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SURVEY OF THE STATUS OF TRUCK SAFETY: BRAZIL, CHINA, AUSTRALIA, AND THE UNITED STATES

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Survey of the Status of Truck Safety:
Brazil, China, Australia, and the United States

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16. Abstract

This report reviews the status of truck safety in four countries, Australia, Brazil, China, and the United States. The report describes the role of road freight transportation in each country; characterizes the current level of safety; and identifies the primary safety problems related to trucks within each country.

Vehicle populations in Australia and the US are currently relatively similar, but both China and Brazil have a much higher reliance on motorcycles and nonmotorized transportation. Truck crash rates also vary among the countries, higher in Brazil and China, lower in the US and Australia. Primary safety issues in China and Brazil are interactions with two-wheeled vehicles and nonmotorists. Interactions with passenger cars and other light-duty vehicles are a greater issue in Australia and the US. Common issues include driver fatigue and hours of service, vehicle condition, and issues related to truck size and weight. Crash and vehicle population data available for this study varied widely in accessibility, comprehensiveness, and detail. Improved crash data are particularly important issues in China and Brazil.

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Contents

1. Introduction

This report presents a survey of traffic safety issues related to trucks in several key countries around the world. The intent was to review the status of truck safety in a broad range of countries, broadly representative of the developing and developed countries, in order to come to a better understanding of the current status of truck safety and the paths to a safer future. The report proceeds by describing the role of road freight transportation in each country; characterizing the current level of safety; and identifying the primary safety problems related to trucks within each country.

The four countries selected—Australia, Brazil, China, and the United States—represent a broad range of economic and social circumstances. Brazil is a dominant power on the Latin American continent, but in some ways its economy is still developing. It is a country with a large population and a relatively low gross domestic product per capita. Truck operations experience a relatively low level of regulation. China is a rapidly developing power, undergoing an accelerated change to a motorized society. The vehicle population is expanding rapidly, and the country is attempting to develop infrastructure, the vehicle population, and the regulatory and enforcement environment all at once. Australia is relatively small in terms of population but enormous in terms of physical extent, with a relatively high per capita GDP. There is a deliberate, safety-oriented, and analytical regulatory environment. Finally, the US is a mature, developed country, with a relatively high per capita GDP, and a regulatory environment that grew in tandem with the development of the infrastructure, the freight carrier industry, and vehicles.

Table 1
Selected Demographic and Geographic Characteristics.

Characteristic	Australia	Brazil	China	US
Population	21,766,711	203,429,773	1,336,718,015	313,232,044
Area (km2)	7,741,220	8,514,877	9,596,961	9,826,675
Land	7,682,300	8,459,417	9,569,901	9,161,966
Water	58,920	55,460	27,060	664,709
GDP per capita	$41,000	$10,800	$7,600	$47,200
Road km	818,356	1,751,868	3,860,800	6,506,204
Paved	n/a	96,353	3,056,300	4,374,784
Unpaved	n/a	1,655,515	804,500	2,131,420

Compiled from [1].

Reviewing the status of truck safety in these countries shows the extent to which local conditions shape the specific safety problems each country is faced with. However, the many issues in common show how certain truck safety issues cross political and economic boundaries and are inherent in the nature of truck operations and the trucks themselves.

2. Brazil

2.1 Vehicle population and demographics

Comprehensive and systematic statistics on truck involvement in traffic crashes in Brazil are not available. Data are collected at federal, state, and municipal jurisdictional levels, and the data systems are not mutually compatible. In order to obtain an overview of truck traffic safety in Brazil, it was necessary to survey a broad range of sources, including annual publications of statistics from the Departamento Nacional de Trânsito (DENATRAN), Agencia Nacional de Transportes Terrestres (ANTT), and Federación Nacional de la Distribución de Vehículos Automotores (FENABRAVE), along with sources in the traffic safety literature and road safety conferences. Few of the sources provided comprehensive and detailed truck crash statistics. Therefore, it was necessary to construct a mosaic of perspectives on different aspects of the truck safety problem in Brazil, sometimes from different years, sometimes grouping light and heavy trucks together and sometimes splitting them, and sometimes including all crash severities and other times just looking at fatal or casualty crashes. The result is a number of perspectives on truck safety in Brazil, which, taken as a whole and in comparison with the other countries examined here, provides insight into the similarities and differences in the issues.

Table 2 shows the distribution of the fleet by vehicle type. In this table, light trucks (*caminhonete*) are distinguished from medium and heavy trucks (*caminhão* and *caminhão trator*). Conventionally, especially in more developed countries, light trucks that have a gross vehicle weight rating (GVWR) of less than 3,500 kg. are differentiated from medium and heavy trucks and included with light vehicles. But in some of the crash statistics from sources in Brazil, light and heavy trucks are combined.

Table 2 is provided to show the relative magnitude of the light and heavy truck population in Brazil. Light trucks are about 61 percent of the set. The data are extracted from vehicle registration files, which are not purged of vehicles that are junked or otherwise retired; it is not known if this affects the distribution (i.e., if some vehicle types are more likely to be junked as they age than others).

Table 2
Distribution of Fleet by Vehicle Type, January 2010.

Vehicle type	N	%
Light vehicle	36,631,084	62.7
Light truck	3,861,622	6.6
Medium/heavy truck	2,422,465	4.1
Motorcycle	14,816,782	25.4
Bus	676,537	1.2
Total	***58,408,490***	***100.0***

Adapted from [5].

The roadway system includes a substantial proportion of unpaved roads. Roads are under the jurisdiction of different levels of government, primarily federal, state, and municipal. There are also some roads that are built and maintained by private organizations, which tend to be the highest quality. Among those maintained by government entities, only about 14 percent are paved. Federal roads account for less than 5 percent of the system, but over 80 percent of federal roads are paved. About half of state roads are paved and only 2.2 percent of municipal roads are paved. Paved municipal roads are overwhelmingly in urban areas. Trucks probably operate more on federal roads, traveling longer distances between urban and economic areas, and so likely travel more on paved roads than other vehicle types, but it should be noted that trucks likely travel more on unpaved roads in Brazil than do trucks in more developed countries. Only about 2,300 km (3.0 percent) of federal roads are double lane (i.e., two lanes in each direction) and about 3,200 km (1.4 percent) of state roads are double lane. Most roads are two-lane, two-way roads.

Table 3
Road System by Jurisdiction and Road Surface.

Road surface	Jurisdiction				Total
	Federal	Combined Federal & State	State	Municipal	
Paved	61,920	17,197	112,182	27,342	218,640
Unpaved	13,775	6,224	111,474	1,236,128	1,367,601
Total	***75,694***	***23,422***	***223,656***	***1,263,469***	***1,586,241***
Percentage by jurisdiction					
Paved	81.8	73.4	50.2	2.2	13.8
Unpaved	18.2	26.6	49.8	97.8	86.2
Total	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***

Adapted from [7], tables 1.1.1 and 1.1.2.

Statistics on the composition of truck configuration in Brazil could not be obtained, but one source identified the primary truck types used and their application. This information is summarized in Table 4. One thing to note is the high gross weights allowed for doubles combinations, apparently without special permit. Weights up to 163,000 lbs. for turnpike doubles are quite high, in comparison with limits in the US, where the federal weight limit on Interstate roads is 80,000 lbs., though some states permit more on certain roadways, including Michigan which allows up to 164,000 lbs. for a compliant vehicle. Still, the weight limits permitted by Brazil are significantly heavier than in most places in the US.

Table 4
Some Truck Types in Use in Brazil.

Truck type	Application	Maximum gross weight	Length
2- and 3-axle straight truck	Short haul		
Tractor-semitrailer	Long haul	45 tonnes (99,210 lbs.)	19.8 m. (65 feet)
Tractor, B-train	Heavy haul	57 tonnes (125,663 lbs.)	
Turnpike doubles	Long, heavy haul	74 tonnes (163,142 lbs)	

Adapted from [17].

2.2 Crash statistics

Table 5 shows the frequency and distribution of types of vehicles involved in injury crashes. Note that light and heavy trucks are combined in this table. Trucks constitute 9.2 percent of the vehicles in injury (fatal and nonfatal injury) crashes, which is slightly less than their share of the vehicle population (10.7 percent). The proportion of motorcycles in the injury crash population is noteworthy. They account for over one-third of the vehicles, compared with about one-quarter in the vehicle fleet (Table 2). This would be expected, since motorcycle riders are inherently more vulnerable compared with other vehicle occupants.

Table 5
Type of Vehicle Involved in Injury Crashes, 2008.

Vehicle type	N	%
Passenger car	246,712	41.6
Bus, microbus	23,052	3.9
Truck (light & heavy)	54,463	9.2
Motorcycle	200,449	33.8
Bicycle	32,496	5.5
Other	9,867	1.7
No information	25,366	4.3
Total	***592,405***	***100.0***

Ref: [6, Table 9].

Table 6 shows the distribution of vehicle types in injury crashes on federal and state highways. The data are for crashes occurring between January and July of 2008. The federal government controls federal roads, and they are policed by the Federal Roadway Police. State roads are the responsibility of individual states, and traffic enforcement is carried out by the Military Traffic Police.[4] Overall, over 80 percent of federal roads are paved, while only about half of state roads are paved (and less than 2 percent of other roads are paved).[7] The proportions of passenger cars and buses are very nearly the same, but the proportions for motorcycles and trucks (combining light and heavy) are quite different. On federal roads, 17.2 percent of the vehicles in injury crashes are trucks but on state roads the proportion is less than half (8.0 percent). Nearly the inverse is true for motorcycles, which account for 36.3 percent on state highways but only 24.4 percent on federal roads. The reason is likely that trucks, particularly heavy trucks, are more often used for heavy hauling over long distances and so accumulate more miles, and consequently more crashes, on the federal roads, which are the primary routes across and between states. The reader is cautioned that trucks, as defined here, include a preponderance of light trucks, but these are probably not used as frequently for long distance travel. Motorcycles are more likely to be used for short distance travel and so have more of their crashes on state highways.

Table 6
Vehicles Involved in Injury Crashes on Federal and State Highways, Jan. – July, 2008.

Vehicle type	Federal highway		State highway	
	N	%	N	%
Passenger car	3,010	44.4	2,870	43.3
Bus, micro-bus	162	2.4	114	1.7
Truck (light & heavy)	1,166	17.2	528	8.0
Motorcycle	1,654	24.4	2,403	36.3
Bicycle	358	5.3	269	4.1
Other	356	5.3	395	6.0
No information	73	1.1	42	0.6
Total	***6,779***	***100.0***	***6,621***	***100.0***

Adapted from [6].

The proportion of trucks in injury crashes in municipal areas is significantly lower than on state highways, at only 5.0 percent of all vehicles. (Table 7.) The proportion of passenger cars is about the same as on federal and state highways (41.0 percent), but the proportion of motorcycles is the highest at 38.9 percent. Clearly, trucks account for the highest proportion of vehicles in the traffic stream on federal highways, less on state highways, and still less in municipal roads. In part, this may be because some cities prohibit trucks from entering during the daytime, to reduce congestion. But it is likely primarily for operational reasons.

Table 7
Vehicles Involved in Injury Crashes in Municipal Areas, Jan. – July. 2008

Vehicle type	N	%
Passenger car	19,531	41.0
Bus, micro-bus	1,844	3.9
Truck (light & heavy)	2,377	5.0
Motorcycle	18,565	38.9
Bicycle	2,647	5.6
Other	709	1.5
No information	2,006	4.2
Total	***47,679***	***100.0***

Adapted from [6].

Truck crash involvements also are more likely to occur during the work week, compared with crashes involving other vehicle types. (See Figure 1.) Almost 80 percent of truck involvements occur Monday through Friday, compared with about 65 percent for other vehicles. In fact, for nontrucks, the most frequent day is Sunday, while the most frequent day for trucks is Friday. These differences most likely reflect operational factors; that is, trucks are operated primarily during the work week, while other vehicles are used for leisure activities as well as commuting to and from work.

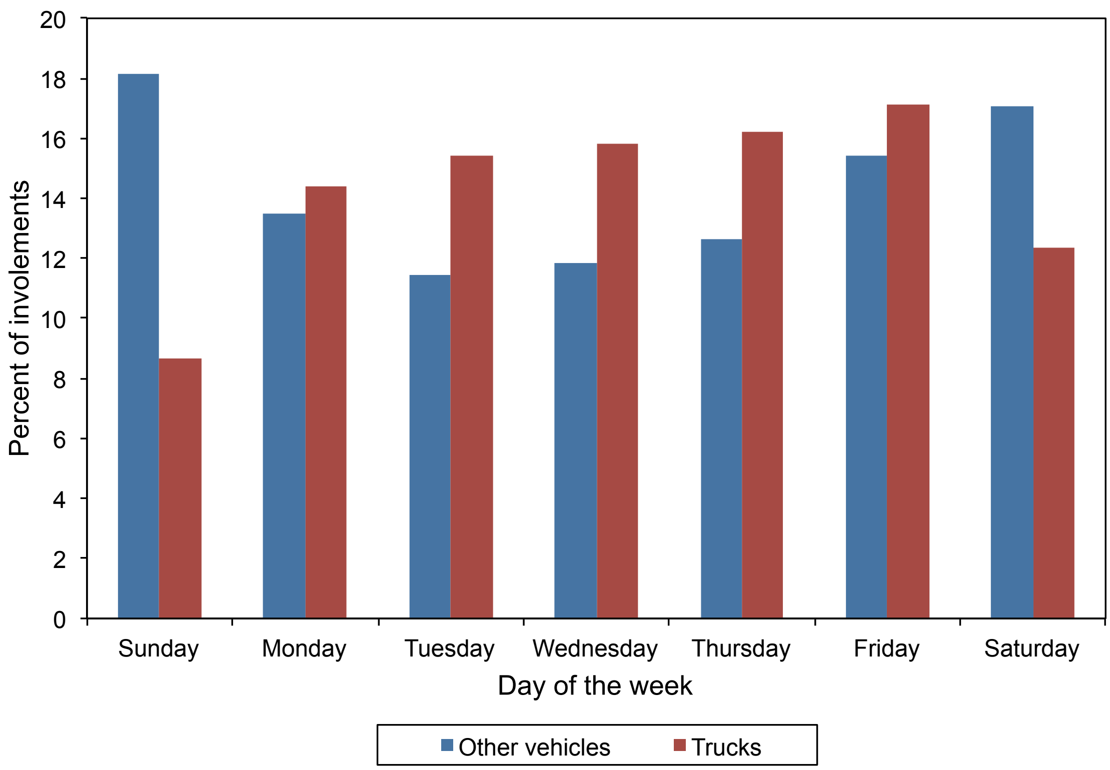

Figure 1. Distribution of Crash Involvements for Trucks and Other Vehicles on Federal Roads. Adapted from [8].

