

Appendix

Table A1. Indices of causation factors

Category	Contributing factor	Fatalities	Number of people injured	Number of accidents
Participant-related contributing factors	Driver talking to passengers	11	18	1
	Driver using cellphone	56	54	4
	Driver focusing on other activities unrelated to driving (besides the above two activities)	22	12	1
	Fatigue driving	270	278	17
	Sudden medical issue affecting driver	23	22	1
	Drug driving	14	20	1
	Drinking and driving	49	32	4
	Improper operation of accelerator	11	4	1
	Improper operation of foot brake	279	272	20
	Improper operation of parking brake	10	2	1
	Improper operation of clutch	121	109	8
	Improper operation of steering wheel	482	551	30
	Overloading of people	907	971	59
	Overloading of cargo	452	347	28
	Loss of load	26	33	2
	Transporting passengers with prohibited type of vehicle (e. g. truck, agricultural vehicle, etc.)	377	253	25
	Transporting dangerous goods with prohibited type of vehicle	41	6	1
	Fail to keep safe distance from other vehicles	10	31	1
	Speeding	1802	2018	122
	Illegal overtaking	270	288	18
Illegal operation when meeting other vehicles	55	80	4	
Driving in prohibited lane	363	289	25	
Unloading goods on road	15	22	1	
Parking vehicle in prohibited lane	83	118	5	
Not giving way to other road users	104	146	8	
Entering prohibited road	73	97	6	
Vehicle-related contributing factors	Tread wear	194	142	13
	Mixed use of tires with different specifications	104	43	6
	Wheel rim fails to meet safety standards	13	22	1
	Using retreaded tire that does not meet standards	45	40	2
	Malfunction of brake	451	457	28
	Malfunction of brake line	158	160	11
	Malfunction of vehicle light	98	139	7
	Fault in steering system	88	35	6
Fault in suspension system	44	35	2	
Road-related contributing factors	Unsuitable road horizontal curve	460	490	34
	Unsuitable road vertical curve	457	452	33
	Narrow road or bridge	101	95	8
	Deficient sight distance	101	79	7
	Damaged road surface or obstacles on road	160	105	13
	Missing or nonstandard warning sign on construction road section or accident road section	158	96	9
Slippery roads due to rain, snow or ice	647	671	45	

	Lack of or nonstandard roadside safety infrastructure	655	624	45
	Missing or nonstandard median strip	148	118	12
	Missing or nonstandard sign or marking	557	479	39
	Missing illumination facility	102	195	8
	Missing or malfunctioning traffic light	49	107	4
Environment - related contributing factors	Driver's sight limited by inclement weather or other atmospheric conditions	164	155	11
	Natural disaster (flood, debris flow, landslide, ground collapse, typhoon, earthquake, etc.)	56	26	4

Table A2. Principal component

Factor ID	Contributing factors	Principal component
1	Speeding	15.49382565
2	Overloading of people	6.510927599
3	Slippery roads due to rain, snow or ice	4.118626935
4	Lack of or nonstandard roadside safety infrastructure	4.005054806
5	Missing or nonstandard sign or marking	2.97427829
6	Improper operation of steering wheel	2.517700112
7	Unsuitable road horizontal curve	2.456718079
8	Unsuitable road vertical curve	2.286802769
9	Malfunction of brake	2.044119332
10	Overloading of cargo	1.721313011
11	Driving in prohibited lane	1.120258752
12	Transporting passengers with prohibited type of vehicle (e. g. truck, agricultural vehicle, etc.)	1.058585111
13	Improper operation of foot brake	0.561519576
14	Illegal overtaking	0.484714079
15	Fatigue driving	0.407434406
16	Tread wear	-0.430632079
17	Driver's sight limited by inclement weather or other atmospheric conditions	-0.583865973
18	Malfunction of brake line	-0.588343026
19	Damaged road surface or obstacles on road	-0.64963957
20	Missing or nonstandard median strip	-0.697343434
21	Missing illumination facility	-0.807630814
22	Missing or nonstandard warning sign on construction road section or accident road section	-0.873311318
23	Not giving way to other road users	-0.946426874
24	Improper operation of clutch	-1.001416229
25	Malfunction of vehicle light	-1.03411128
26	Narrow road or bridge	-1.107230822
27	Deficient sight distance	-1.202293534
28	Parking vehicle in prohibited lane	-1.239875095
29	Entering prohibited road	-1.286634869
30	Mixed use of tires with different specifications	-1.346984913
31	Fault in steering system	-1.4221523

