	**8,860**	**1,048**	***17,253***	**4.5**
Rondônia	1,363	-	1,011	8	*2,382*	10.0
Acre	948	44	357	147	*1,496*	9.8
Amazonas	461	27	619	729	*1,836*	1.2
Roraima	933	-	147	29	*1,109*	4.9
Pará	1,667	-	2,438	113	*4,217*	3.4
Amapá	342	-	40	23	*405*	2.8
Tocantins	1,458	103	4,247	-	*5,808*	29.0
NORTHEAST	**18,967**	**3,685**	**31,909**	**1,557**	***56,118***	**36.1**
Maranhão	3,268	402	3,647	-	*7,317*	22.0
Piauí	2,352	584	2,467	53	*5,455*	21.7
Ceará	2,182	702	5,090	401	*8,374*	56.3
Rio Gr. do Norte	1,388	105	3,055	117	*4,665*	88.3
Paraíba	1,228	256	2,152	50	*3,686*	65.3
Pernambuco	2,513	83	3,816	507	*6,919*	70.4
Alagoas	747	21	1,657	49	*2,474*	89.1
Sergipe	314	5	1,701	152	*2,172*	99.1
Bahia	4,976	1,528	8,325	228	*15,057*	26.7
SOUTHEAST	**13,877**	**7,817**	**32,759**	**15,411**	***69,863***	**75.6**
Minas Gerais	10,194	2,944	11,154	1,166	*25,457*	43.4
Espírito Santo	986	97	2,399	26	*3,508*	76.1
Rio de Janeiro	1,587	532	3,067	2,229	*7,415*	169.7
São Paulo	1,110	4,244	16,139	11,989	*33,482*	134.9
SOUTH	**10,796**	**3,687**	**17,660**	**7,967**	***40,111***	**69.6**
Paraná	3,299	1,442	9,245	6,353	*20,338*	102.0
Santa Catarina	2,144	715	3,812	915	*7,586*	79.6
Rio Gr. do Sul	5,353	1,530	4,604	699	*12,187*	43.3
CENTER-WEST	**10,493**	**1,693**	**15,360**	**788**	***28,334***	**17.6**
Mato Grosso do Sul	3,401	66	3,646	-	*7,112*	19.9
Mato Grosso	3,501	84	3,459	728	*7,771*	8.6
Goiás	3,351	1,436	7,629	60	*12,476*	36.7
Distrito Federal	240	108	627	-	*974*	168.0
Total	*61,304*	*17,056*	*106,548*	*26,770*	*211,679*	*24.9*
Percent	*29.0*	*8.1*	*50.3*	*12.6*	*100.0*	

State 1 = state roads that coincide with federal roads; State 2 = other state roads

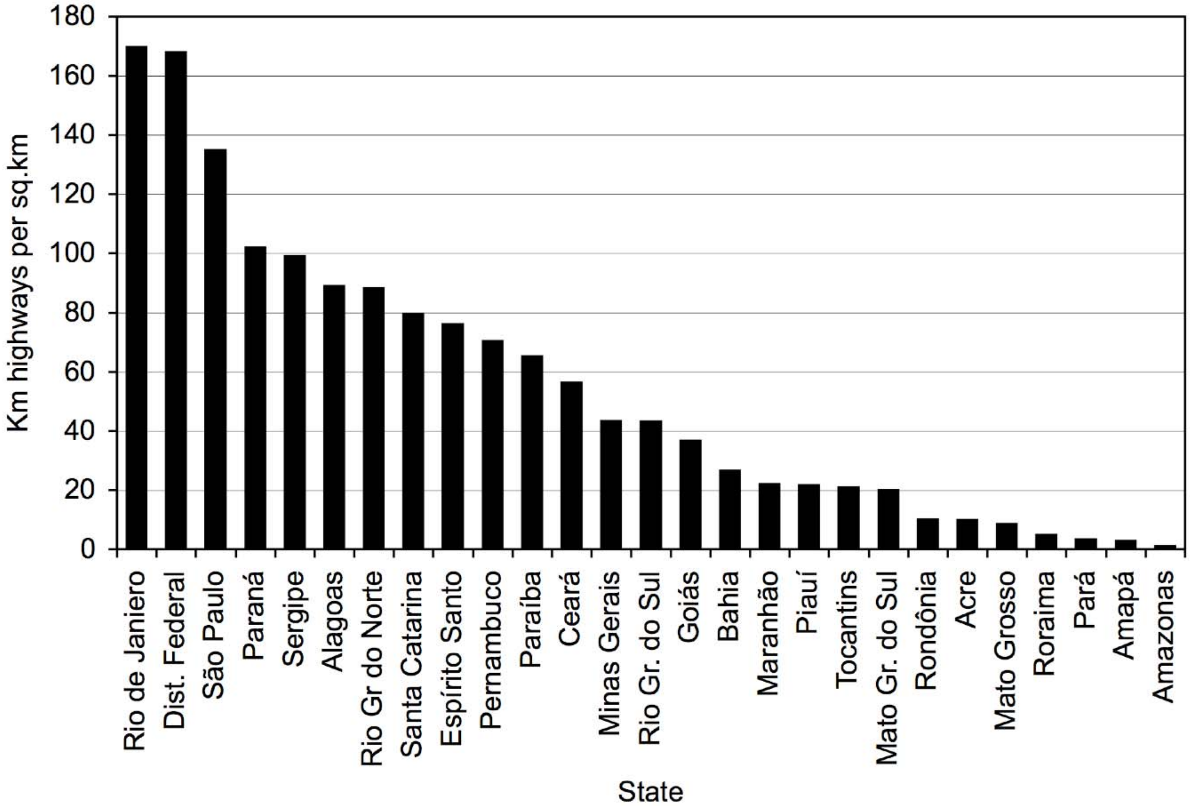

Figure 1. Roadway density (roadway length per land area) by Brazilian states, 2007 (ANTT, 2007).

Figure 2 summarizes the data on roadway length per 1,000 vehicles. There is large variability among the states on this measure, ranging from about 1.0 to 20.5. The highest values are for very large states in the North and Center-West, which have relatively small vehicle fleets but relatively large networks of national roads.

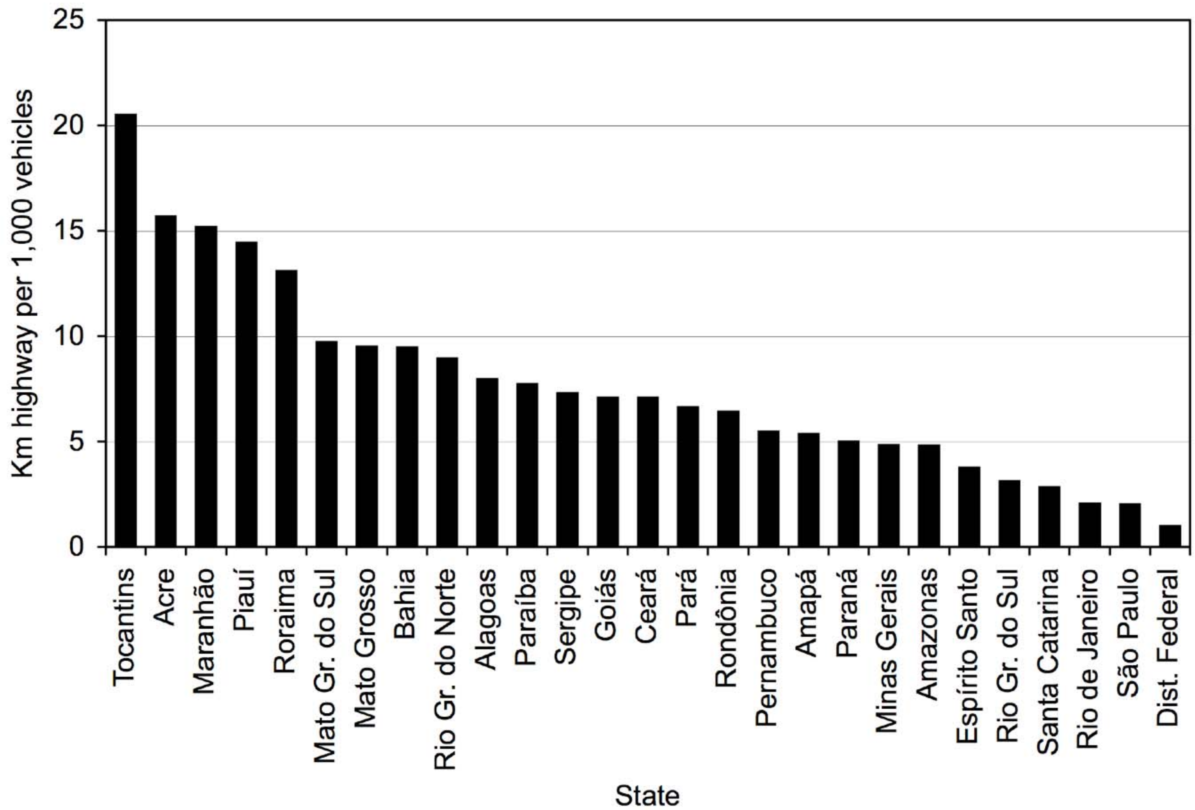

Figure 2. Roadway length per vehicle in Brazilian States, 2007 (ANTT, 2007).

Privatized highways

Road privatization was started in Brazil in the 1990s with the São Paulo-Rio Dutra Highway. Later, several additional roads were privatized, mostly in the state of São Paulo (which has the best roads in the country, with the highest traffic volumes). Privatized roads are run by a mixture of financial and road-building enterprises, under detailed rules set by a special contract. Some contracts require road extensions in a specific time while others do not. All have toll systems with fare values per axle defined by the contract and limited by specific inflation-correction factors. They are also required to implement extensive traffic-safety programs, with adequate human and material resources. Furthermore, they are required to collect crash data that are submitted to public authorities. Because of these conditions, most privatized roads are among the best in the country. Because they are generally higher speed roads, they will be referred to in this report as "highways."

Table 2 summarizes the characteristics of the privatized highway system. In summary, privatized highways have a total length of 9,560 km, corresponding to 5% of all paved roads in the country. Most privatized highways are state roads (85%), located mainly in the state of São Paulo (38%).

Table 2
Length of privatized highways in Brazil, 2007 (ABCR, 2008).

Level	Km	Percent
Federal	1,444	15.1
States		
São Paulo	3,651	38.2
Paraná	2,226	23.3
Rio Grande do Sul	1,724	18.0
Rio de Janeiro	230	2.4
Bahia	217	2.3
Espírito Santo	68	0.7
Total	*9,560*	*100.0*

Roadway characteristics and conditions

Physical and operational conditions of Brazilian roads have been surveyed repeatedly during the last ten years. The surveys have covered a large part of the system, making them relatively representative of the overall conditions.

The results of the most recent evaluation (CNT, 2008) are summarized in Tables 3 and 4. Table 3 indicates that 90% of roads are two-lane facilities. For roads with four or more lanes, only 7% have medians separating opposing traffic. Table 4 shows that only 26% of roads are in "excellent" or "good" condition. The best-rated aspect is "pavement," with 46% of the roads rated as excellent or good. The worst rated aspect is "geometry," with only 23% of the roads rated as excellent or good.

Table 3
Physical characteristics of Brazilian roads, 2007 sample (CNT, 2008).

Type of road	Length (km)	Percent
Two lanes	78,658	89.8
Four lanes, undivided	701	0.8
Four or more lanes, barrier	2,015	2.3
Four or more lanes, median	6,219	7.1
Total	*87,592*	*100.0*

Table 4
Roadway conditions in Brazil, 2007 sample (CNT, 2008).