Figure 2 provides counts of fatalities in truck crashes as well as in all fatal crashes, on all roadways in Brazil, from 2000 to 2009. The "all crash" line shows the overall count of fatalities by year. From 2000 to 2009, fatalities in traffic crashes in Brazil increased from about 29,000 to about 37,500, an increase of about 29 percent. The "truck-related" line shows the count of fatalities in traffic crashes that included at least one truck. Truck-related fatalities increased from about 2,000 to over 4,500, an increase of 125 percent. (The data combine light truck and heavy truck crashes; it is not possible to extract fatalities in heavy truck crashes alone in this case.) The "not in truck" line includes all fatalities where the person was neither in a light truck nor in a heavy truck. In other words, it includes occupants of passenger cars, motorcyclists, bicyclists, and pedestrians. The number of such fatalities in truck crashes (including, of course, crashes of light trucks) increased from about 1,300 to almost 3,500, for an increase of 160 percent. The accuracy of the underlying data, particularly for older years, is not known with confidence, but two things are clear. First, the number of fatalities in truck crashes increased over the period; and second, in truck crashes, most of the fatalities occur outside of the truck.

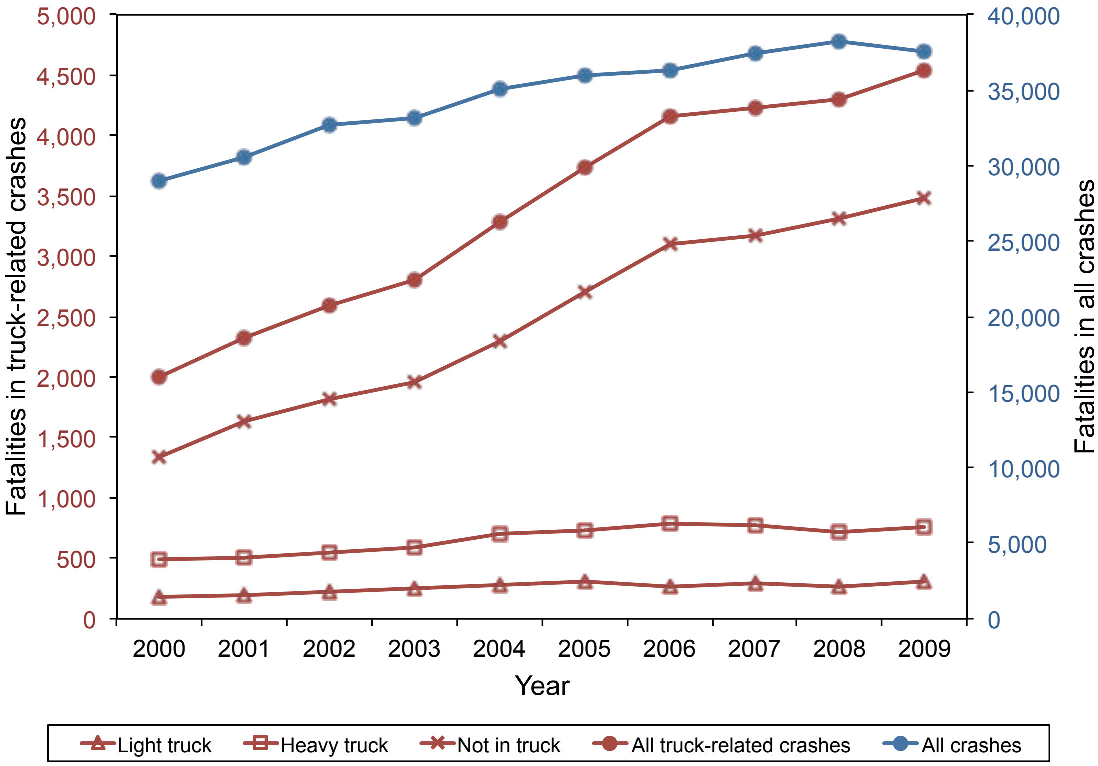

Figure 2. Fatalities in Truck- and All Crashes, Federal Roads. Adapted from [10].

Table 8 shows the distribution of fatalities by person type, that is, the type of road user, whether in a vehicle or a pedestrian or bicyclist. Person type is unknown for almost 29 percent of the fatalities, so percentages are also shown calculated after excluding the unknown type. Most fatalities, either way, are pedestrians, accounting for over 40 percent of fatalities when the unknown category is excluded. If bicyclists are combined with pedestrians, the percentage increases to over 46 percent. Occupants of heavy trucks account for only 2.8 percent of traffic deaths, and occupants of small trucks only 1.1 percent.

Table 8
Fatalities by Person Type, 2007, All Fatal Crashes.

Person type	N	%	%, excluding unknown types
Tricycle*	25	0.1	0.1
Bus	212	0.6	0.9
Small truck	279	0.8	1.1
Heavy truck	708	2.0	2.8
Bicycle	1,389	4.0	5.6
Motorcycle	5,042	14.4	20.2
Automobile	7,188	20.5	28.8
Pedestrian	10,096	28.8	40.5
Unknown	10,145	28.9	n/a
Total	***35,084***	***100.0***	***100.0***

* The tricycle type is a motorized vehicle.
Adapted from [70].

Considering just fatalities in truck crashes (excluding occupants of the trucks), the most common fatality is a motorcycle rider, followed by automobile occupants, and pedestrians. However, if bicyclists are combined with pedestrians, almost a third of the people killed in truck crashes were not in motor vehicles. Fully 70 percent of the fatalities were either on foot or on a bicycle or were on a motorcycle, equally vulnerable.

Table 9
Person Type Fatally Injured in Truck Crashes, 2009, Not Truck Occupant.

Person type	N	%
Automobile	1,044	30.0
Motorcyclist	1,283	36.9
Tricyclist	7	0.2
Pedestrian	842	24.2
Cyclist	301	8.7
Total	***3,477***	***100.0***

Adapted from [10].

The types of crashes trucks are involved in differ from other vehicle types. On federal roads, the most common collisions for trucks are rear-end and side-impact collisions (Table 10). The proportion of rear-end collisions is about the same, but trucks have a significantly higher percentage of side impacts, which may include sideswipes. On the other hand, trucks are involved in relatively fewer lane departure and crossing-path collisions. However, in terms of fatalities, the most significant crash types for trucks are pedestrian (26.5 percent), rollover (20.5 percent), lane departure (18.2 percent), and head-on (15.5 percent).

The seriousness of each of these crash types is clearly shown by the increase in percentage of fatalities relative to the percentage of crashes. Rollover accounts for 9.0 percent of truck-involved crashes but 20.5 percent of fatalities in truck crashes. Head-on collisions are only 4.0 percent of truck crashes, but account for 15.5 percent of fatalities. And only 1.1 percent of truck crashes on federal roads were classified as a collision with a pedestrian, but they accounted for 26.5 percent of the fatalities. Lane departure crashes often result in road departure and rollover, which may explain the severity of that crash type.

Table 10
Crash Type and Crash Fatalities for All Vehicle Types and for Trucks, January-August, 2011; Federal Roads Only.

Crash type	All vehicle types		Trucks	
	Crashes	Fatalities	Crashes	Fatalities
Head-on	4,241	1,617	1,761	127
Lateral side impact (angle)	22,013	425	12,886	51
Rear-end	37,812	479	12,422	62
Crossing paths	12,982	541	3,461	22
Lane departure	18,156	551	4,299	149
Collision with other nonfixed object	1,285	18	631	1
Struck fixed object	7,344	169	1,776	11
Rollover	10,086	411	3,991	168
Fall off (motorcycle, bicycle, vehicle)	4,116	169	139	0
Collision with pedestrian	3,494	1,037	489	217
Collision with animal	3,102	54	685	3
Collision with bicycle	1,423	227	200	2
Possible damage	894	13	499	2
Cargo spillage	689	2	675	1
Fire	505	3	236	3
Total	***128,142***	***5,716***	***44,150***	***819***
Column percentages				
Head-on	3.3	28.3	4.0	15.5
Lateral side impact (angle)	17.2	7.4	29.2	6.2
Rear-end	29.5	8.4	28.1	7.6
Crossing paths	10.1	9.5	7.8	2.7
Lane departure	14.2	9.6	9.7	18.2
Collision with other nonfixed object	1.0	0.3	1.4	0.1
Struck fixed object	5.7	3.0	4.0	1.3
Rollover	7.9	7.2	9.0	20.5
Fall off (motorcycle, bicycle, vehicle)	3.2	3.0	0.3	0.0
Collision with pedestrian	2.7	18.1	1.1	26.5
Collision with animal	2.4	0.9	1.6	0.4
Collision with bicycle	1.1	4.0	0.5	0.2
Possible damage	0.7	0.2	1.1	0.2
Cargo spillage	0.5	0.0	1.5	0.1
Fire	0.4	0.1	0.5	0.4
Total	***100.0***	***100.0***	***100.0***	***100.0***

Adapted from [8].

2.3 Truck safety issues

Congestion and rapid urbanization are significant issues in Brazil. Many municipalities prohibit truck traffic within the central urban area during daylight hours as a way to reduce congestion. Nevertheless, collisions with vulnerable road users, such as pedestrians, bicyclists, and motorcyclists account for the majority of fatalities in truck crashes. Overall, the percentage of pedestrian fatalities in truck crashes is somewhat less than in all crashes, 28.8 percent to 24.2 percent, but bicyclists account for somewhat more (8.7 percent to 5.6 percent) and motorcyclists substantially more, 36.9 percent to 20.2 percent. Together, these three groups account for almost three quarters of the deaths in crashes involving trucks.

A number of safety issues specific to trucks have been identified in Brazil, and it is notable how similar they are to issues in other countries.

- Driver fatigue including hours of service
- Truck driver alcohol and drug use
- Truck driver training
- Heavy truck rollover
- Vehicle mechanical condition (brake adjustment, other defects, low rate of inspections)
- Issues related to oversize and overweight

A sample of 300 drivers taken at a roadhouse in Fortaleza, Brazil, was part of a study of depression in Brazilian truck drivers. The study yielded significant demographic information about the drivers, related to fatigue and a generally unhealthy driver condition. Over a quarter of the drivers were smokers, and 16 percent suffered from hypertension. More significantly, almost half reported consuming alcohol while working and almost 90 percent knew other drivers who did. Over a third used illegal stimulants. Almost 70 percent worked more than 10 hours per day.[14] These results are broadly consistent with another survey of 51 drivers that showed that 82 percent drove more than eight hours per day and 51 percent reported drinking on the job. In addition, over half of the drivers were hypertensive, almost half had vision problems, and almost half were overweight.[15]

There are no specific regulations governing the number of hours driving, as issues related to hours of service are treated as a labor issue, for negotiation between unions and carriers. Labor law requires an 11-hour break between working periods, but there are no truck-driver-specific rules. Not surprisingly, driver fatigue is considered a serious issue. In a sample of truck-involved crashes on federal roads, “sleep” was identified as a cause in 4.5 percent of the crashes. More broadly, inattention was coded for almost half.[8]

Driver training in general is lacking, and licensing allows drivers to legally operate a truck that has very different handling characteristics from the one they trained and qualified on. A driver can train on a class 6, two-axle tractor, and be licensed to drive a two-trailer combination.[12]

Poor vehicle condition is also a safety issue. The average age of a truck in Brazil is 17.2 years, though this is calculated from registration files which typically are not purged of inactive vehicles. Failing to purge inactive vehicles would tend to increase the mean age [page 37, ref. 11]. However, it is reasonable to assume that trucks, as a significant capital good, are used as long as possible. There is no system of mandatory vehicle inspections for all vehicles, only for vehicles hauling hazardous materials and that are transporting cargo in the Southern Common Market (Mercosul). One author reported that 45 percent of trucks that were inspected failed, and presented numerous examples of trucks involved in crashes because of mechanical failures. Trucks are not typically inspected for mechanical faults as part of crash investigations, so only the most obvious vehicle failures are captured in the crash data. Even so, a study of truck crash causes on federal roads identified mechanical failure as the cause in 8.2 percent of the crashes.[8] In general, there does not seem to be a culture of preventive maintenance in Brazil. One researcher who had studied the subject characterized the common attitude as repairing the vehicle only after a part fails. Brake defects are reported in about 20 percent of inspected trucks.[12]

In addition, in spite of generous size-and-weight provisions, it has been reported that 60 percent of trucks in crashes are overloaded, and that 20 percent of trucks that pass by weigh stations are overloaded. Overloading has been identified as a major cause of truck crashes. Excessive gross vehicle weight is associated with mechanical failures of the trucks and loss of control. This is exacerbated by lax driver training and licensing requirements. Drivers are often trained on medium duty trucks, but then assigned to drive more complex and demanding vehicles with multiple trailers. It is not surprising that truck rollover in crashes is identified in over 20 percent of fatal crashes, and also considered to be a primary safety problem.