32	Missing or malfunctioning traffic light	-1.429464032
33	Illegal operation when meeting other vehicles	-1.490191451
34	Driver using cellphone	-1.564035241
35	Natural disaster	-1.647022751
36	Drinking and driving	-1.651752006
37	Using retreaded tire that does not meet standards	-1.73618801
38	Fault in suspension system	-1.754223251
39	Loss of load	-1.818039684
40	Transporting dangerous goods with prohibited type of vehicle	-1.897464003
41	Sudden medical issues affecting driver	-1.907931323
42	Fail to keep safe distance from other vehicles	-1.92306531
43	Unloading goods on road	-1.933659658
44	Wheel rim fails to meet safety standards	-1.940091741
45	Driver focusing on other activities unrelated to driving (besides talking to passengers or using cellphone)	-1.940785761
46	Drug driving	-1.942803379
47	Driver talking to passengers	-1.958379184
48	Improper operation of accelerator	-1.999872939
49	Improper operation of parking brake	-2.00901666

Detailed descriptions of contributing factors in Table A1:

In human-related contributing factors, “fatigue driving” is defined as “continuous driving over 4 hours without a break or a break time less than 20 minutes”. “Drinking and driving” means “vehicle driver’s blood alcohol content greater than or equal to 20mg/100ml”, the legal blood alcohol limit for driving in China. “Illegal overtaking” is defined as “overtaking that occurs in overtaking-prohibited road sections or without safe overtaking conditions”. “Illegal operation when meeting other vehicles” is explained as “speeding when approaching an oncoming vehicle at an intersection, or crossing the yellow line when there is an oncoming vehicle, use vehicle lights improperly (e.g. maintaining high beam) when approaching an oncoming vehicle”. “Driving in prohibited lane” includes several behaviors, such as driving in a non-motorized vehicle lane or footway, driving in an emergency parking lane or on the road shoulder, straddling the lane demarcation line, etc. “Not giving way to other road users” covers 26 traffic violations, among which “right-turning vehicle fails to give way to vehicle driving straight through” and “disturbing other vehicles when changing lanes” are the most common violations.

In vehicle-related causation factors, “mixed use of tires with different specifications” often occurs when worn truck tires are replaced. To reduce costs, the driver or truck owner often replaces the worn tires with cheap tires of different specifications. However, this accelerates tread wear and decreases stability of vehicle. “Wheel rim fails to meet safety standards” usually means the strength of the wheel rim is too low to meet the standards and the rim is therefore prone to deformation or fragmentation. The motivation for “using retreaded tire that fails to meet safety standards” is the same with “mixed use of tires with different specifications”, which is saving money. However, substandard retreaded tires wear quickly and are more likely to burst under a heavy load or at a high environmental temperature. “Malfunction of brake” usually occurs with heavy trucks with drum brakes, due to the increased clearance between brake shoe and brake drum caused by overheating and excessive brake pad wear.

Similar to “Malfunction of brake”, “Malfunction of brake line” also refers to braking performance. It usually related to two issues. One is the leakage of brake air or brake fluid. The other is the disconnection of the tractor brake line by the driver, whose intention is to eliminate the conflict between the semi-trailer and tractor during braking caused by time delay of air transfer by removing the braking ability of the tractor. However, such action decreases the overall braking performance of the tractor-semi-trailer combination significantly.

Regarding road-related contributing factors, “Missing or nonstandard median strip” and “Missing or nonstandard sign or marking” need to be explained. The type, width, and barrier specification of median strips on highways and urban roads with various grades are regulated by highway and road design standards. In related crashes, lack of barrier strength on median strips or missing median strips are often evident. Such road deficiencies tend to cause crashes in which vehicle(s) deviate into the opposite lane and encounter a head-on collision with other vehicle(s). Although the Ministry of Transport has issued a series of standards regarding the design and use of signs or markings, missing warning signs before hazardous locations (e. g. road sections next to slopes/embankments and bodies of water, or with a high roadbed, or situated at a combination of horizontal curve and steep slope) are very common in related SRTCs and PSRTCs. Missing or vague road markings (e. g. lane demarcation line, lane border line, delineators, shoulder rumble strips) are also frequently noted near or at such locations.