Condition	Overall		Signing		Geometry		Pavement	
	Km	Percent	Km	Percent	Km	Percent	Km	Percent
Excellent	9,211	10.5	19,545	22.3	4,521	5.2	34,132	39.0
Good	13,682	15.6	10,794	12.3	15,350	17.5	5,683	6.5
Normal	35,710	40.8	30,022	34.3	18,260	20.8	31,384	35.8
Poor	19,397	22.1	14,315	16.3	26,013	29.7	9,442	10.8
Very poor	9,592	11.0	12,916	14.7	23,448	26.8	6,951	7.9
Total	*87,592*	*100.0*	*87,592*	*100.0*	*87,592*	*100.0*	*87,592*	*100.0*

Vehicle fleet

In December 2008, the Brazilian fleet consisted of 54 million vehicles. Table 5 shows that cars represent about 59% of all vehicles, followed by motorcycles (20%). Most vehicles (53%) are in the Southeast, the wealthiest region.

Table 5
Vehicle fleet in Brazil, December 2008 (DENATRAN, 2009).

Vehicles	North	Northeast	Center-West	Southeast	South	*Total*
Cars	826,339	3,414,170	2,482,113	18,502,724	6,999,029	*32,224,375*
Vans/SUV	191,632	505,173	396,064	1,655,110	736,516	*3,484,495*
Motorcycles	735,397	2,373,196	1,078,608	4,840,591	2,017,894	*11,045,686*
Mopeds	209,618	323,867	292,372	768,240	439,918	*2,034,015*
Bus/microbus	29,630	107,596	46,775	344,332	104,789	*633,122*
Trucks	95,372	277,351	173,169	916,445	476,939	*1,939,276*
Small trucks	56,789	190,051	120,952	926,268	295,042	*1,589,102*
Truck bodies	59,727	134,867	196,371	647,555	475,905	*1,514,425*
Other	1,125	4,662	3,033	18,311	15,034	*42,165*
Total	*2,205,629*	*7,330,933*	*4,789,457*	*28,619,576*	*11,561,066*	*54,506,661*
Percent	*4.0*	*13.4*	*8.8*	*52.5*	*21.2*	*100.0*

Table 6 summarizes the data for the entire country, using a more collapsed classification. Automobiles (cars, vans, and SUVs) represent 66% of the total fleet, followed by motorcycles and mopeds (24%). Trucks represent 9% and buses 1%.

Table 6
Vehicle fleet by major vehicle type in Brazil, December 2008 (DENATRAN, 2009).

Vehicles	Number	Percent
Automobiles (cars, vans, SUVs)	35,708,870	65.5
Motorcycles, mopeds	13,079,701	24.0
Trucks and similar	5,042,803	9.3
Buses, microbuses	633,122	1.2
Other	42,165	0.1
Total	*54,506,661*	*100.0*

Figure 3 shows that trucks have the highest average age among all vehicles in Brazil. This is likely related to the fact that a large part of the trucking industry is composed of individual truck owners and the price of new trucks is relatively high. Motorcycles have the lowest average ages, due in part to the recent rapid increase in their numbers (see below).

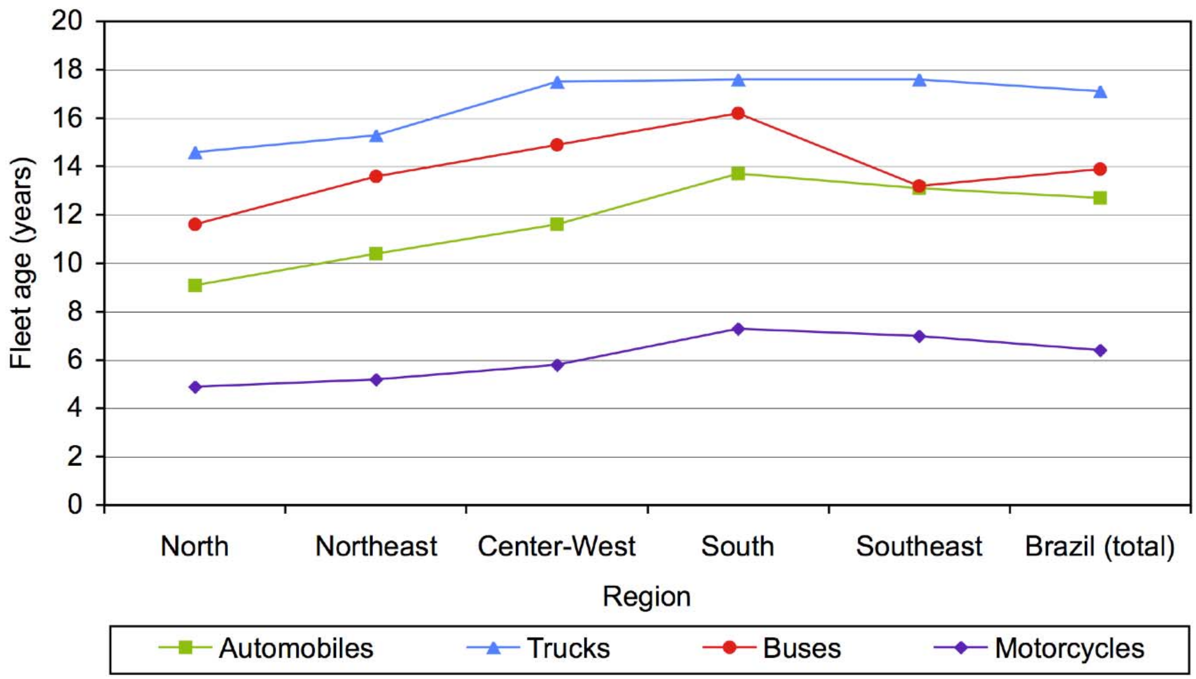

Figure 3. Average vehicle age in Brazil, 2008 (FENABRAVE, 2009).

Table 7 and Figure 4 show the data on the changes in the vehicle fleet for the last ten years. The overall vehicle fleet doubled during that period. The highest increase was for motorcycles (4.6 times higher), followed by automobiles (2.1 times higher).

Table 7
Changes in vehicle fleet in Brazil, 1998-2008 (DENATRAN, 2009).

Vehicles	Vehicle fleet (millions)											2008 divided by 1998
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Automobiles	17.1	18.9	20.3	21.7	23.3	24.7	26.2	28.0	29.9	32.4	35.2	2.1
Motorcycles	2.8	3.3	4.0	4.5	5.3	6.1	7.0	8.1	9.4	11.1	12.7	4.6
Trucks	1.1	1.1	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.7
Buses	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.4	0.4	1.2
Total	*24.4*	*27.2*	*29.7*	*31.9*	*34.3*	*36.7*	*39.2*	*42.1*	*45.4*	*49.6*	*53.8*	*2.2*

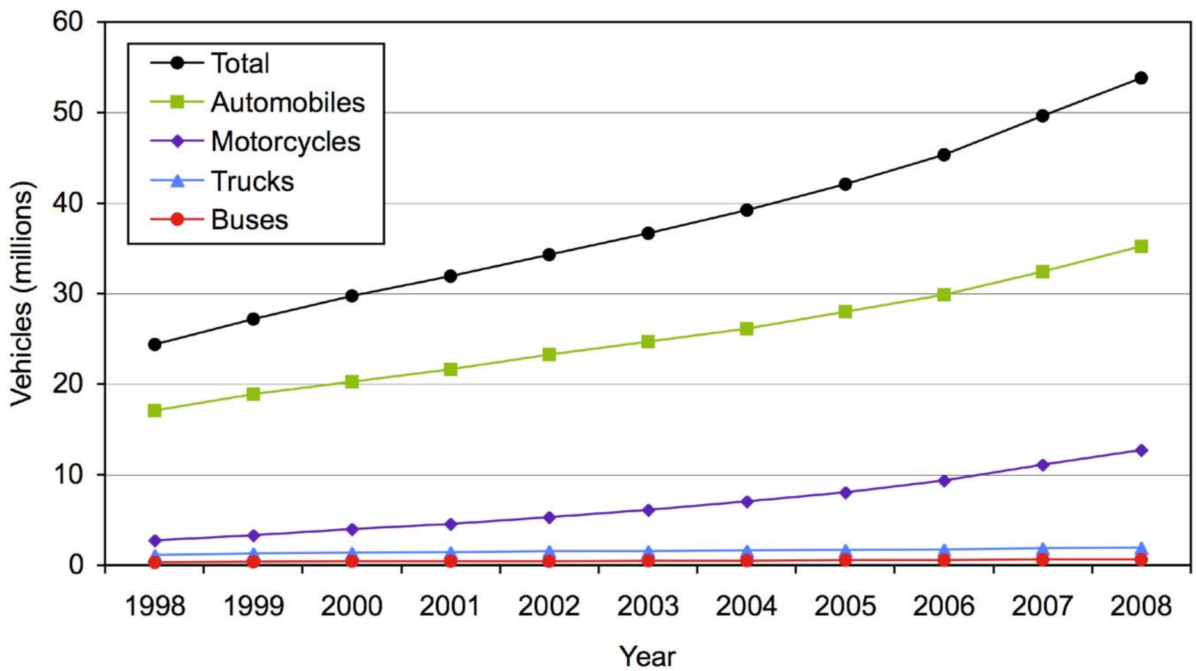

Figure 4. Increase in vehicle fleet in Brazil, 1998-2008 (DENATRAN, 2009).

Selected traffic regulations and practices

BAC limit

Effective in 2008, the maximum blood alcohol content (BAC) was lowered from 0.08% to 0.02%. The fine for a violation of this law is about US$ 470. The law includes the options of losing the driver's license and vehicle impoundment. Furthermore, if the BAC is 0.06% or greater, there is a mandatory prison term ranging from 6 months to 3 years. However, pending an approval by the local police, such a prison term could be avoided by paying an additional fine.

Random breath tests occur both in urban and rural areas, but they are not frequent.

Traffic regulations for motorcycles

The Brazilian Traffic Code allows motorcycles to ride between two lanes of traffic. (Efforts during the 1990s to outlaw this practice were not successful.) While the Code does not allow riding too close to vehicles, this is rarely enforced.

The use of motorcycle helmets was made mandatory in 1984. The enforcement was strengthened after the introduction of the new Traffic Code in 1998. However, no national data exist on the usage rate. A survey in the city of São Paulo found the 2000 rates for the riders and passengers to be 94% and 84%, respectively (CET, 2000). However, the rates in other localities, especially the smaller ones and in the poorer states in the Northeast, are likely to be much lower.

Use of safety belts

Starting in 1994, the use of safety belts is now mandatory (for all occupants in all vehicles). However, there are no national data on the usage rate. A survey in the city of São Paulo found the 2000 rates for the driver, front passengers, and rear passengers to be 91%, 86%, and 5%, respectively (CET, 2000).

Daytime running lamps

The Brazilian Traffic Code mandates the use of daytime running lamps for buses in dedicated lanes and for motorcycles.

Roundabouts

Roundabouts are frequent in Brazilian cities, especially the largest ones.

Right turn on red

Right turns on red lights are not allowed.

Rest periods for truck drivers

A general labor law stipulates that all workers should have an 11-hour rest period between two working periods. The current Traffic Code does not address rest periods for truck drivers because this is considered a labor issue. However, there are current efforts in the legislature to include in the Traffic Code a mandatory 30-minute rest periods for every four hours of driving.

Retroreflective treatments on trucks

All trucks are required to have specially designed reflective treatments to increase their nighttime visibility.

Truck traffic in cities

Most large cities have restrictions on truck traffic, especially during the daytime and in central areas.

ABS

ABS (anti-lock braking systems) systems will be required based on a phased-in schedule between 2010 and 2014.

Air bags

Air bags systems will be required on all passenger vehicles and cargo vehicles up to 3.7 tons based on a phased-in schedule between 2011 and 2014.

Road crashes

General patterns

Traditionally, national information concerning traffic crashes was collected by the federal government, using data from the federal roadway system, the state Departments of Transport, and the state Detrans. This information was summarized in national statistics available to the general public. The problem was that much of these data were not very reliable because of different collecting methods, undercounting of crashes and fatalities, and a lack of human and material resources.

In the last decade, access to new information became available through the database of the Department of Health ("MS-DATASUS" system). This database includes morbidity and mortality information about all transport-related medical services. It covers around 90% of the events in the country.

Table 8 and Figure 5 show annual traffic fatalities in the country by gender and age.