Finally, several sources noted that addressing truck safety issues is hindered by uncoordinated and inconsistent data systems. Crash data reside within multiple agencies and levels of jurisdiction, depending on the agency that has responsibility for the road system. There does not seem to be any central national crash data system that covers all roads and crash severities. Aggregating data from different systems can be difficult, because of inconsistencies between the crash data systems. For example, only on-scene fatalities are counted by DENATRAN while the Ministry of Health includes fatalities that occur within a fixed period after the crash. The primary insurance organization includes still more fatalities, counting the number of traffic fatalities for which insurance compensation is paid. The lack of a uniform, national crash data system impedes systematic data analysis to identify and address the most significant traffic safety issues. [See, e.g., 4, 8, 12, 16, 17.]

3. China

3.1 Vehicle population and demographics

Truck safety in China must be understood in terms of the rapid economic development and other changes over the past decades. From 1980 to 2005, reported GDP increased at an average growth rate of 10 percent annually. The total population grew by 30 percent, while the urban population tripled as people moved from rural areas to the cities. Along with the rapid economic development, the number of motor vehicles increased by 18 times, while the number of drivers increased by 33 times.[18, 22]

More recently, the number of registered passenger vehicles has continued to grow rapidly, while the number of trucks has grown at a more moderate pace. Figure 3 shows that the number of passenger vehicles, which may include buses (the source does not specify), grew from about 42 million in 2005 to almost 100 million in 2009. The number of passenger vehicles is projected to reach 143 million in 2020. If this total is reached, the number of passenger vehicles will have grown by 100 million in just 15 years.[23] Meanwhile, the number of trucks grew from about 20 million in 2005 to about 30 million in 2009. Motorcycle registrations are not shown in the figure, but one estimate put the total at almost 75 million in 2005, projected to reach almost 120 million in 2020.

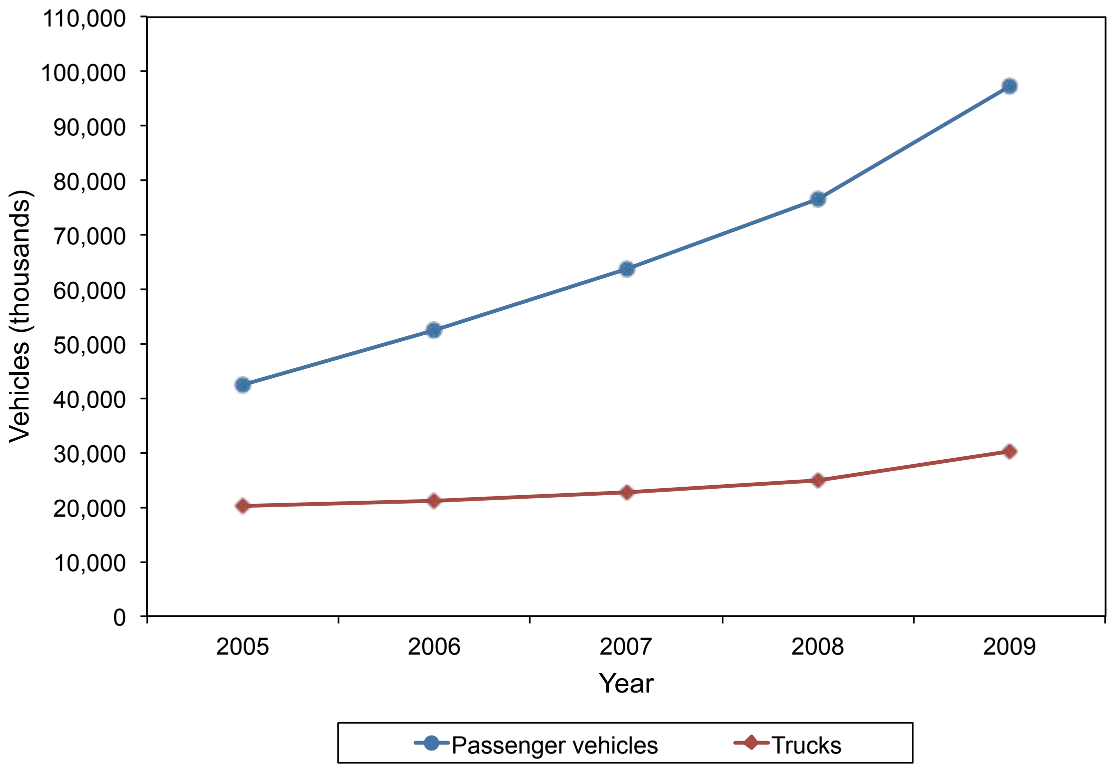

Figure 3. Registered Passenger Vehicles and Trucks in China, 2005-2009. Adapted from [22].

The *China Statistical Yearbook, 2010,* which is the source of the statistics shown in Figure 3, shows registrations for highway transport, private vehicles, and civil vehicles. Trucks classified as private or civil are distinguished as heavy, medium, light, and mini, while the highway transport vehicles are not further subdivided, but would be expected to be primarily heavy. All types of trucks are represented in the figure. However, medium and heavy trucks better represent the vehicles typically considered to be trucks around the world, that is, transport vehicles with a gross vehicle weight of 10,000 lbs. or more. In China, medium and heavy trucks represent about 55 to 60 percent of the vehicles deemed trucks in the figure above. Most of the other vehicles are light-duty trucks, probably the equivalent of small pickups in the US. Considering only vehicles that are most likely equivalent to trucks in the US and elsewhere, like the rest of the vehicle population in China, the number of medium and heavy trucks has shown rapid growth in recent years, increasing from about 11.7 million in 2005, to 17.2 million in 2009, an annual growth rate of about 10 percent.

Table 11
Registered Heavy, Medium, and Highway Business Transport Trucks.

Year	N
2005	11,723,895
2006	12,229,395
2007	12,940,246
2008	14,004,911
2009	17,221,698

Adapted from [22].

The larger point is the nature of the traffic stream in which trucks operate in China. This cannot be ascertained directly, but the registration data clearly indicate that the dominant type of motor vehicles on the road are motorcycles, with a rapidly increasing share of passenger vehicles (primarily private automobiles). At the current rate of growth, the number of cars will overtake motorcycles in about 2014. In contrast, the number of trucks is growing at a lower rate. The share of trucks in the motor vehicle population is about 9 percent. This is larger than in more developed countries and, based on current trends, that share of the overall motor vehicle population will move closer to countries like the US. However, for the next decades, most of the vehicles around trucks in the traffic stream will be motorcycles. This will be less true on high-speed, intercity roads where trucks tend to operate, but the traffic stream and related safety problem for trucks is quite different in China than in the US and Australia. China has a much larger share of the most vulnerable road users.

Total highway mileage was reported at 1.931 million km (1.2 million miles). The first expressway (limited access multilane roads) was an 18.5 km road opened in 1988 near Shanghai. By 2005, there were 41,005 km of expressways in the country, with plans to increase the network to 85,000 km (52,800 miles) by 2040.[18] However, by some accounts, the overall quality of the road infrastructure needs improvement, with poor quality roadways, and inadequate signage to support safe travel.[19, 23]

Even after 30 years of growth in highway mileage and in the number of vehicles, freight transport remains dominated by the rail and water-borne modes. Table 12 shows the distribution of the share of freight transport across the primary modes. Rail and water combine to account for 85 to 90 percent of freight ton/kilometers across the period. Highway transport, which is primarily by truck, ranges from 6.4 percent in 2005 to 13.8 percent in 2000, though it is noteworthy that the highway share is basically flat from 1990 to 2000, and actually declined by three percentage points in 2005. On the other hand, the rail share declined consistently over the period (as did pipeline, though small throughout), while the share of freight transported by waterway significantly increased, from 42.0 percent to almost 62 percent in 2005. Freight transport share is measured in ton/kilometers, which probably favors heavy, low-value freight (such as coal), rather than value. It would be useful to see if the truck share of freight measured by value is in the same direction. In the US, rail increasingly dominates the transport of bulky, low-value freight, while trucking captures the largest share of freight measured by the value of the commodities shipped.

Table 12
Modal Shares (Percent) of Freight Transport by Year [18].

Year	Railway	Highway	Waterway	Civil aviation	Pipeline
1980	47.5	6.4	42.0	0.0	4.1
1985	44.2	10.4	42.1	0.0	3.3
1990	40.5	12.8	44.2	0.0	2.4
1995	36.3	13.1	48.9	0.1	1.6
2000	31.1	13.8	53.6	0.1	1.4
2005	25.8	10.8	61.9	0.1	1.4

Note: freight transport measured in ton/kilometers.

Data challenges. The availability of useful and comprehensive data to evaluate traffic safety conditions in China is limited. This is no doubt in part a reflection that China is a rapidly developing country. As such, it does not have mature and long-standing institutions to compile and make available to researchers data on crashes, vehicles, drivers, the roadway system, and the other elements that can be used to identify the nature of traffic safety problems. As one document scoping the traffic safety problem in China put it, China is becoming an automotive society, and making that transition in a very compressed time frame, relative to more developed societies. As such, it is rapidly acquiring and developing the transport technology and infrastructure, while the institutional structures and cultural attitudes have not caught up.[19]

Overall, very few transport agencies have traffic safety departments, and the expertise to analyze traffic safety data is undeveloped.[19] In terms of the agencies responsible for traffic safety, the Ministry of Public Security deals with traffic accidents; the Ministry of Communications is responsible for the planning, construction, operation, and maintenance of intercity highways; and the Ministry of Construction oversees urban roads.

At the same time, there are certain institutional barriers. In certain critical areas, particularly crash data itself, there is little transparency. Crash data files that are available in other countries for analysis simply are not available in China. The Ministry of Public Security maintains and compiles crash records. This Ministry is not tasked primarily with traffic safety administration, but instead is the nexus in the Chinese central government for all aspects of public security, including the suppression of crime and terrorism; border security; regulation of public rallies and demonstrations; regulation of internet activities; supervision of security within government organs as well as social organizations and enterprises; as well as other security-related responsibilities. In addition, the Ministry is charged with traffic safety as a police matter.[24] The Ministry issues annual reports with aggregate traffic crash statistics, but does not release the underlying data files for more detailed analysis.

Certain contradictions may present impediments to achieving accurate data. Public security bureaus are evaluated in part on the number of fatalities reported, so there may be an incentive to underreport. In the run up to the 2008 Olympics, campaigns were announced to address traffic safety. A State Council was organized in 2003 to coordinate the activities of the Ministries of Public Security, Communication, and Construction.[20] The official annual total of fatalities in China, which rose with only one year of decline from 22,000 in 1980 to 107,000 in 2004. Thereafter, the number declined in each subsequent year to about 68,000 in 2009.[19, 21]

There is some concern about the accuracy and comprehensiveness of the aggregate statistics that are released. A recent paper in *The Lancet* reported that World Health Organization models suggest that the reported number of traffic fatalities in China is less than half of the true number. One WHO study (cited in the *Lancet* report) estimated 224,000 annual traffic deaths, far above the number officially reported. Another WHO study showed that traffic fatalities reported by the Ministry of Public Safety was less than half that derived from death certificates maintained by the Ministry of Health.[25, 26]

In this context, it is probably most reasonable to regard aggregate statistics as incomplete, with significant missing data. It is not known if the missing data significantly biases conclusions in specific areas, like truck traffic safety. Most of the resources used in this review are based on local, investigative studies of specific issues in specific areas. Taken together, they probably reasonably reflect the truck safety situation. In this report, we review the results from a range of these studies that reflect on aspects of the truck safety problem. The goal is to piece together a view of truck safety in China, to identify the primary areas that have been addressed in the existing literature.

3.2 Crash statistics

Table 13 shows a percentage distribution of traffic fatalities in China by the type of road user. Two primary observations may be made. The first is the dominance of pedestrians and nonmotorized vehicle users. Their share ranged from about 44 to about 48 percent of fatalities in traffic accidents over the period. Motor vehicle passengers comprise the next largest group, with about a quarter of deaths, followed by motorcycle drivers with about 20 to 24 percent. Truck drivers and passenger vehicle drivers account for the lowest percentages with about 4 to 5 percent each over the period. The largest share of the traffic safety problem, at least in terms of fatalities, consists of pedestrians, bicyclists, and other nonmotorized vehicle users (tricycles, animal-pulled carts, and so on). This is characteristic of a society entering the automotive stage, where such vulnerable road users are intermingled with powered vehicles. Note also the large share accounted for by motorcycles, which are also highly vulnerable in collisions with passenger cars and trucks. The passenger category probably includes a number of motorcycle passengers,[1] so the share accounted for by motorbikes is likely underestimated here. Finally, the shares accounted for by truck drivers and passenger vehicle drivers is roughly equal. Truck drivers are much less likely to be killed in a fatal crash, compared with occupants of passenger vehicles, but trucks are relatively a larger share of the traffic stream in China than elsewhere.

Table 13
Percentage Distribution of Fatalities by Road-User Type, China, 2000-2005.

Crash year	Pedestrians and nonmotorized vehicle users	Passengers	Motorcycle drivers	Truck drivers	Passenger vehicle drivers
2000	47.5	25.2	19.4	4.2	3.7
2001	47.2	24.5	20.1	4.0	4.1
2002	45.2	25.0	21.1	4.2	4.4
2004*	44.6	22.7	23.1	4.5	5.1
2005	43.8	22.3	24.1	4.4	5.4

* Data for 2003 were not available.
Adapted from [28].

The other thing to note is how the shares of different road-user types changed over the period. The percentage of pedestrians and bicyclists declined, while the shares of motorcycle and passenger vehicle drivers both increased. This reflects the increasing motorization of Chinese mobility, as well as the continued dominance of motorcycles, even though passenger-car ownership is increasing rapidly. Motorcycles are still the primary means of motorized mobility. On the other hand, the truck driver proportion of fatalities has remained relatively stable, possibly increasing only slightly. Though the number of trucks in China is increasing rapidly as the economy develops, the traffic stream around them changes even more dramatically.

Pedestrians and other nonmotorists are the primary traffic safety problem overall. Table 14 shows the distribution of the types of vehicles involved in pedestrian fatalities. The fatality data are from Changsha City in Hunan Province, drawn from police data and

[1] The data are categorized among motor vehicle drivers, motor vehicle passengers, and pedestrians and nonmotor vehicle users, so motorcycle passengers would logically be classified as passengers in this categorization.

hospital records, as reported in [32]. Most nonmotorists are killed in collisions with cars and motorcycles, but in these data, 16 percent were struck by trucks. The registration data are from [22] and are for Hunan Province. Note the percentage of trucks among the striking vehicle types is somewhat lower than the truck share of registrations, which may be related to the fact that many cities restrict truck entry to evening and nighttime hours, while most pedestrian travel is during the day.

Table 14
Pedestrian Fatalities by Striking Vehicle Type, Changsha City.

<table>
<tr><th>Vehicle type</th><th>% of pedestrian fatalities</th><th>% registered vehicles</th></tr>
<tr><td>Car</td><td>52</td><td rowspan="3">79.6</td></tr>
<tr><td>Bus</td><td>9</td></tr>
<tr><td>Motorcycle</td><td>22</td></tr>
<tr><td>Bike</td><td>1</td><td>n/a</td></tr>
<tr><td>Truck</td><td>16</td><td>19.8</td></tr>
</table>

Adapted from [32] and [22].

As would be expected, trucks account for a disproportionate share of fatal crashes. In one study, trucks were about 20 percent of the vehicles in crashes of all severities, but 30 percent of the vehicles in fatal crashes, and it appears this trend is increasing.[33] The share of trucks in fatal and all crashes in China is about four times higher than in the US. This may reflect the fact that truck transport is significantly less safe in China, but it is probably also because trucks are a much greater share of the traffic stream in China.

Another study of crashes over three years on a freeway in northern China identified a significant overinvolvement of heavy trucks in traffic crashes. (See Table 15.) The “heavy vehicle” category here is defined as cargo-carrying vehicles with a gross weight of four tons or more. This is comparable to the customary definition of a truck used internationally. The “car” vehicle type includes passenger vehicles with seating for 11 or fewer, so it may include small buses. The “light vehicle” type is defined to include small trucks (pickup size or smaller) and some small van-type buses, and may include motorcycles. “Heavy vehicles” account for almost 54 percent of the vehicles in these traffic crashes, which is an enormous share, particularly since, nationally, trucks are only about 9 percent of registered vehicles. The distribution of registered vehicles was also given, as a control. Note that the proportion of trucks is given as 31.9 percent, which is much higher than the national average, but this may be representative of the provincial proportion, which may be more rural and industrial. Even so, heavy trucks are overrepresented in the crashes, and light vehicles are underrepresented. Without exposure (travel) data, it cannot be determined if this is a reflection of exposure on the highway, or a difference in crash risk. Trucks tend to accumulate more miles on higher-speed roads than other vehicle types, so one would expect a higher proportion of trucks in the crash population on freeways. On the other hand, if light vehicles include motorcycles, they probably are used more on local, lower-speed roads, with relatively fewer kilometers on freeways.[31]

Table 15
Distribution of Vehicle Type in Traffic Crashes, Freeway Road Type, Northern China.

Auto-vehicle type	Crash involvements	%	% registrations
Cars	194	35.4	35.4
Heavy vehicles	294	53.6	31.9
Light vehicles	29	5.3	19.0
Buses	20	3.7	7.9
Others	11	2.0	5.8
Total	***548***	***100.0***	***100.0***

Adapted from [31].

Table 16 shows the type of other vehicle in the truck crashes in the set of freeway crashes analyzed. The data include an estimate of crash losses, measured in renminbi (Yuan). Collisions with other heavy trucks account for most of the fatal and nonfatal injuries in the truck crashes in this sample. Single-vehicle crashes, which probably include rollover and collisions with fixed objects such as bridges abutments and other roadside furniture, account for the second-highest costs. Crashes involving heavy vehicles accounted for 60 percent of fatal injuries, 60 percent of other injuries, and over two-thirds of property damage. The authors of the study concluded that heavy vehicles are the primary target for improving safety on the highways.

Table 16
Other Vehicle Type, Truck Crashes, Freeway Road Type, Northern China.

Type of other vehicle	Fatalities	Injuries	Accidents losses (RMB￥)	%
With heavy vehicles	74	191	6,767,640	45.7
With passenger cars (buses)	0	1	222,190	1.5
With light vehicles	1	3	171,705	1.2
With cars	13	74	1,982,547	13.4
Single accidents	2	11	3,180,099	21.5
Others	36	56	2,500,676	16.9
Total	***126***	***336***	***14,824,857***	***100.0***

Adapted from [31].

The primary causes of truck crashes identified in the safety literature are overloading, inattentive driving, speed differential between vehicles, moving violations, and following too closely. With respect to overloading, one study reported that most trucks were loaded one to three times more than the design limits, with some loaded up to six times their designed capacity. Overloading makes the trucks more difficult to control, take longer to get up to speed, more difficult to maintain a safe speed, and take much greater distances to stop. Some vehicles were so heavily loaded they were unable to achieve a speed of 10 kph, even under free-flow conditions.[31, 33]

Driver inattention includes both fatigue and distraction. Fatigue was also related to overloading, as a secondary effect. Grossly overloaded vehicles can only attain slow speeds, and require more hours of travel. In addition, it is alleged that in many cases the owners of the goods being transported ride along with the load and prevent the driver from stopping for rest, in order to get the goods delivered. Speed differential between vehicles is also related to overloading; speed differential in the traffic stream is identified as a major reason for truck/car collisions. The 85th percentile speed for cars was 100.5 kph, while for trucks it was 68 kph.[31]

The primary driving violation identified was trucks occupying the passing lane excessively. Since trucks run at slower speeds, and have less acceleration and deceleration (exacerbated by overloading), they pass more slowly and impeded traffic longer, which sometimes prompts drivers of light vehicles to attempt dangerous and illegal passing maneuvers. The authors also indicate that excessively short following distances are common, particularly for heavy trucks.[31]

3.3 Truck safety issues

More than in the other countries examined here, truck traffic safety issues are approached and evaluated in the context of the whole system, and in the context of a rapidly developing motor culture, rather than being considered in isolation. China is undergoing rapid economic development and making the transition to an automotive society. It is experiencing enormous growth in infrastructure, the number of drivers, and motor vehicles of all types. At the same time, it is developing the regulatory and enforcement structure to produce safer drivers, vehicles, and roadways. In short, there is a consciously comprehensive approach to improving traffic safety, which cuts across all aspects of the developing traffic system.

The government has emphasized increasing safety in recent years, but one expert says that there needs to be a fundament shift in basic thinking. He urges that the emphasis should change from blaming road users to addressing all aspects of the traffic environment, including vehicle design, to make vehicles safer and more crashworthy; roadway engineering and design, to make the roadways more accommodating and supportive of safe travel; and emergency medical services, to improve the timeliness and effectiveness of postcrash care.[29]

Another author emphasized that improved traffic-safety data will provide the critical foundation to efforts to reduce the toll of traffic crashes. The first step is to "remove the responsibility for the number of traffic fatalities from the evaluation indices for local officials, in order to avoid underreporting the number of traffic fatalities." The problem is probably particularly acute in rural areas. He called for the implementation of a road-accident investigation system, with proper training for police officers, and the ability to link records with hospitals and insurance records to cross-check the data.[19]

The rapid growth of car ownership has resulted in a steep increase in the number of drivers, which means that a large share of passenger-car drivers are inexperienced. By one reckoning, almost 10 percent of drivers had less than one year of driving experience, 37 percent with less than three years.[29] It is acknowledged that the culture of safety is not well developed. Jaywalking, speeding, and drunk driving are reported as common.[19] One Chinese source observed that since new drivers started on bicycles, they tend to drive in the same way (without regard to traffic controls) as they did on their bikes.[23]

The primary safety problems identified in the literature that relate specifically to trucks include:

- Overloading
- Driver errors, including speeding and following too close
- Driver fatigue and distraction
- Poor mechanical condition of trucks, particularly brakes
- Roadway design that fails to accommodate trucks

Overloading is commonly identified as a primary factor in truck crashes. Reports estimate that 70 to 90 percent of truck crashes are related to overloaded and oversized trucks. The authorities have launched numerous programs to address the problem. One source reported a 2004 campaign to “rectify” overloading. The rate of overloaded trucks was reduced reportedly from 80 percent to about 10 percent. Whether these numbers are accurate cannot be independently confirmed, but they do indicate the perception that truck overloading is a safety issue and that steps were taken to reduce it through enforcement.[19, 20, 29]

Overloading is thought to be common partly because of high tolls on certain roadways. Tolls are so high that trips are only profitable if trucks run overloaded. But, as discussed above, overloading makes vehicles more difficult to control, increases stopping distances and the risk of rollover, and contributes to brake failure. In one 57 km section of highway, in 2002, over 100 overloaded trucks experienced brake failure and had to use escape ramps. In addition, overloading trucks contributes to premature wear of roadways and has been blamed for the catastrophic failure of bridges. The Ministry of Communication, along with eight other ministries set up an intragovernmental working group to reduce overloading. Methods to address this issue includes publicizing the problem, enforcing current law, "standardiz[ing] vehicle manufacturing and refitting," properly labeling trucks with load limits, and lowering road tolls.[30, 33]

Driver fatigue and distraction are not well-measured in the crash data, but are considered to be a primary crash cause, often in the context of overloading. Significantly overloaded trucks can proceed only slowly, keeping the driver on the road longer and contributing to fatigue. In addition, as mentioned above, shippers will ride along, keeping the driver going without regard to rest. Other related driver problems include speeding, failure to yield, and following too close.[18, 31, 33]

By some reckonings, mechanical failure accounts for the second largest share of truck crashes (after driver error), and brake failure is the primary mode. In addition, efforts are being made to improve the training and supervision of drivers, to address the poor mechanical condition of trucks through increased inspection and meaningful penalties, to improve the inherent safety of trucks by requiring antilock braking systems, tire-pressure monitoring systems, engine retarders, and radial tires.[29, 33]

Roadway design, signage, and maintenance are also identified as safety problems with respect to trucks. Roadway design and signage are said to be lacking or intended for passenger cars, not trucks. Many roads have sharp turns (which are difficult for a truck to negotiate), steep grades, poor sight distances, and sections with narrow or no shoulders. A program was initiated to address 250,000 "dangerous spots" and 80,000 km. of roads were reconstructed or otherwise improved. The safety goal was to reduce 100,000 crashes and to save 5,000 lives annually.[29, 31]

Finally, one truck manufacturer identified both the cabover cabstyle and rear-end underride as primary truck safety problems. In one study, cabovers were shown to have a nearly eight times greater fatality rate than conventional cabs. Cabovers are cheaper to manufacture and more common but the flat front of cabovers offers relatively little protection to the truck driver compared with conventional cabs.[33]

Underride is an issue for other road users. It might be expected to have a higher profile, given the traffic mix in China, which has a large share of motorcycles and an explosively increasing share of passenger cars. However, heavy-truck aggressivity as such is not a high priority, though possibly it is subsumed in the overloading issue. Even so, China is adopting underride-guard requirements that follow European standards. A government review of road safety identified standards to address head-on and side collisions with heavy trucks as a priority.[18, 33]

4. Australia

4.1 Vehicle fleet and truck demographics

The distribution of motor vehicle types in Australia is more similar to the distribution found in US than in Brazil or China. Light vehicles, chiefly passenger cars, make up a very high percentage of vehicles, accounting for more than three-quarters of all vehicle registrations. Light commercial vehicles, essentially small vans and pickup trucks, make up about 15 percent of the vehicles. Trucks, on the other hand, are only about 3.3 percent of vehicles, about the same proportion as motorcycles. (Please see Table 17.) Trucks are classified as either "articulated" or "rigid." An articulated trucks consists of a tractor (*prime mover*) pulling one or more trailers attached to the tractor by means of a fifth wheel (called a *turntable* in Australia). This includes everything from a tractor-semitrailer to a road train. The rigid truck type consists primarily of power units (prime movers) that have a permanently attached cargo body or working body. In the US, these are often called straight trucks or single-unit trucks. Typically, the rigid-truck classification in Australia also includes rigid trucks pulling a trailer, which is accomplished by means of a drawbar or other hitch (other than a turntable). This grouping of truck configurations is typically used also in Australian crash data.

Table 17
Registrations by Vehicle Type, Australia 2005 & 2010.

Vehicle type	2005		2010	
	N	%	N	%
Passenger vehicles	10,896,410	78.3	12,269,305	76.4
Campervans	40,693	0.3	48,504	0.3
Light commercial vehicles	2,030,254	14.6	2,460,568	15.3
Rigid trucks	368,520	2.6	431,278	2.7
Articulated trucks	69,723	0.5	82,436	0.5
Non-freight carrying trucks	19,962	0.1	22,367	0.1
Buses	72,620	0.5	86,367	0.5
Motorcycles	421,923	3.0	660,107	4.1
Total	***13,920,105***	***100.0***	***16,060,932***	***100.0***

Adapted from [34].

The domestic freight task grew by about eight times in the 40 years between 1961 and 2007, and it is expected to double again between 2010 and 2030. The primary modes are rail, road, sea, and air. Air accounts for a negligible share of freight transport. The growth in rail freight is largely related to export of minerals, chiefly iron ore and coal. Marine shipping carriers also transport bulk commodities around the coast for further processing; road transport predominates for urban and intercity and regional freight, as well as container transport for export. The road-freight task increased by about six times over the period from 1971 to 2008, growing at a faster rate than rail or sea in the period. At the same time, there were significant changes in the shape of the truck fleet. Freight increasingly shifted from rigid trucks to articulated trucks. Because new and larger trucks were permitted to operate on the roads, the average load allowed more than doubled.[35]

Table 18
Percentage Share by Transport Mode (measured by tonne[2]-kilometers), Australia 1961 & 2008.