Table 8
Mortality in traffic crashes by age and gender in Brazil, 2006 (MS-DATASUS, 2007).

Age	Men		Women		*Total*	
	N	Percent	N	Percent	*N*	*Percent*
0 to 4	311	1.1	222	3.4	*533*	*1.5*
5 to 9	445	1.6	292	4.5	*737*	*2.1*
10 to 14	565	2.0	291	4.5	*856*	*2.5*
15 to 19	2,384	8.4	625	9.7	*3,009*	*8.6*
20 to 24	4,258	15.0	732	11.3	*4,990*	*14.3*
25 to 29	3,559	12.5	575	8.9	*4,134*	*11.8*
30 to 39	5,620	19.7	904	14.0	*6,524*	*18.7*
40 to 49	4,650	16.3	872	13.5	*5,522*	*15.8*
50 to 59	3,190	11.2	637	9.9	*3,827*	*11.0*
60 to 69	1,879	6.6	562	8.7	*2,441*	*7.0*
70 to 79	1,089	3.8	531	8.2	*1,620*	*4.6*
80 and older	507	1.8	218	3.4	*725*	*2.1*
Total	*28,457*	*100.0*	*6,461*	*100.0*	*34,918**	*100.0*
Percent	-	*81.5*	-	*18.5*	-	*100.0*

* The total shown in this table (34,918) is lower than the total shown in other tables and figures (35,155) because the age and/or gender were unknown for 237 individuals.

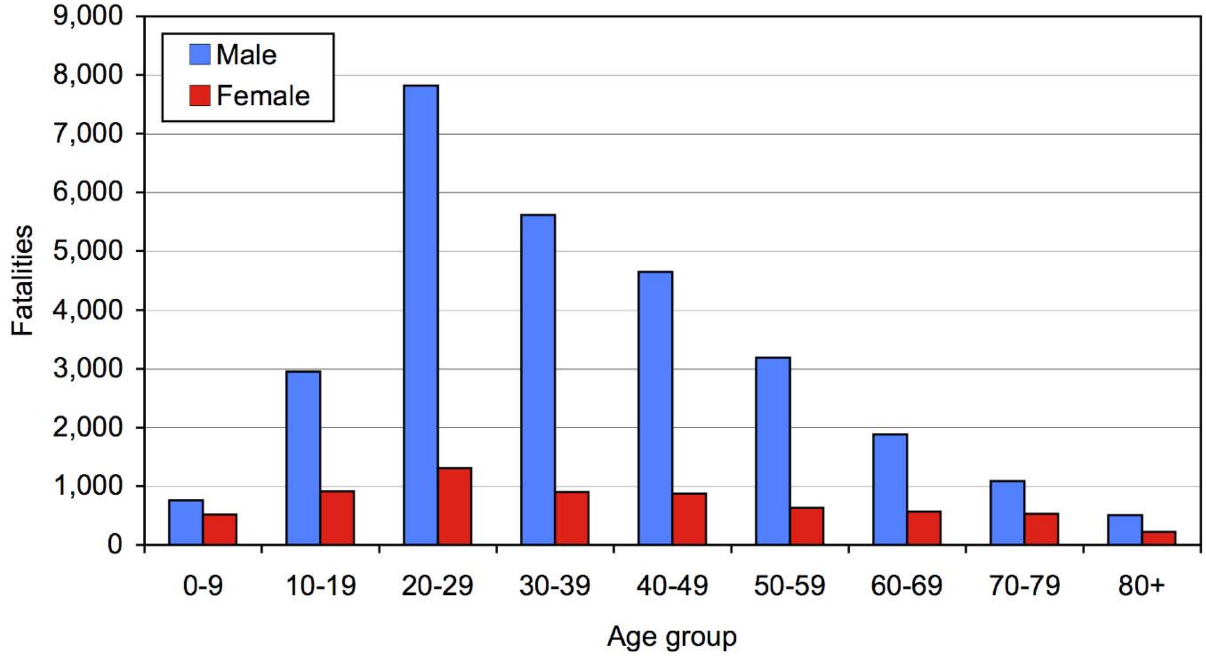

Figure 5. Traffic fatalities by age and gender in Brazil, 2006 (MS-DATASUS, 2007).

As indicated in Table 8, in 2006 there were 34,918 traffic fatalities. Men constituted 81% of all fatalities. This results from higher motorized traveling activity by males (related to their dominant role as household financial income providers). People between 20 and 49 years of age are the most frequent victims, again due primarily to their greater involvement in traffic. Although the peak at this age group applies to both men and women, the age effect is much greater for males than for females (see Figure 5).

Transportation modes used by people who died in traffic crashes in 2006 are summarized in Table 9. It is important to note that the transportation mode for 23% of the fatalities is listed as "unknown." Pedestrians are the most frequent victims, as is the case in all developing countries. If "unknowns" are excluded from the analysis, pedestrians account for 36% of the fatalities. Automobile users come in second place (27%), followed closely by motorcyclists (26%), partly as a result of the recent large increase in the motorcycle fleet.

Table 9
Traffic fatalities by transportation mode in Brazil, 2006 (MS-DATASUS, 2007).

Mode	Fatalities	Percent	
		"unknown" included	"unknown" excluded
Tricycle	39	0.1	0.1
Bus	232	0.7	0.8
Small truck	257	0.7	0.9
Heavy truck	765	2.2	2.8
Bicycle	1,627	4.6	6.0
Motorcycle	6,970	19.8	25.7
Automobile	7,399	21.0	27.3
Pedestrian	9,812	27.9	36.2
Unknown	8,054	22.9	-
Total	*35,155*	*100.0*	*100.0*

Recent trends

Figures 6 to 8 summarize the data on fatalities by transportation mode for the period from 1996 to 2006 (with "unknowns" included). Figure 6 shows that the total number of fatalities decreased after the approval of the new Traffic Code (CTB) in 1998 but eventually increased again, reaching the same level as before the introduction of the CTB. Figure 7 indicates that important changes occurred in the relative involvement of transportation modes. Most notably, between 1996 and 2006 the proportion of pedestrian fatalities decreased substantially, while the percentage of motorcycle fatalities increased substantially. (During the same period, the percentage of "unknowns" decreased from 48 to 23.) Figure 8 documents similar patterns for fatalities per population.

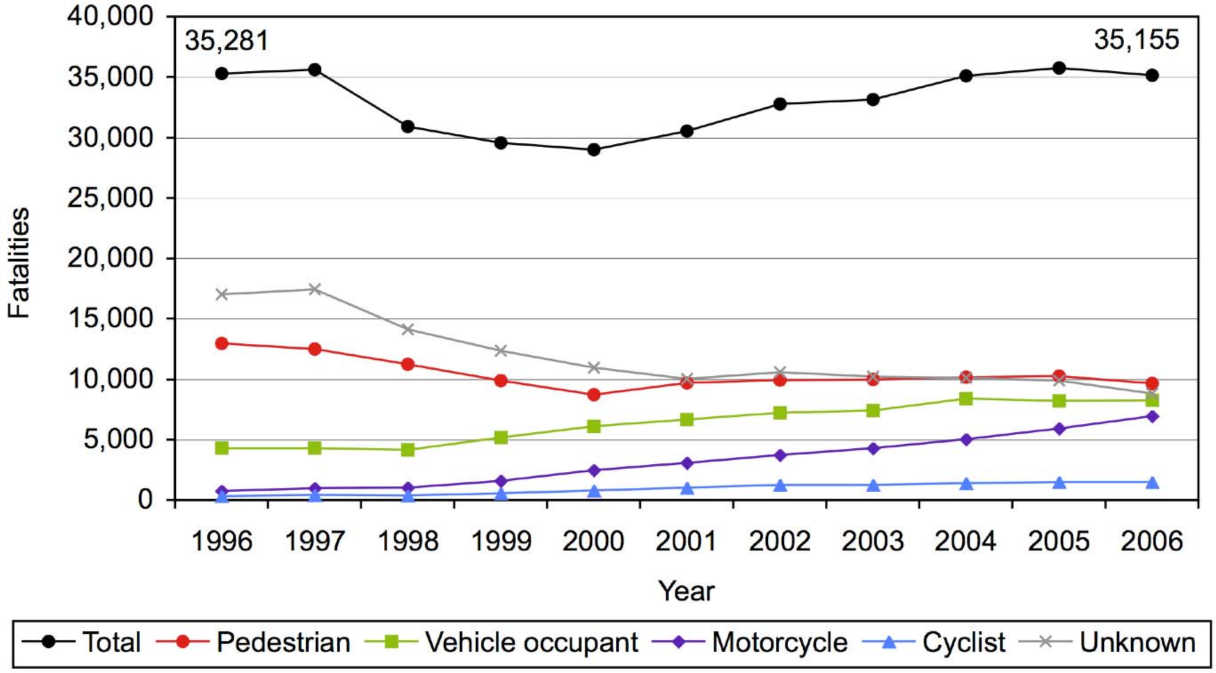

Figure 6. Fatalities by transportation mode in Brazil, 1996-2006 (MS-DATASUS, 2007).

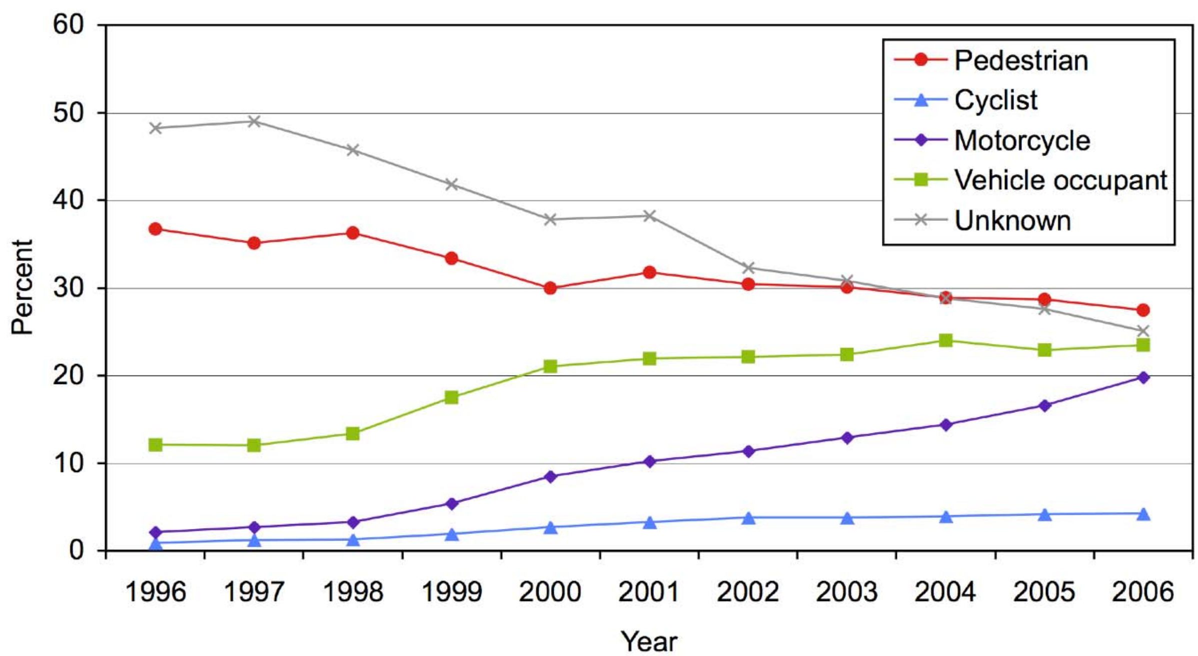

Figure 7. Fatalities by transportation mode (%) in Brazil, 1996-2006 (MS-DATASUS, 2008).