Mode	1961	2008
Rail	24	41
Road	20	35
Sea	56	24
Air	<0.1	<0.1

Adapted from [35].

The shape of the truck fleet is different from the US. The Australian fleet includes certain types of three and four trailer combinations that are not generally found elsewhere. These high productivity vehicles are allowed under a Performance Based Standards (PBS) regime and restricted to the PBS network of roads. In the PBS regime, standards specify safe performance requirements rather than specific designs. Double trailer trucks can be over 120 feet long, triples over 108 feet. Australia allows very large, so-called road trains, that can have up to four trailers, over 175 feet long and 148 tonnes (360,000 lbs.), but these vehicles are restricted to certain road systems in remote areas such as the Northwest Territories. In most areas, trucks are limited to two trailers, combination about 26 m (85 feet), grossing 62.5 tonnes (about 138,000 lbs.). Most tractor-semitrailers have three axles on the trailer and are limited to 41 tonnes (about 90,000 lbs.).

The B-double is increasingly the workhorse freight truck. A B-double consists of a tractor and two trailers. The first trailer is joined to the tractor by means of a fifth-wheel, just like in a US double combination. But what makes it a B-train is that the first trailer has a fifth wheel mounted over the rear axles, so that the second trailer also connects to a fifth wheel. Up to 1998, 60 percent of freight was transported by single-trailer combinations. B-doubles were introduced in late 1980s, and in by 2007, about 32 percent of freight was hauled in B-doubles. B-doubles are now the dominant type, though about 30 percent for of trucks are single-trailer combinations. Road trains carry about 17 percent of freight. “Rigid trucks” carry about 20 percent.[35]

[2] Metric ton; 1000 kilograms.

4.2 Crash statistics

In recent years, there has been an average of about 1,380 fatal traffic crashes in Australia, though the trend has been steadily down, with 1,472 in 2005, decreasing to 1,248 in 2010. (See Table 19.) The number of fatal crashes involving truck has also declined, from 219 in 2005 to 195 in both 2009 and 2010. Overall, truck fatal crashes account for about 15 percent of all fatal crashes in Australia, and this percentage has remained fairly consistent over that period. In the aggregate fatal crash data compiled by BITRE, trucks are classified as articulated and rigid. About two-thirds of the trucks involved in fatal crashes in Australia are articulated vehicles and about one-third are rigid vehicles. This split is similar to that in the US.

Table 19
Fatal Crashes by Type of Truck Involved, Australia 2005-2010.

Year	Truck involved			No truck involved	All
	Articulated	Rigid	Total truck		
2005	132	87	219	1,253	1,472
2006	145	66	211	1,241	1,452
2007	147	77	224	1,229	1,453
2008	129	91	220	1,095	1,315
2009	117	78	195	1,151	1,346
2010	127	68	195	1,053	1,248
Percentage by year					
2005	9.0	5.9	14.9	85.1	100.0
2006	10.0	4.5	14.5	85.5	100.0
2007	10.1	5.3	15.4	84.6	100.0
2008	9.8	6.9	16.7	83.3	100.0
2009	8.7	5.8	14.5	85.5	100.0
2010	10.2	5.4	15.6	84.4	100.0

Adapted from [38].

The number of fatalities in traffic crashes has also declined, at least considering the crashes of all vehicle types. In 2005, a total of 1,608 people were killed in traffic accidents in Australia, which declined to 1,380 in 2010. (Table 20.) However, the number of fatalities in truck crashes varied fairly widely, from 235 in 2005, increasing to 272 in 2008, then declining to 216 in 2009 (during the world-wide financial crisis), and then increasing again to 237 in 2010. As in the case of fatal crashes, articulated trucks accounted for about two-thirds of the fatalities and rigid trucks one-third. Overall, about 16 percent of traffic fatalities, ranging from 15 to 18 percent, occur in crashes involving trucks. About 10 percent involve articulated vehicles and 6 percent involve rigid trucks. Crash rates are not available for specific truck configuration types.

Table 20
Fatalities by Type of Truck Involved, Australia 2005-2010.

Year	Articulated	Rigid	Total truck	No truck involved	Total
2005	138	97	235	1,373	1,608
2006	181	73	254	1,348	1,602
2007	162	84	246	1,351	1,597
2008	174	98	272	1,208	1,480
2009	135	81	216	1,275	1,491
2010	153	84	237	1,143	1,380
	Percentage by year				
2005	8.6	6.0	14.6	85.4	100.0
2006	11.3	4.6	15.9	84.1	100.0
2007	10.1	5.3	15.4	84.6	100.0
2008	11.8	6.6	18.4	81.6	100.0
2009	9.1	5.4	14.5	85.5	100.0
2010	11.1	6.1	17.2	82.8	100.0

Adapted from [38].

Table 21 shows the average number of deaths by road-user type in traffic crashes with rigid or articulated trucks. The fatalities are divided between light vehicles, heavy vehicles (meaning a rigid or articulated truck), and pedestrians, which includes all non-motorists. The data in the table are annual averages for 2004-2008. Single-vehicle crashes as defined here do not include another road user, so deaths in single-vehicle crashes are to truck occupants. Almost 18 percent of fatalities in articulated truck crashes occurred to truck occupants, almost always the driver. This proportion was much lower in fatal crashes involving rigid trucks, at 9.4 percent. The numbers are small, but it is likely that, for operational reasons, rigid trucks are involved in fewer single-vehicle crashes.

Table 21
Average Number of Deaths by Road-User Type in Truck Crashes, Averaged over 2004-2008.

Crash type	Rigid truck involved		Articulated truck involved		Total	
	N	%	N	%	N	%
Single vehicle	8.8	9.4	27.0	17.8	35.8	14.6
Occupant light vehicle	63.0	67.5	95.2	62.6	158.2	64.5
Occupant heavy vehicle	7.4	7.9	13.2	8.7	20.6	8.4
Pedestrian/non-motorist	14.2	15.2	16.6	10.9	30.8	12.6
Total	***93.4***	***100.0***	***152.0***	***100.0***	***245.4***	***100.0***

Adapted from [39].

It does not appear that either pedestrians or motorcyclists are overinvolved in fatal crashes with trucks, but there may be some overinvolvement with bicyclists. Table 22 shows the distribution of fatal injuries by road-user type for crashes involving a rigid truck, an articulated truck, and all crashes, with any vehicle type (including no trucks). The data are limited to 2010 crashes. The share of pedestrians is about the same for rigid trucks, articulated trucks, and all crashes. On the other hand, the share of motorcyclists in rigid truck crashes is much greater than for articulated trucks, but only slightly lower than for all crashes. With respect to bicyclists, their proportion of fatalities is greatest in crashes involving rigid trucks and lowest for crashes involving articulated trucks. It is likely that operational factors account for these differences. Rigid trucks are used more often on lower speed roads in urban areas, and probably encounter motorcyclists and bicyclists more often than articulated trucks.

Table 22
Fatalities by Person Type in Crashes with Trucks and All Crashes, Australia 2010.

Road-user type	Rigid truck involved		Articulated truck involved		All crash	
	N	%	N	%	N	%
Drivers *	44	54.3	90	62.5	645	47.2
Passengers *	10	12.3	28	19.4	284	20.8
Pedestrians	11	13.6	20	13.9	174	12.7
Motorcyclists	11	13.6	4	2.8	224	16.4
Bicyclists	5	6.2	2	1.4	39	2.9
Total	***81***	***100.0***	***144***	***100.0***	***1,366***	***100.0***

* Includes truck occupants.
Adapted from [38].

Truck crashes tend to occur during the work week: about 85 percent of fatal truck crashes occur Monday through Friday, and the percentage is higher for all truck crashes (89 percent). Figure 4 shows the distribution for New South Wales, averaged over the period 2008 through 2010. Fatal involvements are somewhat more likely on the weekend than nonfatal crashes, probably reflecting the involvement of articulated trucks operating in long haul (and therefore on higher speed roads) service. Rigid trucks are used more in urban, local service, during the work week. The greatest percentage of fatal involvements occur toward the end of the work week. Only about 10 percent of fatal involvements occur on Monday, compared to 16 percent of all truck crashes. The tendency of fatal crashes to increase toward the end of the week may reflect an increasing incidence of driver fatigue.

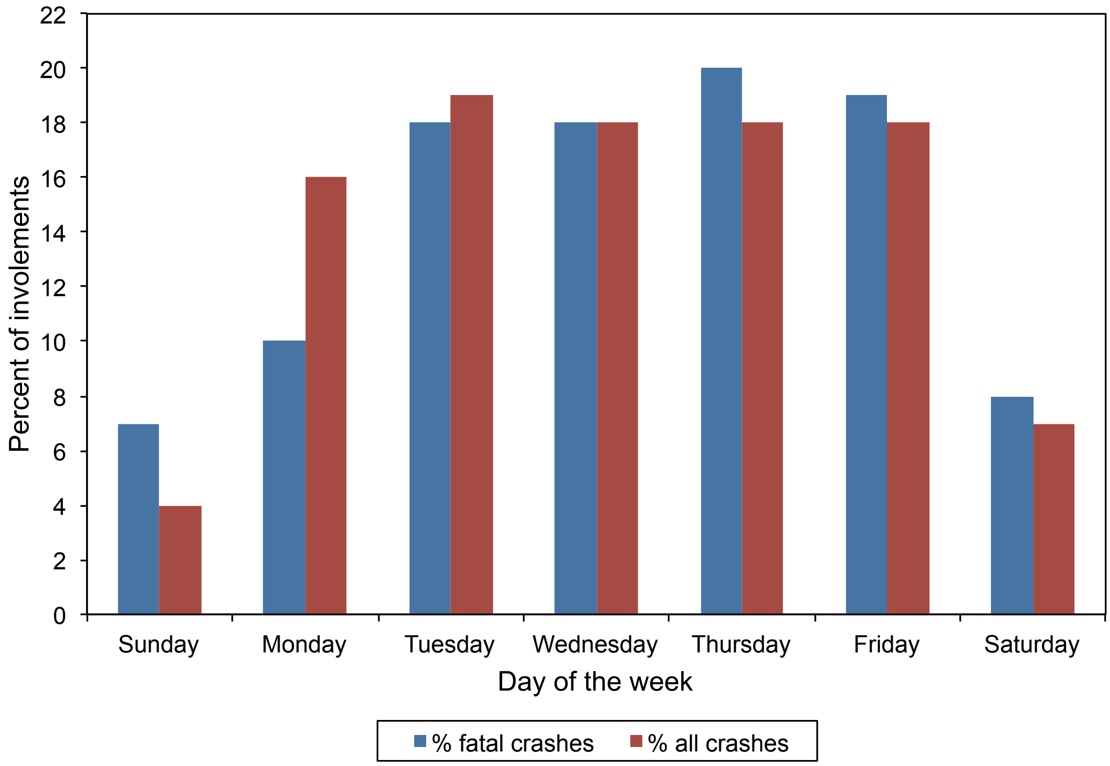

Figure 4. Truck Crashes by Day of Week, New South Wales. [43]

The majority of heavy-truck crashes occur during the normal work day, from 6 a.m. to 4 p.m., but the proportion of fatal truck crashes tends to be higher during evening and night hours than is the case for all crashes. In crash data reported from New South Wales, the proportion of fatal involvements was higher for every two-hour period from 6 p.m. to 6 a.m., with the largest difference between 4:00 a.m. and 6 a.m. About 11 percent of fatal truck crashes occurred in this period, compared with only about 5 percent of all truck crashes.[43] Nighttime driving is more likely to be long distance, on high speed roads, which increases the fatality risk, of course, but fatigue is also more likely to be a factor then. The greatest overrepresentation of fatal truck crashes compared with all crashes is in the early morning hours of Friday and Saturday.

Fatal truck crashes tend to be on high-speed roads, in rural areas, and, where another vehicle is involved, are most often head-on collisions. Heavy-truck single-vehicle crashes, particularly fatal crashes, tend to occur on road segments away from intersections and on curved road segments. One study of major incidents, defined as crashes with damages more than A$50,000 (Australian dollars) found that tractor-semitrailers tended to be overinvolved compared with B-doubles. The truck fleet in Australia increasingly is moving to the B-double configuration for long haul, so they tend to be newer, in better mechanical condition, and are inherently more stable.[40, 42, 43]

4.3 Truck safety issues

Australia shares many truck safety issues with other countries, and is in a strong position to address the issues. Crash data are fairly readily available for analysis. Nationally, fatal crash data are compiled and regularly published by agencies of the national government. Nonfatal data at the national level are less available, and are the province of the several states. However, at least two (New South Wales and Victoria) make their crash data available using web-browser tools that allow simple analysis by anyone with internet access. Several universities have very strong research truck safety research programs, and there is active research by the major truck-insurance company.

Truck crashes, along with crashes involving other vehicle types, have been declining in recent years. There is a commitment among national and state governments, a trucking industry association, and the major transport-insurance firm to continue the reduction. Strategy and policy documents identify the factors contributing to crashes and tend to be in agreement on the issues that need to be addressed.[47, 36]

Issues relating to drivers, vehicles, and roads have all been identified as targets for improving truck safety.

The driver issues include fatigue and other impaired driving, as well as speeding. The driver issues are often couched in terms of fitness for duty–insuring that the driver is rested, healthy, and unimpaired by drug use, through a combination of regulation and enforcement. In one study of major truck crashes, 10 percent involved driver fatigue. Speeding was a factor in 32 percent. These two factors were identified in almost 42 percent of the most severe (costs over A$50,000) truck crashes.[42] A review of 61 crashes in which a truck driver was fatally injured found one-sixth of the drivers tested positive for illegal drugs or stimulants. Almost three-quarters had a “significant medical condition” (e.g., high blood pressure, heart disease, diabetes). Over 36 percent were speeding and only about 40 percent were using seat belts. These findings were based on coroner’s inquest examinations.[44]

Alcohol was not a major factor: only one driver had a BAC over the legal limit. Alcohol tends not to be a significant issue for truck drivers in crashes, though illegal stimulants and drugs are more likely to be indicated. In random mandatory testing, 1.6 percent of truck drivers tested positive for illegal drugs, compared with 0.9 percent of the general population.[44] On the other hand, in the crash data of one state (New South Wales), 7.2 percent of car drivers in crashes tested positive for alcohol, compared with 1.2 percent of truck drivers.[41]

Both the Australian Trucking Association (an association of truck operators) and the Australian Transport Council (an alliance of state transport ministers) have identified truck-driver fatigue as a major issue.[36, 47] Each proposed a series of strategies, including enforcement, education, and shared responsibility. The current hours-of-service driving standard is a 15-minute break every 5.5 hours and no more than 12 hours driving in a 24-hour period, except for Western Australia, which requires a 10-minute break every 5 hours, and a 7-hour minimum sleep period in 24.[35] In addition, "chain of responsibility" laws have been enacted since 2005. These laws hold anyone with significant control over a transport operation accountable for violations of laws during the transport. For example, a shipper with a demanding delivery schedule may be held accountable if a driver exceeds hours of service or speed limits.

Additional speed enforcement, including speed limiters on trucks, is a complementary strategy. Speeding is often held to be caused by tight shipping schedules, so the "chain of responsibility" is one response there. In addition, speed limiters on trucks have been proposed. Certain states are taking other actions. In one innovative approach, NSW has implemented a point-to-point speed enforcement program to target heavy vehicles. On certain, well-publicized routes, cameras are used to identify specific vehicles along the route, and average speeds are calculated. If the truck traverses the road faster than consistent with the legal speed, violations are issued.[48]

The low rate of seat-belt use by truck drivers is also identified as an issue. As in other countries, truck drivers in Australia tend to use seat belts at much lower rates than other drivers. In one 1999 study, only 10 percent of fatally injured drivers were belted at the time of the crash. A more recent study of fatally injured truck drivers showed that only 41 percent were belted. Increasing rates of belt use among truck drivers is one of the strategic objectives of national regulatory bodies, and could reduce truck driver fatalities by one half.[40, 47]

In terms of vehicles, several strategies for improving the safety have been advanced. The first is the adoption of advanced technologies to help the driver avoid unsafe situations (such as speed limiters and adaptive cruise control); to warn of imminent conflicts (lane-departure warning, curve-speed warnings); or to help the driver control his vehicle (electronic braking, electronic stability control). In addition, load securement, overloading, and poor mechanical condition, particularly brakes, have been identified as factors in heavy-truck crashes. Strategies to address these factors include improved maintenance, education on the significance of these factors, and more rigorous roadside inspections.[34, 36, 46,47]

Vehicle design is also a target that is particularly salient given the relative aggressivity of trucks in collisions with light vehicles. Most fatalities and injuries in collisions with light vehicles occur in the light vehicles. Although pedestrian and bicycle crashes are not particularly overrepresented, they are a significant proportion of fatalities in truck crashes. Various strategic plans and overview evaluations of truck safety in Australia propose research and possible additional regulation to strengthen underride standards. Properly designed side underride guards are proposed to keep pedestrians and bicyclists from going under the wheels. Rear underride guards can help absorb some of the collision energy in rear-end crashes. Front underride is a major target because head-on collisions are the primary configuration in fatal crashes with light vehicles, though more difficult to address.[34, 36, 47]

Finally, improvements to the roadway system is another of the methods proposed to enhance the safety of heavy vehicles. Many of the roads in the more remote areas of Australia are not built to high standards, and may not be paved at all. About 60 percent of truck fatalities are said to occur in rural and remote parts of Australia. Accordingly, the Australian Road Research Board has called for improvements to the design and condition of roads, including sight distances, lane delineation, shoulders, and paving.[46] The Australian Trucking Association has proposed the installation of more rumble strips and rest stops to help address the driver fatigue issue.[36]

5. United States

5.1 Vehicle population and share of freight transport

In the US, trucks are generally defined as cargo or work vehicles with a GVWR greater than 10,000 pounds. Pickups are colloquially termed trucks, but only those meeting the specified GVWR threshold are included as trucks in this analysis. Trucks with a GVWR between 10,000 pounds and 26,000 pounds are classed conventionally as medium trucks, and those with a GVWR over 26,000 pounds are classed as heavy trucks. This corresponds roughly with the terminology in most countries.

The motor-vehicle fleet in the US consists predominantly of passenger vehicles and other light-duty vehicles, which include pickup trucks, minivans, sport utility vehicles, and the like. Trucks make up only a small share of the fleet. Light-duty vehicles account for over 96 percent of the vehicles and 92 percent of the travel, while all types of trucks account for 3.5 percent of the vehicles (registrations), and 7.5 percent of the travel (Table 23). In the table, single-unit and combination trucks are distinguished. In a single-unit truck, the cargo body is mounted to the frame of the vehicle itself; it is not pulling a trailer. Combination trucks are mostly truck tractors pulling one or more trailers, though they also include a small number of single-unit trucks pulling trailers. In the US, most of these are medium-duty trucks pulling work-related trailers (like a landscaping contractor's equipment trailer), but some are heavy-duty trucks with heavy trailers, like a dump truck pulling a dump trailer. Single-unit trucks outnumber combination trucks by about 3 to 1, though combination trucks accumulate almost twice as many miles. As a result, the average vehicle-miles traveled (VMT) for combination vehicles is about 65,000 miles per year, while single-unit trucks average about 12,000 miles per year. Combination trucks, mostly tractor-semitrailers, are the workhorse of freight transport, hauling large quantities of freight over very long distances. Many of these vehicles average well over 100,000 miles per year.

Table 23
Motor Vehicle Fleet in the US, 2007.

Vehicle type		Registrations	%	VMT (millions)	%	Average VMT
Trucks	Single unit	6,806,630	2.7	81,954	2.7	12,040
	Combination	2,220,995	0.9	145,008	4.8	65,290
	Truck subtotal	*9,027,625*	*3.5*	*226,963*	*7.5*	*25,141*
Light vehicles	Pass. Car	135,932,930	53.4	1,670,994	55.2	12,293
	Other light vehicles	101,469,615	39.9	1,111,278	36.7	10,952
	Motorcycle	7,138,476	2.8	13,611	0.4	1,907
	Light vehicle subtotal	*244,541,021*	*96.1*	*2,795,883*	*92.3*	*11,433*
Bus		834,436	0.3	6,980	0.2	8,365
Total		***254,403,082***	***100.0***	***3,029,826***	***100.0***	***11,910***

Adapted from [49], Appendix D: truck profile, passenger car profile, bus profile.

Trucks are a lower proportion of the motor fleet population in the US compared with the other countries in this survey, primarily because the number of private passenger vehicles is so great. Note also the small share that motorcycles make of the motor-vehicle fleet, with only 2.8 percent of registered vehicles and only 0.4 percent of total VMT. This is in sharp contrast with Brazil and China, in which motorcycles are about 25 and over 70 percent of motor vehicles, respectively.

Trucking plays a dominant role in freight transport in the US, at least in terms of the value of the goods shipped and tons of goods shipped. Rail tends to transport heavy, low-value commodities (such as coal, ores, agricultural commodities) over long distances, so the rail share of freight flow measured by ton-miles is about the same as for trucks. Trucking, on the other hand, is ubiquitous in the freight transportation system, transporting high-value cargoes between nodes and then distributing them across the road network to retail stores and, increasingly, directly to homes through parcel delivery. Table 24 shows the distribution of freight transport in the US by transport mode in 2007. The table displays freight transport by value, tons, and ton-miles. Intermodal transport (particularly truck/rail and truck/water) has increased rapidly in the past decade, as freight transporters try to rationalize the freight-transport task in the face of rapidly growing demand. The freight-transport task as measured by ton-miles increased by over 25 percent between 1997 and 2007.[49]

Table 24
Freight Transportation by Mode, United States, 2007.

Mode	Value (billion $)	Tons (millions)	Ton-miles (billions)
Truck	8,335.8	8,778.7	1,342.1
Parcel, USPS or courier	1,561.9	33.9	28.0
Truck/other	245.6	371.1	295.2
Rail	436.4	1,861.3	1,344.0
Water	114.9	403.6	157.3
Air	252.3	3.6	4.5
Other/unknown	738.0	1,091.1	127.3
Total	***11,684.9***	***12,543.4***	***3,298.4***
Column percentages			
Truck	71.3	70.0	40.7
Parcel, USPS or courier	13.4	0.3	0.8
Truck/other	2.1	3.0	8.9
Rail	3.7	14.8	40.7
Water	1.0	3.2	4.8
Air	2.2	0.0	0.1
Other/unknown	6.3	8.7	3.9
Total	***100.0***	***100.0***	***100.0***

Adapted from [49], table 1-58.

The states set some of the rules that constrain truck size and weight through regulations that control the lengths, axle loads, and axle spacing that are allowed on state highways and roads. Federal laws govern gross weights and trailer configurations that are allowed on the Interstate Highway System and other highways in the National Network. On these highways, with some exceptions, trucks are permitted up to 80,000 pounds gross weight. States must allow trailers of 48 feet long, and for two-trailer combinations, minimum lengths of 28 feet each. Many states allow for longer trailers, and most trailers in tractor-semitrailer combinations run from 48 feet to about 57 feet. States can allow for heavier gross weights off the National Network, with most state maximum weights ranging from 80,000 up to 130,000 pounds, though Michigan allows vehicles with 11 axles to weigh up to 164,000 pounds, depending on axle spacing.

Most of the trucks in long-haul freight transport are tractor-semitrailers. These are typically three-axle tractors pulling a two-axle trailer. Doubles combinations are used mostly for long-distance transport on the interstate highway system. These trucks are typically a two-axle tractor pulling two 28-foot trailers, though some states allow what are called "turnpike doubles," which consist of two long (40-48 feet) trailers. Only a few states allow triples, which consist of three 28-foot trailers. Straight trucks are more often used as work vehicles or for short, interurban delivery trips.

5.2 Crash statistics

Trucks are more likely to be involved in fatal crashes, compared with other vehicles, though they are less likely to be involved in a traffic crash in the first place. Trucks account for 3.5 percent of registrations and 7.5 percent of total VMT, but only 3.7 percent of the vehicles involved in traffic crashes. However, trucks account for 8.3 percent of the vehicles in fatal crashes (Table 25). Since trucks are typically much heavier than other vehicles on the road, with frames that tend to be stiffer and higher than other vehicles, their crashes are more likely to be serious and the other vehicles in the crash to sustain the most damage. (The light trucks in Table 25 below include pickup trucks, vans, and other light-duty trucks.) On the other hand, the truck share of the vehicles in injury crashes is actually lower than their share of either registrations or VMT. Table 25 shows the distribution of the primary types of vehicles in crashes, by crash severity. (The data are averaged over five years of data, 2005-2009.) The truck share of property damage only (PDO) crashes is only slightly higher than their proportion of registrations, but much less than their share of VMT. The overinvolvement of trucks in fatal crashes is basis for most of the safety issues with respect to trucks in the US.

Table 25
Distribution of Vehicle Types Involved in Crashes by Severity.

Vehicle type	Crash severity			
	Fatal	Injury	PDO	Total
Cars	42.4	56.6	55.1	55.5
Light trucks	39.8	38.1	40.4	39.7
Large trucks	8.3	2.4	4.3	3.7
Motorcycles	9.5	2.9	0.2	1.1
Total	***100.0***	***100.0***	***100.0***	***100.0***
Total vehicles	***52,397***	***3,010,800***	***7,208,200***	***10,271,397***

Adapted from [50], table 3.

When measured by VMT, trucks in the US tend to have higher involvement rates per mile traveled in fatal crashes than smaller motor vehicles, but they have substantially lower rates in injury and PDO crashes. Table 26 shows crash rates for the most recent five years of data, for the primary vehicle types and crash severities. Crash severities are fatal, injury, PDO, and all crashes severities, which is the aggregate of the previous three. Crash rates are shown, expressed as crashes per 100 million VMT. Table 26 illustrates several points. The first is that crash rates gradually declined over the period. The fatal rate for trucks actually declined by 50 percent between 2005 and 2009, from 2.22 fatal crashes per 100 million miles to 1.12. Secondly, fatal crash rates for trucks were higher than for passenger cars in 2005 through 2007, but actually dipped below passenger cars in 2008 and 2009. (This dip may be related to the severe economic downturn that began in 2008.) Next, note that the rates for motorcycles are much higher than any other motor-vehicle type, for every crash severity other than the PDO type.

Table 26
Crash Rates (per 100M VMT) by Vehicle Type, 2006-2009.

Vehicle types	Year				
	2005	2006	2007	2008	2009
Fatal crash rates					
Passenger cars	1.56	1.50	1.47	1.34	1.22
Light trucks	2.03	1.94	1.92	1.73	1.60
Trucks	2.22	2.14	1.52	1.32	1.12
Motorcycles	44.79	41.19	24.8	25.99	22.09
Injury crash rates					
Passenger cars	117	111	110	107	100
Light trucks	107	104	102	99	95
Trucks	37	36	25	21	19
Motorcycles	769	694	458	433	406
Property damage only crash rates					
Passenger cars	258	250	258	258	244
Light trucks	258	254	265	258	256
Trucks	159	135	110	100	83
Motorcycles	174	128	93	88	80
All crash severities					
Passenger cars	377	363	369	366	345
Light trucks	367	360	369	359	353
Trucks	198	173	137	122	103
Motorcycles	988	863	576	547	508

Adapted from [50], Table 3.

It might also be noted that, while trucks typically have higher fatal crash rates than passenger cars (excepting 2008 and 2009), the injury and PDO crash rates are dramatically lower than passenger cars. The higher fatal rate for trucks is probably largely explained by the physical mismatch between trucks and most of their crash partners; it may also be because much of their travel occurs on high-speed roads, so the crashes take place at higher speeds. The lower injury and PDO crash rates may reflect the fact that most truck drivers are professional drivers and are at work when driving.