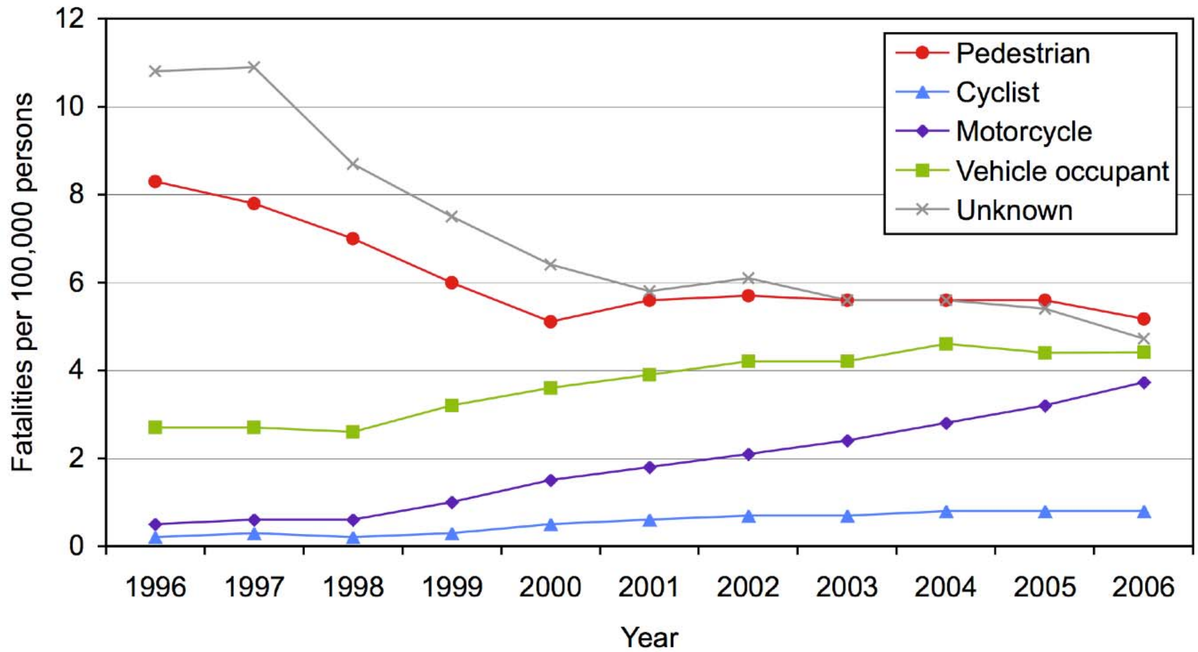

Figure 8. Fatality rates by transportation mode in Brazil, 1996-2006 (MS-DATASUS, 2007). (The values for 2006 are estimates using population projections from the National Bureau of Statistics [IBGE, 2009].)

State-level data

Tables 10 and 11 summarize data for the 27 states in the country and the Federal District (Brasilia).

Table 10 shows that the overall fatality rates per 100,000 persons vary from 12.5 to 32.5, and that rates per 10,000 vehicles vary from 4.4 to 20.7. The variability in these indices is likely a consequence of the variability in the proportion of urban population, the length of the intercity roadway system, the level of motorization, and the safety conditions of the traffic environment.

Table 10
Overall traffic fatality rates in Brazilian states, 2006 (ANTT, 2009).

State	UF	Population	Fatalities	Fatalities per 100,000 persons	Fatalities per 10,000 vehicles
Acre	AC	686,650	86	12.5	10.4
Alagoas	AL	3,050,649	579	18.9	20.6
Amapá	AP	615,724	120	19.4	18.2
Amazonas	AM	3,311,046	429	13.0	12.5
Bahia	BA	13,950,125	1,740	12.5	12.2
Ceará	CE	8,217,140	1,703	20.7	16.1
Distrito Federal	DF	2,383,784	453	19.0	5.1
Espírito Santo	ES	3,464,280	910	26.2	11.0
Goiás	GO	5,730,762	1,361	23.7	8.6
Maranhão	MA	6,184,543	789	12.8	19.1
Mato Grosso	MT	2,857,024	804	28.2	11.0
Mato Gr. do Sul	MS	2,297,994	689	30.0	10.4
Minas Gerais	MG	19,479,262	3,578	18.3	7.4
Pará	PA	7,110,462	1,014	14.3	18.2
Paraíba	PB	3,623,198	692	19.1	16.5
Paraná	PR	10,387,408	2,975	28.6	7.9
Pernambuco	PE	8,502,602	1,470	17.3	12.9
Piauí	PI	3,036,271	690	22.7	20.7
Rio de Janeiro	RJ	15,561,720	2,762	17.7	8.2
Rio Gr. do Norte	RN	3,043,740	481	15.8	10.6
Rio Gr. do Sul	RS	10,963,216	1,985	18.1	5.4
Rondônia	RO	1,562,406	413	26.3	12.6
Roraima	RR	403,340	54	13.5	7.5
Santa Catarina	SC	5,958,295	1,936	32.5	7.9
São Paulo	SP	41,055,761	6,756	16.4	4.4
Sergipe	SE	2,000,768	375	18.7	13.9
Tocantins	TO	1,332,443	312	23.4	12.4
Total		*186,770,613*	*35,155*	*18.8*	*12.4*

Table 11 shows that the fatality rates per 100,000 persons vary from 0.8 to 9.1 for vehicle occupants, from 1.0 to 8.1 for motorcycles, and 2.0 to 9.6 for pedestrians. The corresponding average values for the country are 4.4, 3.7, and 5.2, respectively.

Table 11
Overall traffic fatality rates by type of user in Brazilian states, 2006 (ANTT, 2009).

State	Fatalities and rates per 100,000 persons					
	Vehicle occupants		Motorcycles		Pedestrians	
	Fatalities	Rate	Fatalities	Rate	Fatalities	Rate
Acre	13	1.9	7	1.0	19	2.8
Alagoas	41	1.3	111	3.6	207	6.8
Amapá	5	0.8	11	1.8	59	9.6
Amazonas	43	1.3	62	1.9	160	4.8
Bahia	546	3.9	246	1.8	479	3.4
Ceará	380	4.6	580	7.1	562	6.8
Distrito Federal	165	6.9	63	2.6	154	6.5
Espírito Santo	316	9.1	194	5.6	198	5.7
Goiás	307	5.4	326	5.7	254	4.4
Maranhão	134	2.2	206	3.3	189	3.1
Mato Grosso	245	8.6	218	7.6	132	4.6
Mato Gr. do Sul	194	8.4	164	7.1	128	5.6
Minas Gerais	1,068	5.5	469	2.4	833	4.3
Pará	126	1.8	196	2.8	467	6.6
Paraíba	73	2.0	102	2.8	108	3.0
Paraná	892	8.6	559	5.4	743	7.2
Pernambuco	279	3.3	329	3.9	511	6.0
Piauí	46	1.5	238	7.8	111	3.7
Rio de Janeiro	513	3.3	471	3.0	1,151	7.4
Rio Gr. do Norte	173	5.7	144	4.7	94	3.1
Rio Gr. do Sul	432	3.9	281	2.6	471	4.3
Rondônia	47	3.0	102	6.5	33	2.1
Roraima	7	1.7	16	4.0	8	2.0
Santa Catarina	536	9.0	480	8.1	331	5.6
São Paulo	1,448	3.5	1,174	2.9	2,093	5.1
Sergipe	102	5.1	125	6.2	101	5.0
Tocantins	110	8.3	89	6.7	50	3.8
Total	*8,241*	*4.4*	*6,963*	*3.7*	*9,646*	*5.2*

Table 12 and Figure 9 summarize fatalities by transportation mode and region of the country. The largest numbers of fatalities are in the Southeast, Northeast, and South regions, where the concentrations of vehicles, urban population, and roads are the highest.

Table 12
Traffic fatalities by user condition and region in Brazil, 2006 (ANTT, 2009).

Mode	North	Northeast	Southeast	South	Center-West	*Brazil (total)*
Tricycle	-	13	16	6	4	*39*
Bus	8	45	136	29	14	*232*
Small truck	24	51	79	51	52	*257*
Large truck	51	135	280	210	89	*765*
Bicycle	92	273	651	384	227	*1,627*
Motorcycle	483	2,086	2,309	1,320	772	*6,970*
Automobile	282	1,593	3,127	1,599	798	*7,399*
Pedestrian	803	2,387	4,380	1,552	690	*9,812*
Unknown	678	1,920	3,070	1,714	672	*8,054*
Total	*2,421*	*8,503*	*14,048*	*6,865*	*3,318*	*35,155*
Percent	*6.9*	*24.2*	*40.0*	*19.5*	*9.4*	*100.0*

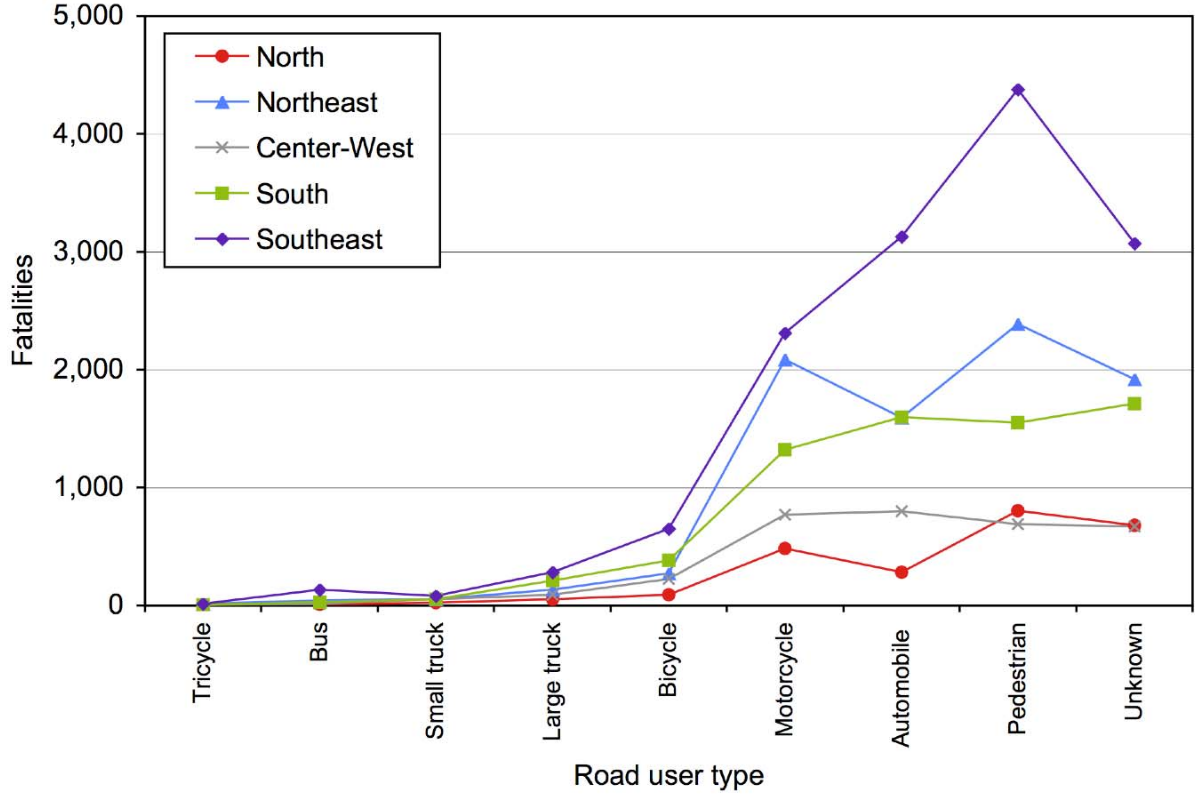

Figure 9. Traffic fatalities by mode and region in Brazil, 2006 (ANTT, 2009).

Crashes on federal roads

The federal roadway system is most representative of intercity and interstate traffic in the country. While the federal system includes mostly rural roads, it crosses several urban areas as well. The system has a good crash recording system, controlled by the Federal Roadway Police. The recording system covers most of the roads and has reliable information on non-subjective aspects such as day of occurrence, time of occurrence, vehicles involved, and people injured. However, information on crash causation is less reliable, mainly because it depends on the subjective opinion of the police officer registering the crash and on people who were involved in the crash. Tables 13 to 15 and Figures 10 and 11 summarize the data.