Most fatalities in truck crashes occur in other motor vehicles in the crash. Compared with rates in Brazil and China, the proportion of pedestrians and pedalcyclists is relatively small. (Table 27.) Over the period from 2004 to 2008, an average of 5,316 people were killed in truck-involved traffic crashes, of which 878 (16.5 percent) were in the truck, 3,970 (74.7 percent) were in another motor vehicle, and 468 (8.8 percent) were not in a motor vehicle, chiefly pedestrians (6.8 percent) but also some bicyclists (1.6 percent). Pedestrians and bicyclists are actually underrepresented in fatal truck crashes compared with all fatal crashes.

Table 27 includes the proportion of fatalities in all fatal crashes by whether they were occupants of trucks, other motor vehicles, or nonmotorists. Truck occupants make up 1.9 percent of all fatalities. But 13.5 percent of the fatalities in all crashes are not in motor vehicles at all, compared with 8.8 percent when a truck is involved in the crash. Trucks tend to operate more on limited access or other high-speed roads, where pedestrians and bicyclists are legally excluded, compared with other vehicle types in the US. In addition, more of the traveling population use motor vehicles, compared with populations in other countries. In the US, the primary truck safety problem is collisions with light motor vehicles, chiefly passenger cars, SUVs, and pickup trucks, not motorcycles, pedestrians, pedalcyclists, and other nonmotorists, as in less developed countries.

Table 27
Annual Fatalities in Truck and All Crashes by Role in Crash, US, 2004-2008.

Vehicle/Person type	Truck-involved		All fatal crashes
	N	%	%
	In the truck		
Driver	739	13.9	-
Passenger	137	2.6	
Unknown type	2	0.0	
Truck total	*878*	*16.5*	*1.9*
	In the other motor vehicle		
Drivers	2,934	55.2	-
Passengers	1,033	19.4	
Unknown type	4	0.1	
Other vehicle total	*3,970*	*74.7*	*84.6*
	Nonmotorists		
In parked vehicle	15	0.3	-
Pedestrian	362	6.8	11.3
Cyclists, etc.	87	1.6	1.8
Other/unknown	4	0.1	0.4
Nonmotorist total	*468*	*8.8*	*13.5*
Total	***5,316***	***100.0***	***100.0***

Adapted from [51], table 1-7, [74], table 4.

Table 28 shows a relatively high-level classification of the different types of crashes that trucks get into, for each of the three levels of injury severity. The first two rows—"ran off road" and "hit object in road"—are single-vehicle crashes, that is, no other motor vehicle was involved in the crash. The "hit object in road" set includes collisions with pedestrians, bicyclists, and other nonmotorists, and accounts for almost 10 percent of fatal crashes. Note also that 6 percent of the fatal crashes are classified as ran off road, resulting in a fatal injury to the truck driver, either because of a rollover or collision with a large fixed object.

Table 28
Percentage Distributions of the Primary Truck Crash Types by Crash Severity, TIFA 2003-2008, GES 2003-2008.

Crash type		Injury severity			All severities
		Fatal	Injury	PDO	
Single vehicle	Ran off road	6.0	7.7	7.3	7.4
	Hit object in road	9.9	2.6	6.8	6.0
Multiple vehicle	Rear-end	15.9	28.2	18.1	20.2
	Same direction sideswipes	4.4	13.7	22.5	20.4
	Head-on	13.4	1.8	0.4	0.9
	Opposite direction sideswipes	11.9	5.5	3.5	4.0
	Turning	10.0	16.0	18.5	17.8
	Intersection	11.5	7.2	2.5	3.6
	Backing	0.6	2.1	8.3	6.9
	Other	14.5	15.0	11.4	12.2
Unknown		1.9	0.3	0.6	0.6
Annual average		5,068	75,000	273,000	350,000

Based on [53] for fatal crashes and [52] for nonfatal crashes.

Among fatal collisions with other motor vehicles, the most common are rear-ends, head-on collisions, and opposite-direction sideswipes. Most of the turning and intersection type crashes involve the front of a truck striking the side of a light vehicle, often on the driver's side. These crashes highlight the physical mismatch between trucks and light vehicles. In crashes in which trucks are struck in the rear, the higher structure of the truck often allows the striking vehicle to go under, even though underride guards are required for many trucks and trailers. Where the front of the truck is involved, the greater mass and stiffness of trucks means that the light vehicle absorbs most of the energy in the crash.

The safety problem is different for truck drivers. Table 27 shows that an average of 739 truck drivers were fatally injured in the five years between 2004 and 2008. This number has remained relatively stable, from about 700 to 750 deaths per year, even while total motor-vehicle fatalities in the US declined by about 14 percent over that period, and truck crash rates are declining. Compared with light passenger vehicles, there has been relatively little in the way of change to truck cabs to protect the driver. Seat belts are increasingly used, but the usage rates are still well below those of light vehicle drivers.[58] A primary mechanism in fatal truck driver injuries is rollover, particularly when the driver is unbelted and ejected.

Overall, the probability of injury for truck drivers in traffic crashes is low. Only about 5.6 percent of truck drivers are injured in a crash, and only 0.2 percent are fatally injured. However, rollover is probably the primary factor in fatal injuries to truck drivers. About half of truck driver fatalities involve rollover. Rollover increases the probability of fatal injury to the driver by about 30 times. The other primary mechanisms of fatal truck driver injury is a massive frontal impact, in which the truck strikes some very large object such as a bridge abutment and the driver is ejected, or fire. Rollover, ejection, or fire occur in over 72 percent of truck driver fatalities.[51, 57]

Table 29
Percent Distribution of Truck Driver Injury Severity, By Truck Rollover, United States.

Driver injury severity	No rollover	Rollover
Fatal	0.1	3.1
Incapacitating injury	0.5	15.0
Non-incapacitating, evident injury	1.2	23.2
Complaint of pain	2.0	16.6
No injury	96.1	42.1
Total	***100.0***	***100.0***

Source: [57].

Driver factors and driver condition are a major focus in truck safety efforts in the US. However, overall, the incidence of alcohol and illegal drug use in truck crashes is not large. Each year, interstate motor carriers are required to randomly test 10 percent of drivers for alcohol use and 50 percent for illegal drug use. Pre-employment tests are also required, as are postcrash tests in more serious crashes. A random survey of drivers in 2008 found blood alcohol levels in 0.2 percent of drivers, and illegal drug use in 1.0 percent. Among the group of carriers surveyed, illegal drug use was found in 2.0 percent of crashes; alcohol in 0.1 percent of crashes. Public crash databases have similarly low rates. Among truck drivers in fatal crashes, 2.0 percent were reported with blood alcohol levels over the legal limit; this compares with over 23 percent for passenger-car drivers in fatal crashes. Only 1.2 percent of truck drivers in fatal crashes were reported to have used illegal drugs.[51, 59]

The reported incidence of fatigue in truck crashes is similar in magnitude to reported drug and alcohol use, though fatigue is much more difficult to detect and therefore probably underreported. In fatal crashes, only around 2 percent of truck drivers are reported as fatigued or asleep, though the true rate is commonly considered to be significantly higher.[51] In the most intensive investigation of serious truck crashes to date in the US, fatigue was identified in about 13 percent of crashes.[61]

Truck driving as an occupation is considered to be an unhealthy lifestyle, which contributes to fatigue and inattention. Long-haul trucking obviously consists of many hours sitting behind the wheel, driving. Often this is followed by the intense physical activity of loading or unloading the truck. Some surveys indicate over 50 percent of truck drivers are smokers. One survey at a trade show estimated that almost three-quarters of drivers were overweight or obese. Moderate or severe sleep apnea is estimated in over 10 percent of drivers, with mild sleep apnea in an additional 18 percent. A 1990 study of truck crashes fatal to the driver found that 10 percent of the drivers had such severe heart problems that they probably contributed to the crash. A more recent in-depth study of serious and fatal truck crashes showed that almost 30 percent of drivers was taking one or more prescription drugs, often related to blood pressure, cholesterol, or stress.[60, 61]

In addition to drivers, the mechanical condition of trucks is also identified as contributing to crash risk. In the primary, public, crash-data sets used for safety analysis in the US, mechanical defects are seldom identified, primarily because police officers rarely perform a detailed vehicle inspection. Yet other data show that many trucks have serious defects. The FMCSA maintains a comprehensive system of inspections, including roadside inspections when a vehicle is stopped by a traffic officer, inspections at trucking terminals, and effectively random inspections. In 2004, there were over 3 million inspections at varying levels of scrutiny, with over 1 million at the most comprehensive level. Though that number is large, it is likely that most trucks are not inspected in any given year. In any case, in 2004, almost three quarters of the trucks that received the most intensive examination had at least one violation of vehicle, carrier, or driver standards.[55] Brakes are the most common system on the truck with defects. A series of unannounced brake inspections by the Commercial Vehicle Safety Alliance in 2011 found that over 16 percent of trucks inspected should be put out of service because of brake problems. In 2010, a series of announced brake inspections nevertheless put over 13 percent of trucks out of service for brake defects.[62]

The most intensive investigation of trucks involved in serious crashes also found substantial incidence of vehicle defects that pre-existed the crash and probably contributed to the crash. One study showed that over 36 percent of trucks in serious crashes have brake defects, and almost 20 percent would have been put out of service for brake defects if they had been inspected prior to the crash. Almost 55 percent had some mechanical violation, and almost 30 percent had a vehicle defect that would have put them out of service.[56]

These results may not reflect the general population of trucks because the inspections are often targeted, that is, conducted on vehicles that enforcement officers had stopped for a traffic violation or because they had reason to suspect that a defect existed. However, inspection results from trucks involved in crashes show that a substantial proportion of these vehicles have significant mechanical defects.

5.3 Truck safety issues

The trucking industry in the US is relatively mature, not marked by the dramatic changes in the economy, regulatory environment, and road system that China and Brazil are undergoing. Trucks are operated throughout the economy of the US, from farmers and small businesses, which may have only one or two running locally, to large carriers who operate thousands of trucks throughout the country. The regulatory environment is also fairly stable, with two large US DOT administrations exercising national oversight over safety- and efficiency-related (e.g., emissions) vehicle-design standards and carrier operations, respectively. States exercise jurisdiction over in-state operations, and establish a variety of size and weight standards for state and local roads, within boundaries set by federal control of the national highway system.

The regulation of truck design and operation is marked by a gradualism, with incremental changes to improve safety. For example, NHTSA recently published new shorter stopping distance standards for trucks. Initially, when the standards were first proposed, it was thought the shorter standard would move truck brake technology to disc brakes, which are common in Europe. But improvements in brake pad friction material and brake drums have allowed the old S-cam drum brakes to meet the new standards. Thus, the fundamental braking technology that has been in use for almost a century continues, adapted to current standards. In terms of the regulation of carrier operations, FMCSA has recently implemented its Compliance, Safety, and Accountability (CSA) program, which replaces the prior Safer program. The new program will more closely monitor carriers by exploiting more data, and intervene with carriers earlier, but it does not fundamentally change the regulatory approach.

In this context, the primary focus of truck safety in the US is on drivers and vehicles. The goals are to avoid crashes if possibly by improving driver performance, or, failing that, to mitigate the severity of crashes. The primary areas currently being addressed are:

- Driver fatigue and hours of service
- Driver distraction
- Heavy truck rollover
- Heavy truck aggressivity in collisions with light vehicle.
- Light vehicle underride of trucks

In terms of drivers, the primary current issues relate to driver fatigue, hours of service, and driver distraction. Driver fatigue has been identified as the primary cause contributing to heavy-truck crashes, though, as shown above, evidence from crash data indicates that, while a significant problem, only a minority of truck crashes seem to be related to fatigue. Nevertheless, reducing driver fatigue has been a major regulatory goal in the past decade. FMCSA, which regulates carrier operations, has introduced new hours of service standards, which restrict the number of hours a driver may drive or be on duty within a given work period or over a series of days. The rules include mandatory rest periods, limitations on the number of consecutive hours of work, and provisions to restart the clock on these counts. These rules, first issued in 2003 after many delays, have been subject to almost continuous litigation from trucking firms and from traffic safety advocates, and it is expected that efforts to overturn the rules will continue. In force in one form or another since 2003, it appears that the rules have improved truck safety, at least in terms of the overall truck crash rate.

Driver distraction has also been identified as major contributor to truck crashes. Modern trucking can be very tightly managed, and many fleets have the ability to remain in virtually constant contact with their drivers, communicating about loads, schedules, and even traffic delays. In addition, truckers are responsible for documenting their activities, both for job-related reasons and to satisfy federal regulations. These are all in addition to the distractions related to the proliferation of cell phones, with the concomitant ability to remain in communication while driving. As a result, distraction is considered to be a growing problem for drivers. One result is new regulations banning texting and the use of cell phones while in motion.

At the same time, however, there is an emerging development of advanced technologies to help the driver control the vehicle and even take over control of the truck in certain circumstances. A set of technologies is in early stages of deployment by manufacturers, with NHTSA considering regulation to require them. These include electronic stability control (ESC), forward collision warning (FCW), collision mitigation braking (CMB), and lane departure warning (LDW). As identified above, the primary crash problem for heavy trucks is interactions with light vehicles. These technologies are aimed at reducing those interactions by avoiding collisions if possible or, failing that, lessening their severity by slowing the trucks prior to impact.

ESC is a technology that can help the driver maintain control of the vehicle if the driver loses lateral control. Studies show that, at least for tractor-semitrailers, a major benefit will be in reducing heavy-truck rollover, by intervening to keep the truck on its wheels before the driver perceives the need to react. This may address one of the major factors in truck driver fatal injury.[63]

FCW and CMB both address rear-end crashes in which a truck is the striking vehicle. These technologies warn a driver who may be inattentive to traffic in front so that he can react. If the driver fails to react appropriately, the CMB system will apply the brakes to slow the truck and reduce the severity of impact. LDW warns a driver who inadvertently leaves the lane of travel. This technology can reduce the number of same direction sideswipes, but it also can alert a sleepy driver who is unknowingly allowing his truck to drift off the road.[e.g., 64] In addition, other technologies are under consideration to warn truck drivers about pedestrians and other non-motorists who may be in blind areas around a truck. These include mirrors, radars, and camera systems.

Heavy-truck aggressivity is more directly addressed in the reconsideration of the truck underride-guard standard. Underride guards are intended to prevent light vehicles from going under large trucks in collisions and dissipating some of the energy, by engaging the bumpers and crush zones on light vehicles. Several studies have indicated that current underride guards are not strong enough or low enough to do the job they are intended to do.[65, 66] NHTSA is currently collecting data to evaluate whether and how to strengthen the standard. However, there is currently no practical solutions on the horizon to lessen the aggressivity of trucks in frontal collisions with light vehicles.

Finally, FMCSA's rollout of the CSA scheme to monitor the safety of carriers and intervene should incrementally improve the safety of heavy trucks in the US. In practical terms, the main emphases of this effort are driver condition, driver behavior, and vehicle maintenance. These will be the primary triggers for interventions with carriers. Because the CSA program will affect more carriers earlier in the process, it may have the effect of causing carriers to improve driver compliance with traffic and hours-of-service standards, and to insure that their vehicles are in compliance with mechanical standards.[67]

6. Summary and discussion

This study reviewed the status of truck safety in four countries and identified the primary issues related to truck safety in each of the countries. The countries selected for review represent a broad range of conditions in which trucks are operated, from a rapidly developing economy attempting to build a safety culture to a mature motorized economy with long-standing regulatory and enforcement institutions. In this section, we bring together and review some of the major findings. Some of the issues identified are particular to the specific circumstances of a country, but many of the safety issues are common to all the countries.

Crash and population data available for this study varied widely in accessibility, comprehensiveness, and detail. Data were most accessible for the US, which maintains comprehensive national crash databases as well as vehicle demographic statistics. National data from Australia are mostly confined to fatal crashes, though some of the individual states make available their state-level nonfatal crash data. Acquiring information about truck safety in Brazil and China was significantly more challenging. Comprehensive data are generally not available. Certain aggregate statistics are published, though accessing these statistics in China is difficult. For the most part, it was necessary to piece together a picture of the truck situation in the countries from secondary literature, using studies of specific topics in restricted areas. For these reasons, it was not possible to develop parallel statistics across all of the countries, but the results assembled here aim to provide reasonably comparable statistics. Typically, the most comprehensive and detailed statistics are found for fatal crashes.

The vehicle populations of the countries provide some insight into the traffic and transportation environment in which trucks are operated. Table 30 shows the distribution of the main vehicle types in each of the countries. The percentages vary widely between countries, suggesting one aspect of the different traffic streams in which trucks travel. Distributions for Australia and the US are fairly similar. Each has very large populations of light vehicles, typically owned by private individuals for private transportation. The proportion of trucks in the US is somewhat higher than in Australia, but the percentages of motorcycles and buses are small in both and of comparable magnitude. For both countries, trucks are only a small part of the vehicle population, amounting to less than five percent in each. In both countries, the primary motor vehicle on the road is a light-duty passenger vehicle, typically an automobile or light truck. In both Brazil and China, a much larger share of transportation is provided by two-wheeled vehicles. In Brazil, over a quarter of the vehicle population consists of motorcycles, and in China, almost 71 percent of registered motor vehicles are motorcycles. China has the smallest share of light four-wheel vehicles at only 20 percent. On the other hand, the truck share of vehicle registrations is the highest in China, with over 9 percent, more than twice the share in the United States. China has about the same number of trucks as the US, though less than a tenth of the number of light-duty vehicles. These statistics are for registrations rather than miles traveled, but they suggest that the traffic stream in which trucks are embedded in China and even Brazil are quite different than in Australia and the US.

Table 30
Distribution of Vehicle Types in Selected Countries.

Vehicle type	Australia	Brazil	China	US
Light vehicle	14,778,377	40,492,706	21,341,000	234,467,679
Truck	513,714	2,422,465	9,716,000	10,973,214
Motorcycle	660,107	14,816,782	75,565,000	7,929,724
Bus	86,367	676,537	n/a	841,993
Total	***16,060,932***	***58,408,490***	***106,622,000***	***254,212,610***
Percentages by country				
Light vehicle	93.2	69.3	20.0	92.2
Truck	3.1	4.1	9.1	4.3
Motorcycle	3.0	25.4	70.9	3.1
Bus	0.5	1.2	-	0.3
Total	***100.0***	***100.0***	***100.0***	***100.0***

Dates and sources: Australia, 2010, [34]; Brazil, 2010, [5]; China, 2005, [28]; US, 2009 [2].

Crash rates, both for trucks and for all vehicles, also varied significantly between the countries. Table 31 presents truck and all fatality crash rates per population and per vehicle registration. All rates shown could not be computed for each country because of data differences. Crash rates tend to be highest in Brazil and China, whether measured in terms of population or registrations, and whether the rates are for all vehicles or just trucks. The safety culture, both in terms of the regulatory environment and customary traffic behavior, is not as well developed. On the other hand, fatal crash rates for all vehicles and truck crash rates are somewhat higher in the US than in Australia. Regulations in Australia permit larger (heavier and longer) trucks, but the constraints on where the biggest trucks are allowed to operate and the specific configurations (e.g., the B-train double) operated probably contributes to their better safety result.

Table 31
Fatality Rates for Truck and All Fatal Crashes.

Crash rate	Australia	Brazil	China	US
Total crash fatalities/10k vehicle registrations	1.0	6.6	9.4*	1.3
Total crash fatalities/100k population	6.2	18.8	7.5*	10.8
Fatalities in truck crashes/10k truck registrations	4.3	17.7	n/a	6.7
Fatalities in truck crashes/100k population	0.9	2.1	n/a	1.7

* Likely underestimated.
Dates are 2005-2010. Rates computed using population figures from Table 1 above; registration data consolidated in Table 30; crash data from tables in the sections for each country in this report.

Motorcycles, bicycles, and other nonmotorized vehicles make up a much larger share of the vehicle population involved in fatal crashes in Brazil and China than in the US and Australia. Both Brazil and China are significantly less motorized and a much higher share of the motor vehicle population consists of motorcycles and other small vehicles.

Table 32 shows roughly comparable statistics for vehicles in fatal traffic crashes. (Vehicle level statistics could not be obtained for China.) The share of automobiles is about the same between Brazil and the US, but in Brazil over a third of the vehicles in fatal crashes are motorcycles, compared with only about 10 percent in the US. The difference is made up by the large number of light trucks (e.g., pickups) and other light utility vehicles in the US. Only about 7 percent of the vehicles involved in fatal crashes in the US are heavy trucks, while the combination of light and heavy trucks in Brazil fatal crashes makes up about 9 percent. Unfortunately, data could not be obtained to determine the key question of the heavy truck share of vehicles in fatal crashes in each country.

Table 32
Percentage Distribution of Vehicle Types in Fatal Crashes.

Vehicle type	Australia[1]	Brazil[3]	China[4]	US [50]
Automobile	58.5	41.6	27.4[5]	40.4
Light truck	25.9[2]	9.2[2]	4.4[2]	39.4
Heavy truck				7.1
Bus	1.3	3.9		0.5
Motorcycle	12.1	33.8	24.1	10.1
Bicycle/other	2.2	7.2	43.8[6]	1.3

[1] New South Wales. [41]
[2] Light and heavy truck combined.
[3] Injury crashes. [6]
[4] Distributed by fatalities, not vehicles. [28]
[5] Includes buses.
[6] Combines all nonmotorist types.

Table 33 compares the road-user type of persons killed in crashes involving trucks. The distribution is similar for the US and Australia. In the US, about three-quarters of the fatalities are light-vehicle occupants, overwhelmingly of passenger cars but also including some (about 2 percentage points) motorcycle occupants. In Australia, car occupants account for about 76 percent of fatalities, while an additional 7 percent were motorcycle riders. In contrast, in Brazil (on federal roads, which are typically higher speed), almost 30 percent of the fatalities are motorcycle riders, with pedestrians accounting for almost 20 percent and bicyclists about 7 percent. In total, well over 50 percent of the people killed in truck crashes are motorcyclists or nonmotorists. In Australia, those vulnerable road-user categories total only about 24 percent. In the US, they are probably less than 10 percent. This information was not available for China, but it seems likely that the percentage of vulnerable road users is more similar to Brazil than to the US. It is clear that in such countries, the major truck safety issue is interactions with pedestrians, bicyclists, and motorcycle riders. In the US and Australia, the major issues relate to interactions with light, four-wheeled vehicles.

Table 33
Percentage of Fatalities by Road-User Type in Truck Crashes.

Road-user type	Australia	Brazil[2]	China	US
Automobile	76.4[1]	23.0	n/a	74.7[4]
Motorcycle	6.7	28.4	n/a	
Pedestrian	13.8	18.6	n/a	6.8
Pedalcyclist	3.1	6.6	n/a	1.8
Truck	n/a	23.3[3]	n/a	16.5

[1] Includes some truck occupants.
[2] Federal roads.
[3] Includes light and heavy trucks.
[4] Includes motorcycles (~2%).
Australia, 2010, [38]; Brazil, 2009, [10]; US, 2009 [51].

Driver issues were a common concern in all of the countries, though the nature of them varied. In both Australia and the US, it appears that alcohol and illegal drugs, though a concern, are not major contributors to fatal truck crashes. Only about 1 to 2 percent of truck drivers in fatal crashes had been using either alcohol or illegal drugs. Good statistics on alcohol- or drug-related crashes could not be obtained from Brazil, but surveys of drivers showed very high rates of drug and alcohol use. Over half admitted to drinking while driving, and over a third admitted to using illegal drugs (typically stimulants) while driving.

Table 34
Incidence of Selected Truck Driver Factors in Fatal Crashes.

Driver factor	Australia	Brazil	China	US
Alcohol	1.2%[1]	n/a[2]	n/a	2.0%
Drugs	1.6%	n/a[3]	n/a	1.2%
Fatigue	10.0%	4.5%	n/a	2.0%[4]

[1] From random survey.
[2] Survey: 51% admitted drinking on the job.
[3] Survey: >33% admitted using illegal stimulants.
[4] Coded; likely 2-4 times higher.
Sources: Australia [41,42]; Brazil [8, 15]; US [51].

Driver fatigue was acknowledged as a significant truck safety issue in each of the four countries surveyed, though it is difficult to measure and identify in crashes. Both Australia and the US have regulatory and enforcement regimes to limit excessive driving in order to reduce the incidence of fatigued driving. In Australia, about 10 percent of truck drivers in fatal crashes are coded as fatigued. The percentages reported in Brazil and the US are lower, but at least in the case of the US, they are thought to be significantly higher. It is clear that truck driving is a tough, demanding job wherever practiced. In each country, there are pressures to deliver according to tight schedules and to drive, one way or another, even when fatigued.

Table 35 attempts to gather together the primary truck safety issues identified in each country. In the table, some evidence was required from the country's safety literature to indicate that the problem was a priority for the country.

Some of the issues are common across all four. Fatigue and controlling hours of service are common themes. Truck driving is an inherently demanding and time-constrained job, so there is a risk of going long hours without rest, regardless of the country. Similarly, the mechanical condition of the truck was also a common issue, mostly focusing on braking. Trucks are work vehicles and used as such. There are inspection and enforcement regimes in both the US and Australia, yet truck brakes remain a problem even in those countries. On the other hand, overloaded trucks are considered to be a major problem in both Brazil and China, contributing both to road damage as well as to crashes. Overloading was not identified as a significant safety hazard for trucks in Australia and the US. This is not to say that excessive loading does not occur in those countries, just that the incidence is low and it does not appear to be a major safety issue.

Table 35
Primary Truck Safety Issues.

Safety issues	Australia	Brazil	China	US
Pedestrian/nonmotorists		X	X	
Fatigue	X	X	X	X
Hours of service	X	X	X	X
Alcohol		X		
Belt use	X			X
Driver training		X	X	
Overloading		X	X	
Aggressivity/underride	X			X
Mechanical condition	X	X	X	X
Rollover		X		X
Size and weight	X	X	X	X
Roadway condition & design	X		X	

There are also important differences in the truck safety issues in each country. Collisions with pedestrians and other nonmotorists are primary issues in both China and Brazil, because of the nature of the traffic environments in those countries. In these two countries, bicyclists and pedestrians are a bigger part of the traffic stream than in the US or Australia. Both countries also rely heavily on motorcycles for mobility. In Australia and the US, light four-wheel vehicles are the primary crash partner, so both countries have efforts to address the problem of heavy-truck aggressivity and underride or override in collisions.

In addition, both the US and Australia are trying to reduce truck driver injury by increasing the use of seat belts. In contrast, truck driver training and licensing are bigger issues in both Brazil and China. Brazil has not developed a comprehensive system of licensing, so drivers can train and be tested on one vehicle type but then licensed to drive bigger and more complex vehicles. In China, the rapid transition to motorized society means that many new truck drivers are needed and the proportion of inexperienced drivers is relatively high, both among truck drivers and light-vehicle drivers.

Overall, truck safety is a significant traffic issue in each of the countries. The way it is expressed depends on the circumstances within each country, including the mix of vehicles and nonmotorists in the traffic stream, the extent to which truck operations and vehicles are regulated and monitored, and the types and conditions of trucks. Trucking is a critical element in the economy and life of each country. By virtue of their size relative to other vehicles, and substantial performance differences, reducing the toll of fatalities and injuries in truck crashes will remain a significant challenge. Countries may pursue different approaches, tailored to their circumstances and state of development. But the fundamental nature of truck travel in traffic remains, so that solutions in one country may be more broadly shared.

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