As indicated in Table 13, most crashes (61%) involve no injuries, and fatalities occur in 4% of crashes. The fatalities tend to be elevated on Fridays, Saturdays, and Sundays (see Figure 10).

Table 13
Traffic crashes by type on federal roads in Brazil, 2008 (ANTT, 2009).

Type of crash	Number	Percent
With fatality	5,620	4.0
With injuries	49,601	35.2
No injuries	85,792	60.8
Total	*141,013*	*100.0*

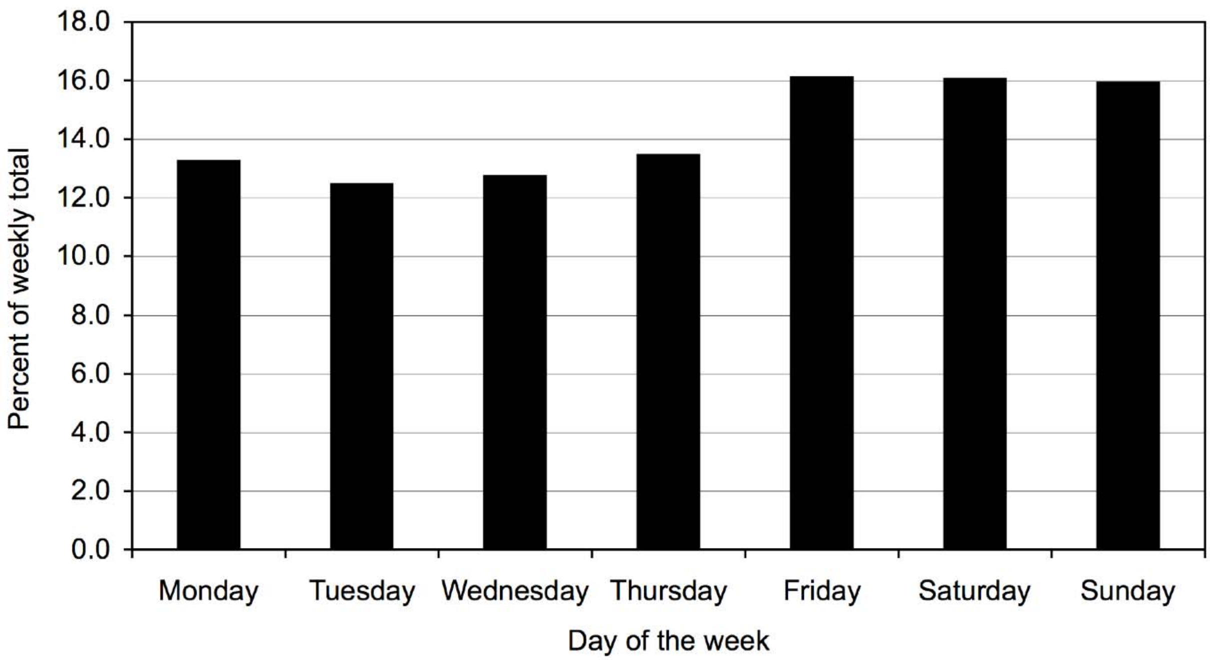

Figure 10. Crash occurrence by day of the week on federal roads in Brazil, 2007 (ANTT, 2009).

The highest numbers of crashes occur in late afternoon and early evening (see Figure 11). However, adjusting for volume, crashes peak between midnight and 06:00 (Table 14).

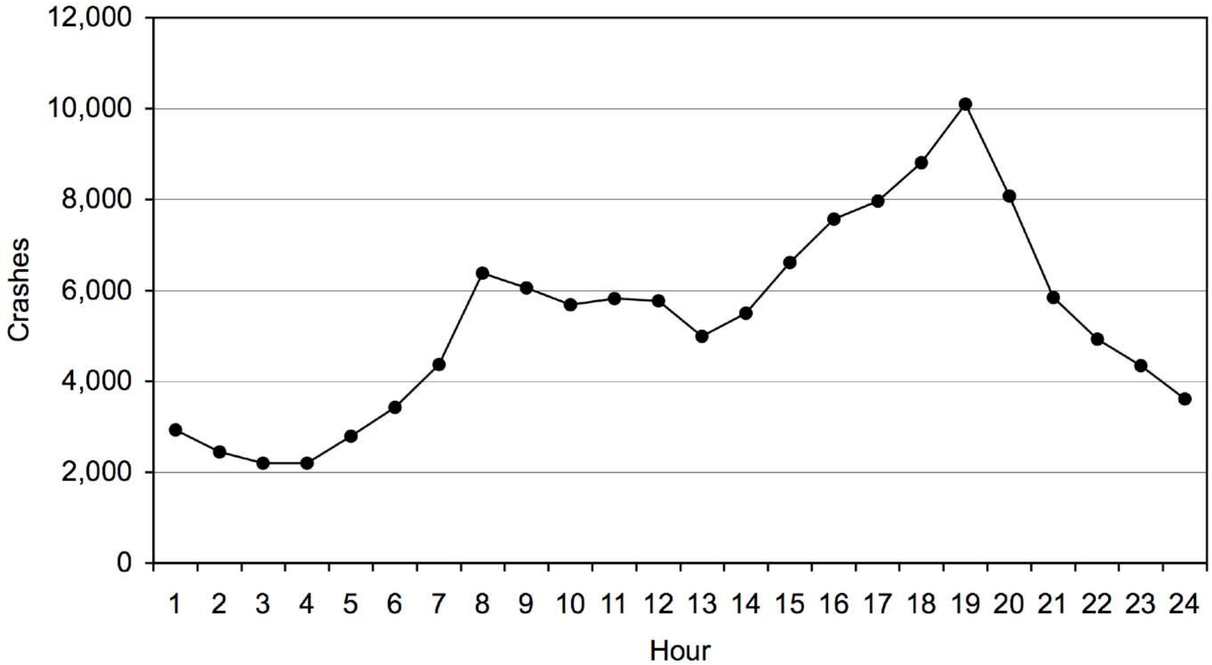

Figure 11. Crash occurrence by time of day on federal roads in Brazil, 2007 (ANTT, 2009).

Table 14
Traffic volume and crashes by time of day on federal roads, 2004 (ANTT, 2009).

Time period	Percent of traffic volume	Percent of crashes	Crashes per traffic volume
00:00 to 05:59	6.6	13.5	2.0
06:00 to 20:59	82.2	73.5	0.9
21:00 to 23:59	11.1	12.9	1.2
Total	*100.0*	*100.0*	-

Table 15 presents a breakdown of crashes on federal roads by weather condition. About 66% of the crashes occur in fair weather, 20% occur in rainy weather.

Table 15
Crashes by weather condition on federal roads in Brazil, 2004 (IPEA-ANTP, 2006).

Weather condition	N	Percent
Fair	73,667	65.5
Cloudy	11,629	10.3
Foggy	1,686	1.5
Rainy	22,466	20.0
Other	3,009	26.8
Total	*112,457*	*100.0*

Table 16 indicates that 57% of all road crashes and 74% of all fatalities in 2004 occurred on two-lane roads.

Table 16
Crashes by roadway type on federal roads in Brazil, 2004 (IPEA-ANTP, 2006).

Roadway	Crashes		Fatalities		Fatalities per crash
	N	Percent	N	Percent	
Two-lane	64,409	57.3	4,532	74.1	0.070
Four-lane	41,931	37.3	1,395	22.8	0.033
> Four lanes	6,117	5.4	192	3.1	0.031
Total	*112,457*	*100.0*	*6,119*	*100.0*	*0.054*

Table 17 summarizes data on traffic crashes that occurred on federal roads in Brazil from 2003 to 2007 by region and state. The number of crashes has increased from about 105,000 in 2003 to about 128,000 in 2007. The Southeast has the highest number of crashes (about 50,000 in 2007), while the North has the lowest number (about 7,000 in 2007).

Table 17
Traffic crashes on federal roads in Brazil, 2003-2007 (ANTT, 2007).

Region and State	2003	2004	2005	2006	2007
NORTH	**4,313**	**4,632**	**4,964**	**5,841**	**6,829**
Amapá	96	98	131	160	150
Amazonas	131	129	199	244	164
Pará	1,723	1,959	2,036	2,470	3,139
Rondônia e Acre	1,390	1,427	1,533	1,819	2,196
Roraima	265	387	463	498	459
Tocantins	708	632	602	650	721
NORTHEAST	**21,058**	**21,381**	**21,945**	**23,817**	**26,851**
Alagoas	1,332	1,336	1,352	1,391	1,616
Bahia	5,618	6,116	6,249	6,113	7,128
Ceará	1,927	1,543	1,661	2,038	2,275
Maranhão	1,423	1,479	1,657	1,765	2,119
Paraíba	2,187	2,220	2,053	2,469	2,744
Pernambuco	4,272	4,043	4,037	4,327	4,803
Piauí	1,135	1,200	1,400	1,643	1,897
Rio Grande do Norte	2,147	2,332	2,540	2,881	3,098
Sergipe	997	1,112	996	1,190	1,171
SOUTHEAST	**42,592**	**44,564**	**43,880**	**44,501**	**49,867**
Espírito Santo	4,562	4,823	5,346	5,784	6,251
Minas Gerais	16,618	18,051	17,592	18,104	20,709
Rio de Janeiro	10,517	11,273	11,233	11,011	11,735
São Paulo	10,895	10,417	9,709	9,602	11,172
SOUTH	**27,430**	**30,925**	**29,916**	**28,562**	**32,832**
Paraná	7,343	7,929	7,317	6,804	7,118
Santa Catarina	10,424	12,114	12,724	12,455	14,641
Rio Grande do Sul	9,663	10,882	9,875	9,303	11,073
CENTER-WEST	**9,659**	**10,955**	**8,541**	**10,067**	**11,697**
Distrito Federal	1,885	2,263	2,427	2,519	1,125
Goiás	3,115	3,338	3,642	4,617	5,620
Mato Grosso	2,609	3,113	2,528	2,261	2,647
Mato Grosso do Sul	2,050	2,241	1,923	1,829	2,305
Total	*105,032*	*112,457*	*109,246*	*112,788*	*128,076*

Tables 18 through 20 summarize the main characteristics of crashes and vehicles involved in them. Table 18 indicates that 62% of reported crashes resulted in no injuries. Table 19 shows that the number of vehicles involved in crashes increased from 177,000 in 2003 to 217,000 in 2007 (an increase of 22%), and that automobiles are present in 67% of all crashes, while trucks are present in 26% of crashes. Table 20 indicates that the number of people involved in crashes increased from 430,000 in 2003 to 543,000 in 2007 (an increase of 26%), with about 7,000 persons killed in 2007.

Table 18
Crashes by presence of injuries on federal roads in Brazil, 2007 (ANTT, 2009).

Injury presence	2003	2004	2005	2006	2007	Percent in 2007
With injuries	38,814	40,771	42,128	42,061	48,814	38.1
No injuries	66,218	71,686	67,118	70,727	79,262	61.9
Total	*105,032*	*112,457*	*109,246*	*112,788*	*128,076*	*100.0*

Table 19
Vehicles involved in crashes on federal roads in Brazil, 2007 (ANTT, 2009).

Vehicle type	2003	2004	2005	2006	2007	Percent in 2007
Automobile	110,085	120,080	111,393	120,671	146,041	67.4
Buses	7,815	8,005	7,960	7,968	8,846	4.1
Trucks	45,796	50,498	46,871	46,511	55,903	25.8
Other	13,296	8,876	18,519	11,169	5,946	2.7
Total	*176,992*	*187,459*	*184,743*	*186,319*	*216,736*	*100.0*

Table 20
Injured persons involved in crashes on federal roads in Brazil, 2007 (ANTT, 2009).

Injury type	2003	2004	2005	2006	2007	Percent in 2007
Fatal	5,780	6,119	6,392	6,168	7,060	1.3
Injured	60,326	66,117	69,407	69,624	81,515	15.0
Non-injured	364,248	385,173	354,512	421,220	454,147	83.7
Total	*430,354*	*457,409*	*432,316*	*497,012*	*542,722*	*100.0*

Crash types on federal roads are summarized in Tables 21, 22, and 23. Table 21 shows that crashes most frequently involve rear-end collisions (24%) and run-off-the-road collisions (13%).

Table 22 indicates that the most frequent fatal crashes on two-lane roads are head-on collisions (30%) and those involving pedestrians (14%), while on four-lane roads it is those involving pedestrians (35%) and rear-end collisions (12%) that are most frequent. Finally, on multilane roads, the most frequent fatal crashes are those involving pedestrians (40%) and rear-end collisions (15%). The high involvement of pedestrians in crashes on four and multilane roads is primarily on urban sections of such roads where a substantial pedestrian exposure occurs under unsafe conditions (e.g., lack of pedestrian overpasses, non-use of existing overpasses, deficient lighting).

Table 23 presents information about the severity of crashes on federal roads. The most severe crashes are head-on collisions (0.33 fatalities per crash) and pedestrian collisions (0.29 fatalities per crash).

Table 21
Crash types on federal roads in Brazil, 2004 (ANTT, 2009).

Crash type	Number	Percent
Head-on collision	4,538	4.0
Lateral collision	19,118	17.0
Rear-end collision	27,124	24.1
Right-angle collision	7,982	7.1
Rollover	7,353	6.5
Side rollover	6,418	5.7
Run off the road	14,574	13.0
Collision with object	10,430	9.3
Pedestrian hit	3,996	3.6
Animal hit	3,479	3.1
Multi-vehicle crash	1,134	1.0
Other	6,311	5.6
Total	*112,457*	*100.0*

Table 22
Fatalities by crash type and roadway type on federal roads in Brazil, 2004 (ANTT, 2009).

Crash type	Two lanes		Four lanes		Multiple lanes	
	Number	Percent	Number	Percent	Number	Percent
Head-on collision	1,373	30.3	129	9.2	6	3.1
Lateral collision	500	11.0	90	6.5	10	5.2
Rear-end collision	357	7.9	164	11.8	29	15.1
Right-angle collision	364	8.0	92	6.6	16	8.3
Rollover	330	7.3	111	8.0	8	4.2
Side rollover	127	2.8	33	2.4	2	1.0
Run off the road	419	9.2	87	6.2	1	0.5
Collision with object	157	3.5	102	7.3	22	11.5
Pedestrian hit	610	13.5	484	34.7	76	39.6
Animal hit	38	0.8	12	0.9	4	2.1
Multi-vehicle crash	26	0.6	4	0.3	0	0.0
Other	231	5.1	87	6.2	18	9.4
Total	*4,532*	*100.0*	*1,395*	*100.0*	*192*	*100.0*

Table 23
Fatalities per crash by crash type on federal roads in Brazil, 2004 (ANTT, 2009).

Crash type	Fatalities per crash
Head-on collision	0.33
Lateral collision	0.03
Rear-end collision	0.02
Right-angle collision	0.06
Rollover	0.06
Side rollover	0.03
Run off the road	0.03
Collision with object	0.03
Pedestrian hit	0.29
Animal hit	0.02
Multi-vehicle crash	0.03
Other	0.05

Crashes on privatized highways

Privatized highways are usually of better quality. Furthermore, they have better crash recording systems, which are mandatory. Table 24 shows that the volumes of both light and heavy vehicles on privatized highways have recently been increasing. Interestingly, while the number of crashes has been increasing, the number of fatalities has been decreasing (see Table 25). The rate per vehicle (see Figure 12) has also been decreasing.

Table 24
Annual traffic volume (in millions) on privatized highways in Brazil, 2002-2007 (ABCR, 2008).

Vehicle type	2002	2003	2004	2005	2006	2007
Light vehicle	382.7	378.6	410.5	447.1	457.7	490.3
Heavy vehicle	152.6	152.2	163.9	166.5	167.3	177.8
Total	*535.3*	*530.8*	*574.4*	*613.6*	*625.0*	*668.1*

Table 25
Annual crashes and people involved on privatized highways in Brazil, 2002-2007 (ABCR, 2008).

Events	2002	2003	2004	2005	2006	2007
Crashes	55,470	54,563	59,113	59,397	55,882	60,773
Uninjured people	154,962	141,834	155,453	151,308	133,188	137,442
Injured people	30,143	29,204	31,746	31,228	31,765	33,426
Fatalities	1,799	1,752	1,788	1,536	1,358	1,515

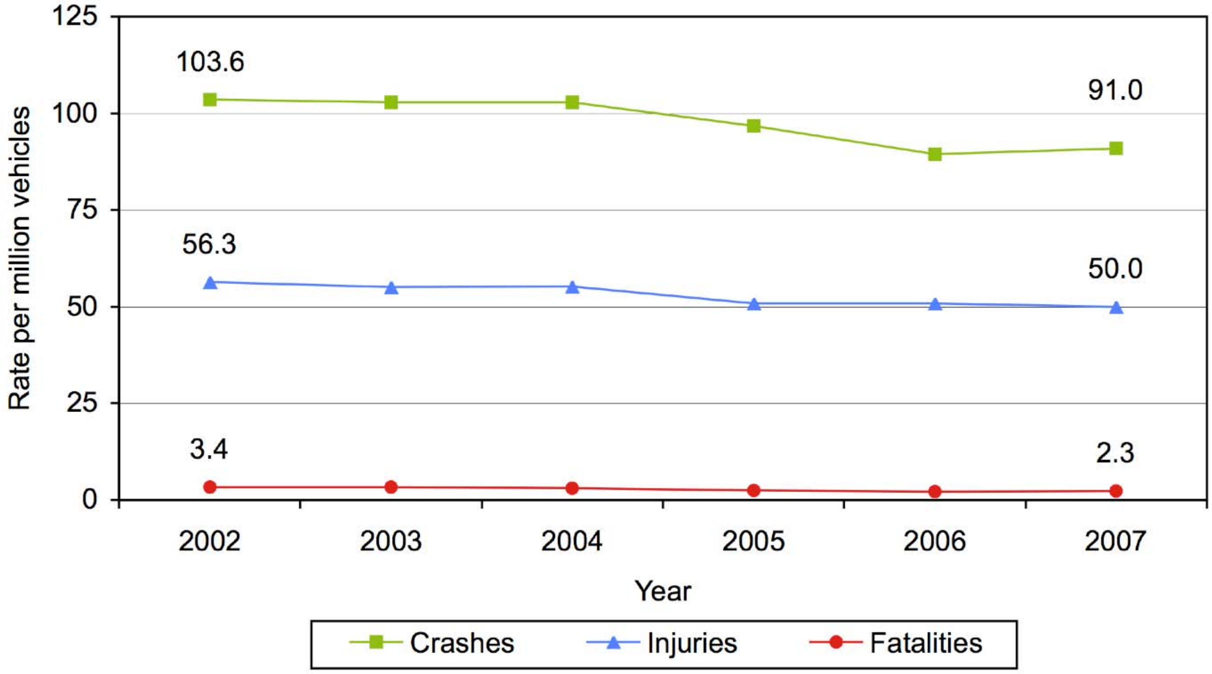

Figure 12. Traffic crashes and injuries on privatized highways in Brazil, 2002-2007 (ABCR, 2008).

The information in Tables 18, 20, and 24 allows a comparison of the likelihood of a severe crash on the federal and privatized systems. On federal roads, in 2007 there were 128,076 crashes (Table 18) and 7,060 fatalities (Table 20), corresponding to one fatality per 18 crashes. In contrast, on privatized highways there were 60,773 crashes and 1,515 fatalities (Table 25), corresponding to one fatality per 40 crashes. This comparison indicates that the likelihood of a fatality given a crash is substantially lower on privatized highways than on federal roads.

Crashes in urban areas

There is no specific crash database for urban areas in Brazil. Thus, this section analyzes data from three large cities that are known to have good crash records—São Paulo (11 million people), Belo Horizonte (2 million people), and Porto Alegre (1.5 million people). Table 26 summarizes the number of fatalities from 1991 to 2005, and Figure 13 shows the fatality rates per person. Both the numbers of fatalities (Table 26) and the fatality rates per person (Figure 13) have been decreasing.

Table 26
Traffic fatalities in São Paulo, Belo Horizonte, and Porto Alegre, 1991-2005
(CET, 2009; BHTRANS, 2008; EPTC, 2008).

Year	Traffic fatalities		
	São Paulo	Belo Horizonte	Porto Alegre
1991	2,626	374	201
1992	2,291	481	183
1993	2,436	551	176
1994	2,401	446	274
1995	2,278	508	270
1996	2,245	418	219
1997	2,042	383	248
1998	1,558	307	199
1999	1,683	392	198
2000	1,490	297	167
2001	1,526	315	141
2002	1,370	155	156
2003	1,268	238	170
2004	1,419	217	175
2005	1,505	177	162

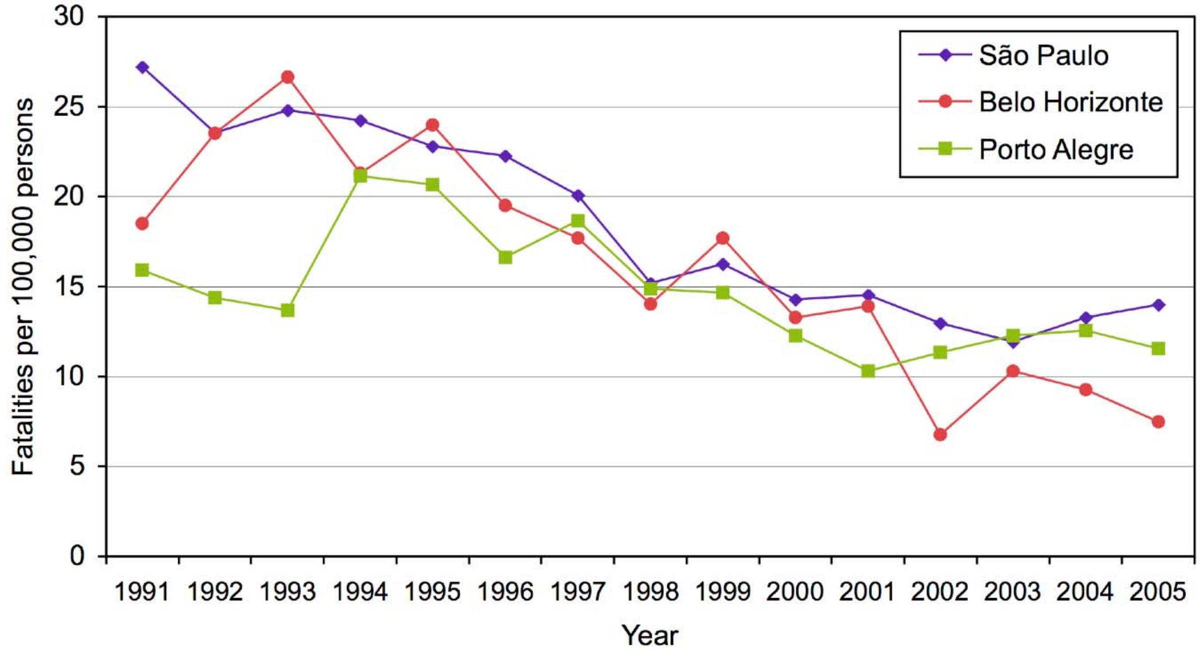

Figure 13. Traffic fatality rates in São Paulo, Belo Horizonte, and Porto Alegre, 1991-2005 (CET, 2009; BHTRANS, 2008; EPTC, 2008).

Figures 14 through 17 and Table 27 provide detailed data on the traffic crashes in São Paulo. Figure 14 indicates that traffic fatalities in São Paulo are distributed relatively uniformly throughout the week (generally 12% to 14% per day), with somewhat higher levels on Friday and Saturday (16%).

Figure 15 shows that crashes, in general, follow an hourly pattern similar to that of traffic volumes, with the highest numbers between 06:00 and 18:00. On the other hand, fatalities are highest in the early morning hours and in late evening. The likely reasons are higher speeds and increased involvement of alcohol.

Overall, the largest numbers of fatalities occur for persons between 20 and 30 years of age (about 65% of all fatalities). This is shown in Figure 16. However, the peak varies with transportation mode (Figure 17). For example, the peak is at 10 to 19 years for cyclists and at over 40 years for pedestrians.

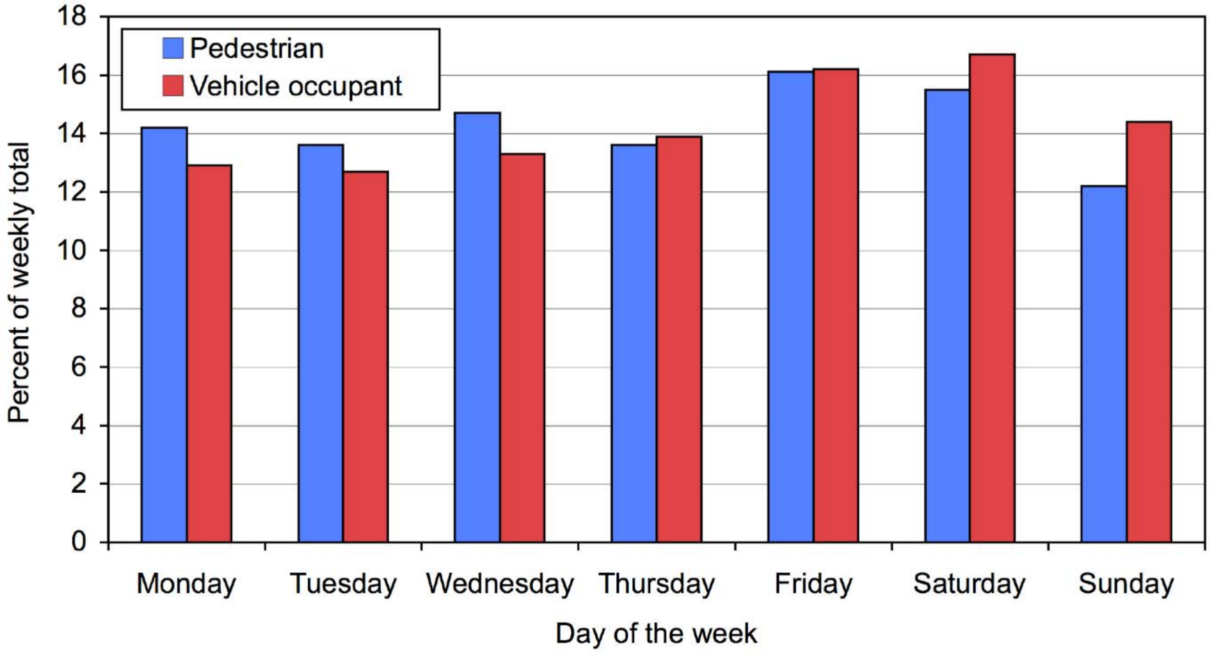

Figure 14. Traffic fatalities by day of the week in São Paulo, 2007 (CET, 2009).

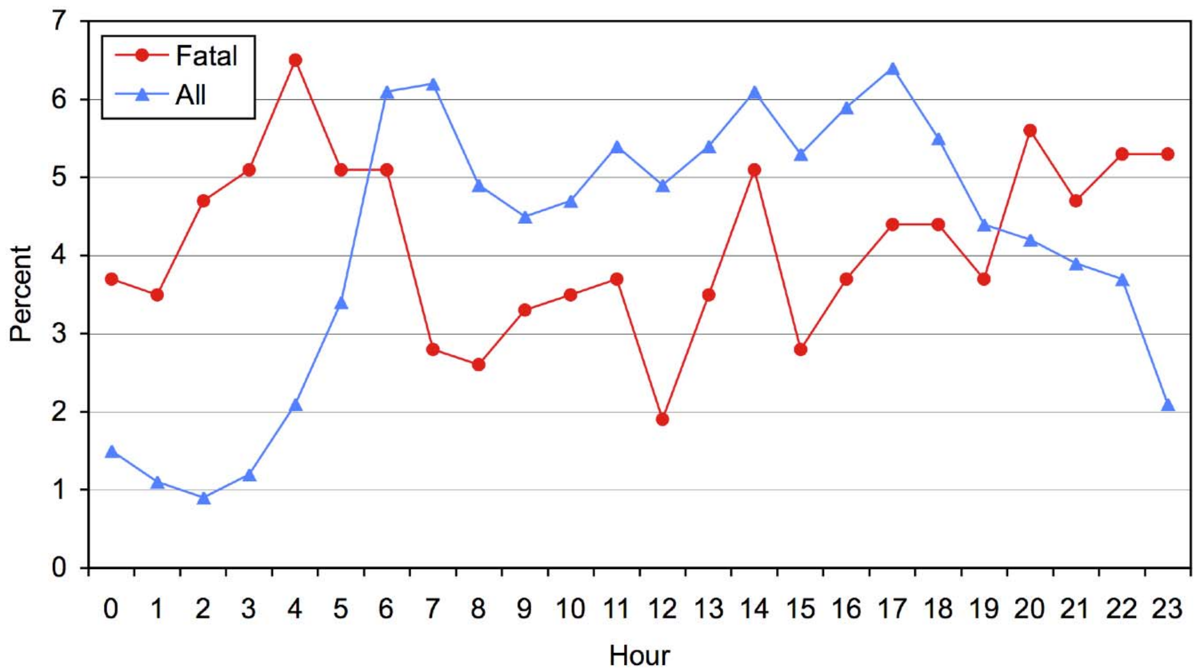

Figure 15. Traffic crashes and fatalities by hour of the day in São Paulo, 2007 (CET, 2009).

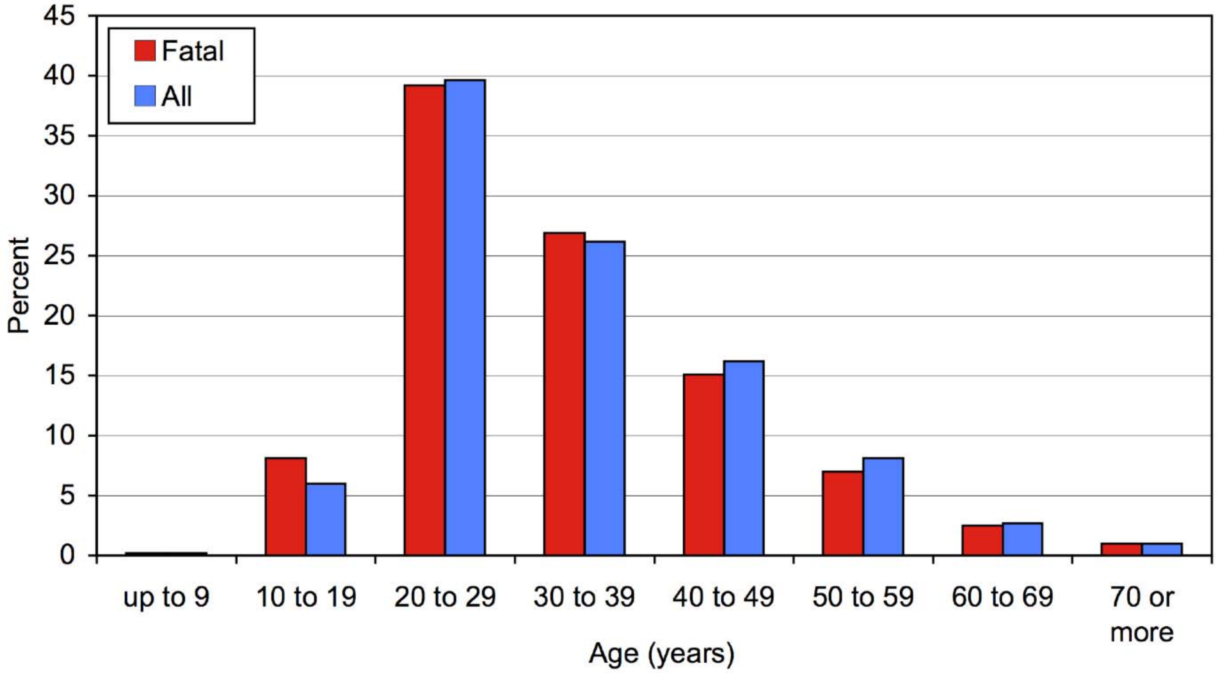

Figure 16. Traffic fatalities and age of victims in São Paulo, 2007 (CET, 2009).

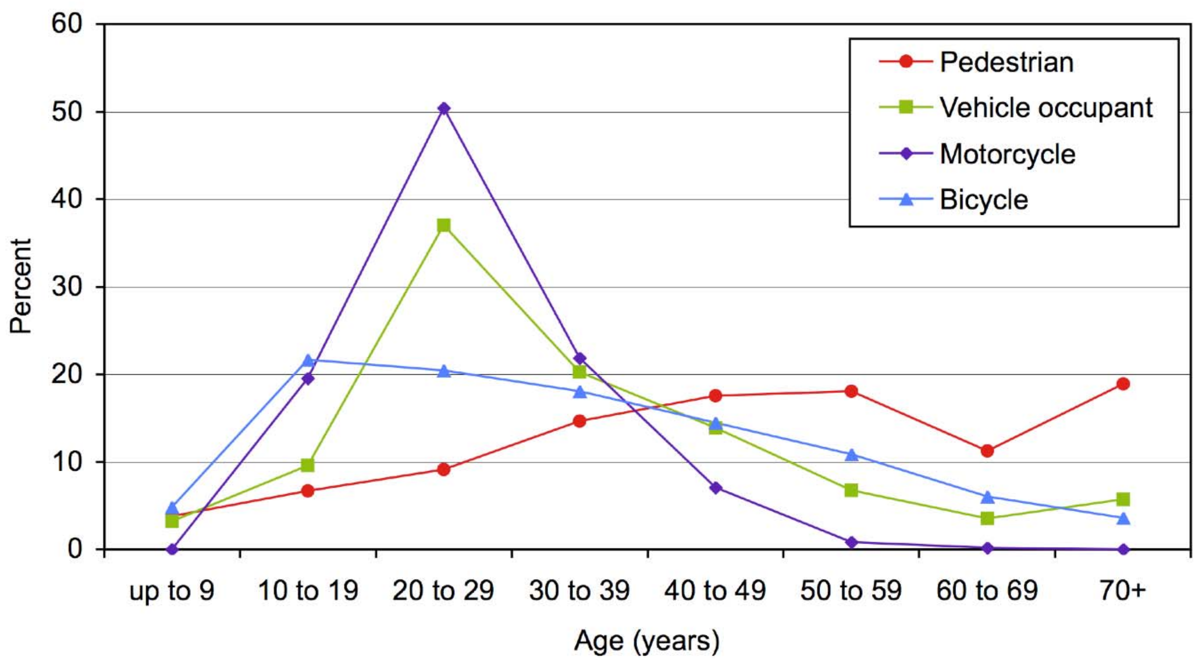

Figure 17. Traffic fatalities by condition and age in São Paulo, 2007 (CET, 2009).

Table 27 shows that traffic fatalities resulted mostly from collisions (the most frequent were head-on collisions, with 35% of total collisions), followed by hitting fixed obstacles (mostly poles and walls), and falling (mostly) from motorcycles.

Table 27
Type of crashes in São Paulo, 2005 (CET, 2005).

Crash type	Percent
Collision	54.2
Hit fixed obstacles	25.0
Fall from bicycles and motorcycles	16.9
Rollover	3.9

Costs of traffic crashes in Brazil

Two major recent studies examined for the first time the cost of traffic crashes in Brazil. The first study analyzed the costs of crashes in major metropolitan areas (IPEA-ANTP, 2003). The second study analyzed the cost of rural crashes (IPEA-ANTP, 2006). Both studies used the traditional methodology of considering loss of years of production, medical costs, and vehicular costs.

The costs of crashes in major metropolitan areas are summarized in Table 28. The total cost in 2003 was US$ 1.2 billion. (To obtain an estimate of the costs for *all* urban crashes, the costs for crashes in major metropolitan areas should be multiplied by 1.47.) Loss of production (because of death or injury) accounts for 43% of all costs in major metropolitan areas, followed by vehicle repairs, and medical costs. Table 29 indicates that 55% of all costs are related to automobiles, followed by motorcycles (19%). Motorcycles, buses, and trucks have disproportionate impacts on crash costs in relation to their share in the vehicle fleet. For example, on average, for every 10 motorcycle crashes there are 7 injured or killed persons, as opposed to 0.8 in the case of automobile crashes (IPEA-ANTP, 2003).

The costs of rural crashes are summarized in Table 30. The total cost in 2005 was US$ 9.7 billion, mostly for crashes on state roads. Table 31 shows that average cost per crash on federal roads was US$ 25,825, with fatal crashes averaging US$ 183,483 each.

The annual total cost for road crashes in Brazil (the cost of rural crashes plus 1.47 times the cost of crashes in major metropolitan areas) is estimated at US$ 11.5 billion (9.7 plus 1.47 times 1.2).

Table 28
Cost of crashes in major metropolitan areas in Brazil, 2003 (IPEA-ANTP, 2003).

Type of cost	US$	Percent
Loss of production	492,628,205	42.8
Vehicle repair	331,745,192	28.8
Medical costs	152,570,513	13.3
Legal	42,013,782	3.7
Other	131,914,744	11.5
Total	*1,150,872,436*	*100.0*

Table 29
Cost of crashes in major metropolitan areas by type of vehicle in Brazil, 2003 (IPEA-ANTP, 2003).

Vehicle	US$	Percent of total cost	Percent of fleet
Automobiles	635,107,485	55.2	84
Motorcycles	219,536,905	19.1	11
Urban bus	147,473,509	12.8	1
Trucks	129,523,859	11.3	4
Total	*1,150,872,528*	*100.0*	*100*

Table 30
Costs of rural crashes in Brazil, 2005 (IPEA-ANTP, 2006).

Roadway system	US$	Percent
Federal	2,856,177,654	29.6
State	6,188,621,655	64.1
Municipal	615,992,678	6.4
Total	*9,660,791,987*	*100.0*

Table 31
Costs of crashes by type of crash on federal roads in Brazil, 2005 (IPEA-ANTP, 2006).

Type of crash	US$	US$ per crash
No injuries	505,381,363	7,386
Injured people	1,394,850,386	37,733
Fatality	955,945,905	183,483
Total	*2,856,177,654*	*25,825*

Conclusions

General considerations

The traffic-crash fatality rates in Brazilian states vary from 12.4 to 32.3 per 100,000 persons, and from 4.4 to 20.6 per 10,000 vehicles. The differences in state rates are likely related to several factors, such as the proportion of urban population, the length of the intercity roadway system, the level of motorization, and the safety conditions of the regional traffic environment. The national rates are 18.7 per 100,000 persons and 7.7 per 10,000 vehicles. These rates are high when compared with those of industrialized nations. For example, the current rates in the United States are 14.9 per 100,000 persons and 1.8 per 10,000 vehicles (NSC, 2008).

At the national level, the total number of fatalities temporarily decreased after the implementation of the new stricter traffic code (CTB) in 1998, but the fatality rates have begun to increase again. Several changes introduced by the new CTB appear to be effective in improving traffic-safety conditions, especially the grade system attached to the number of violations of each driver, higher fine levels, the transfer of traffic planning and operation to the local level, and the consequent implementation of safety surveillance systems and local civilian traffic-police corps. However, some of the initial targets (such as the use of dedicated funds in educational efforts, the organization of a national database on traffic violations, and the mandatory vehicle-inspection program) were partially delayed by bureaucratic barriers and political conflicts among various levels of government.

The cost of road crashes in Brazil is substantial. The annual costs of all crashes are estimated at US$ 11.5 billion (see page 37). This represents about 1.4% of the total GDP of Brazil (Economist, 2007).

Although the quality of crash data has recently improved, additional improvements are needed to better understand the status quo and the potential countermeasures. For example, currently about 23% of Brazilian road fatalities are classified as “unknown” in terms of their transportation mode prior to the crash (MS-DATASUS, 2007). Thus, the promising areas for intervention and the proposed countermeasures to be outlined in the following sections are based on incomplete data. A uniformed, detailed reporting on all fatal crashes in the country would be a step in the right direction.

Promising areas for intervention

Based on the above analysis, we selected four areas for which to examine potential countermeasures in the next part of the report. Successfully dealing with these four areas is likely to bring about substantial improvement in road safety in Brazil.

(1) Pedestrian crashes. Although the involvement of pedestrians among road fatalities in Brazil has recently decreased, pedestrians currently account for about 36% of all road fatalities if "unknowns" are excluded (Table 9). While this percentage is lower than in some other developing countries, such as China (Zhang, Tsimhoni, Sivak, and Flannagan, 2008), it is higher than in developed countries, such as the United States (NSC, 2008). Pedestrians represent the single largest group among (a) all road fatalities (Table 9), (b) urban fatalities of persons over 40 years of age (Figure 17), and (c) the fatalities on the federal roads with four or more lanes of traffic (Table 22), presumably primarily on sections that traverse urban areas.

(2) Motorcycle crashes. Currently, motorcyclists account for 26% of all road fatalities in Brazil (Table 9). Because of the rapid increase in the number of motorcycles (an increase by a factor 4.6 from 1998 to 2008 [Table 7]), both the absolute number of motorcycle fatalities and their proportion among the total fatalities has increased dramatically during the past 10 years (Figures 6 and 7). Furthermore, it is important to note that during this period, the increase in motorcycle fatalities was proportionally greater than the increase in the number of motorcycles.

(3) Nighttime crashes. The evidence indicates that the likelihood of a crash per volume of traffic on federal roads is greatest during the period from midnight through 06:00. Specifically, the likelihood of a crash during this period is twice the likelihood expected based on traffic volume alone (see Table 14). Furthermore, the data for São Paulo indicate that the nighttime crashes are more severe than daytime crashes. Specifically, given a crash, the likelihood of a fatality is greatest between 20:00 and 06:00 (see Figure 15).

(4) *Crashes on two-lane roads*. The information from federal roads indicates that the frequency of crashes is greater on two-lane roads than on roads with four or more lanes (Table 16), presumably reflecting both a more extended network and worse traffic-safety conditions of two-lane roads. Importantly, however, crashes on two-lane roads are also more severe than those on multi-lane roads. Specifically, the likelihood of a fatality given a crash on two-lane roads is more than twice the likelihood on multi-lane roads (Table 16). The likely explanation for this pattern is that crashes on two-lane roads are dominated by head-on collisions (Table 22).

OPPORTUNITIES: PROMISING COUNTERMEASURES

General approach to identification of potential countermeasures

The approach that we used in this report is based on the concept of total harm (Thulin and Nilsson, 1994; Sivak and Tsimhoni, 2008). As we discussed in Sivak and Tsimhoni (2008, p. 453),

> …total harm is conceptualized as a product of exposure, risk, and consequences. Exposure is the probability of a particular, potentially risky recent event (condition, situation) per distance traveled or per unit of time. Risk is the conditional probability of a crash, given the event in question. Consequence is the conditional probability of undesirable outcomes (i.e., fatality, injury, and property damage) given a crash that was precipitated by the event in question. For each event, the values along the three dimensions (exposure, risk, and consequences) define a three-dimensional space. The volume of this space is the total harm for this particular event.

The goal of traffic-safety countermeasures should be a reduction in total harm, based on influence on exposure, risk, or consequences.

Proposed countermeasures for Brazil

Table 32 lists proposed countermeasures for each of the four problem areas discussed above. The countermeasures are classified by three components that contribute to total harm (exposure, risk, and consequences).

Before discussing countermeasures for each of the four major problem areas, it is important to point out that these four areas are not independent. For example, some pedestrian crashes involve motorcycles and occur at night on two-lane roads. Thus, a countermeasure aimed at a particular problem area might have beneficial consequences on other areas as well.

Table 32
Summary of promising countermeasures.

Problem area	Exposure	Risk	Consequences
Pedestrian crashes	Enforcement of prohibitions on pedestrian crossing at midblock Better separation of motorized and non-motorized traffic	Stricter speed-limit enforcement Improved pedestrian conspicuity	Pedestrian-friendly front ends of vehicles
Motorcycles crashes	Restriction on driving between lanes for motorcycles Restriction on the use of motorcycles on roads with high volume of truck and bus traffic	More frequent use of random breath alcohol testing	More uniform enforcement of the helmet-use law
Nighttime driving		Improved headlighting Improved vehicle conspicuity Improved pedestrian conspicuity More frequent use of random breath alcohol testing Rest regulations for truck drivers	Stricter enforcement of safety-belt laws
Crashes on two-lane roads	Better road-shoulder conditions (e.g., pavement and signing) for pedestrian traffic	Increased restrictions on and stricter enforcement of overtaking Stricter speed-limit enforcement More frequent use of random breath alcohol testing Rest regulations for truck and bus drivers	Stricter enforcement of safety-belt laws

Pedestrian crashes. Two countermeasures—enforcement of prohibition on pedestrian crossing at midblock and improved pedestrian conspicuity at nighttime—recognize the fact that pedestrians themselves can contribute to reducing this problem. Another countermeasure—stricter speed-limit enforcement—is based on the nonlinear relationship between vehicle speed and severity of pedestrian injuries in crashes. Improved pedestrian friendliness of vehicle front ends points out an area where vehicle manufacturers could contribute significantly to a reduction of this problem. Finally, better separation of motorized and non-motorized traffic would also be very effective, but expensive to implement.

Motorcycle crashes. The currently sanctioned practice of motorcyclists being allowed to ride between two lanes of traffic should be reexamined in terms of the tradeoff between mobility in congested urban areas (frequently involving document-delivery services) and increased risk of crashes. Furthermore, more frequent use of random breath alcohol testing and more uniform enforcement of the helmet-use law would likely lead to major reductions in motorcycle crashes. Finally, because motorcycles are at a special disadvantage in crashes with trucks and buses, serious consideration should be given to not allowing the use of motorcycles on roads with high volume of truck or bus traffic.

Nighttime crashes. The available data do not allow quantification of the relative contribution of visibility, alcohol, and fatigue to the increased risk of nighttime driving in Brazil. Consequently, the recommendation is to address all of these mechanisms with a combination of countermeasures: improved headlighting and conspicuity of all traffic participants, more frequent random breath alcohol testing, and rest regulations for truck drivers.

Crashes on two-lane roads. Fatalities on two-lane roads are most frequently a consequence of head-on collisions. This fact implicates unsafe overtaking as a major problem. Consequently, it is recommended that increased restrictions on overtaking on two-lane roads be put in place and that overtaking restrictions be more strictly enforced. Additional promising countermeasures include rest regulations for truck and bus drivers, more frequent random breath alcohol testing, stricter speed-limit enforcement, stricter enforcement of safety-belt laws (especially for rear-seat passengers), and better road-shoulder conditions for pedestrian traffic.

SUMMARY

This report was designed to analyze the traffic-safety situation in Brazil, and to identify countermeasures for areas in which the total harm caused by crashes can be substantially and readily reduced. The report focuses on two aspects of traffic safety in Brazil: challenges and opportunities. The first part of the report provides a comprehensive analysis of the current traffic-safety situation in Brazil. Based on this analysis, the following four areas are identified as having potential for substantially reducing fatalities in Brazil: (1) pedestrian crashes, (2) motorcycle crashes, (3) nighttime crashes, and (4) crashes on two-lane roads. The second part of the report outlines several promising countermeasures for each of these four areas.

The discussion of the current traffic-safety situation and the proposed countermeasures were based on the available data that, in many respects, are not comprehensive and uniform. Consequently, it is recommended that a uniform, detailed reporting system on all fatal crashes in the country be instituted.

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