A Review on Factors Affecting Large Truck–Involved Crashes

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ABSTRACT

Crashes involving large trucks have a significant association with increasing fatalities or serious injuries. Identifying the factors affecting large trucks crashes can be helpful in reducing the number of crashes and corresponded consequences. The purpose of this review was to appraise the published papers on factors affecting large truck-involved crashes. Data were compiled through searching Google Scholar, Scopus, Science Direct, and Web of Science using keywords included "large truck and accident severity", "large truck and accident", "large truck and crash severity", "large truck and crash", "large truck and fatal accident", "large truck and fatal crash", "large truck and injury", and "large truck and collide". The accomplishment process had two steps: excluding unrelated studies and reviewing related ones to select papers meeting the inclusion criteria. According to data collected, 31 papers achieved the inclusion criteria. The results indicated that speed, driver age, location type, collision type, seat belt wearing, light condition, vehicle technical condition, time, road surface condition, and accident type were common factors in the included papers. From the perspective of our study, speed, location type, and light condition seem to be the most frequent factors in crashes involving large trucks. The present study helps to access the studies on factors affecting the large truck-involved crashes. Thereby, the experts can perform measures to decrease the probability and severity of traffic accidents.

Keywords: Crash; Large Truck; Large Truck-Involved Crashes; Severity

INTRODUCTION

The significance of freight logistics transportation and its effect on the financial well-being of a country is well-confirmed [1-3]. Besides, the influence that truck traffic accidents can impose on society is notable. Truck traffic accidents end in huge costs including possession damage, personal injury, and lost productivity [1]. Therefore, the large truck safety has drawn remarkable attention from public and government agencies [2]. A large truck in the Fatality Analysis Reporting System (FARS), General Estimates System (GES), and Motor Carrier Management Information System (MCMIS) refer to trucks with Gross Vehicle Weight Rating (GVWR) or Gross Combination Weight Rating (GCWR) heavier than 10,000 pounds [3]. Such vehicles have many singular operating features such as high weight, long length, and low acceleration/deceleration rates, which have a significant impact on crash severity. Prior studies have indicated that crashes involving trucks augment the probability of occurring fatalities or serious injuries due to the size inequality of car/truck and other factors [2].

According to the reports of the Federal Motor Carrier Safety Administration (FMCSA) in 2014, injuries and fatality rates per 100 million miles traveled by a large truck have been estimated to be 39.80 and 1.40, respectively [4]. National Highway Traffic Safety Administration (NHTSA) report in the United States in 2012 also stated that 104,000 subjects were injured in large trucks related crashes. Moreover, there were more than 3900 fatalities in large trucks related crashes, so 83% have been occupants of other vehicles or no occupants [5]. Based on the FMCSA report (2016), from 2015 to 2016, the large truck involved rate in fatal crashes augmented by 3%, from 4,074 to 4,213 [6]. A large truck crash imposes costs on the truck and its driver, other drivers involved in the crash, and society [7]. In addition, charges such as injuries and fatalities, travel postpones, property damage, and emergency services impose important charges [9]. It has been estimated that the cost average associated with the large truck-involved crashes for no injury (for

example, property damage only), non-fatal injury, and fatal traffic crashes were $15,114, $195,258, and $3,604,518, respectively [8]. According to the FMCSA (2017), total financial loss for injuries and fatalities of bus and large trucks related crashes have been estimated at about $46 billion and $44 billion, respectively [3]. Traffic crashes are generally caused by disruptions in the systemic reciprocal action between humans, vehicles, roads, and environmental factors [9, 10]. So far, a number of studies have determined factors related to large trucks crashes, however, few studies have assessed the influence of risk factors on large truck crashes. Therefore, the purpose of this review was to systematically assess the papers that studied factors contributing to large truck-involved crashes.

MATERIALS AND METHODS

All published papers from 1983 to 2021 written in English on the large truck-involved crashes and/or corresponded injuries/deaths as the consequence were included. Required data were gathered by searching keywords of "large truck and accident severity", "large truck and accident", "large truck and crash severity", "large truck and crash", "large truck and fatal accident", "large truck and fatal crash", "large truck and injury", and "large truck and collide". The following databases were searched: Google Scholar, Scopus, Science Direct, and Web of Science.

The papers were classified by study design, assessed factors, and outcomes using an extraction table. Two reviewers independently to select those that matched the inclusion criteria appraised the papers. A reference management program (Endnote X8) was used to organize the papers. Descriptive statistics were carried out using Excel 2016.

RESULTS

From 115 papers that resulted in an initial search of databases, 31 full-text reports from 1980 to 2019 fulfilled the inclusion criteria and were included in this review (Table 1). According to Table 2, of all included papers, 28 papers were cross-sectional, 2 papers were a case study and one was a case-control study. The main outcomes were the severity of a crash, the occurrence of a crash, and both. In summary, human-related factors, road-related factors, vehicle-related factors, environment-related factors, and crash-related factors were investigated as risk factors.

Table 1: Search strategy and selection of papers for review

Included papers	Limitations					Total studies in different electronic databases			
	Papers of annual meetings	Papers of conferences	Unspecified journal papers	Unrelated papers	Duplicate papers	Science Direct	Scopus	Web of science	Scholar
						15	34	20	46
31	2	2	2	18	60	115			

Table 2: Factors affecting large truck–involved crashes: summary of epidemiological evidence

Reference	Study design	Outcome	Data source	Factors	Most significant factors
Chirachavala *et al*. 1984), US [11]	Cross-sectional	Severity of accident	Bureau of Motor Carriers Safety (BMCS) data file	Accident type, Vehicle, Gross vehicle weight, Operation, Driver, Road, Environment	Collisions involving passenger cars and doubles, straight trucks, or loaded flatbed or tanker singles on undivided rural roads; Collisions involving passenger cars and van singles on undivided rural roads at night; Collisions involving cars and doubles on divided rural roads.
Chira-Chavala and Cleveland (1985), US [12]	Cross-sectional	Accident rate	The BMCS file for the accident involvements and the Highway Cost Allocation Study (HCAS) file for truck mileage and uses	Road class, Day-night, Road surface condition, Region of the country, Loading status, Driver age, Driver experience, Trailer body Style, Vehicle configuration, Number of axles of power unit, Model year, Trip length, Straight-truck subset	Trailer style; Vehicle configuration; Number of axles of power unit; Trip length; Road class; Road surface condition; Loading status; Day/night; Driver experience; Driver age.

Reference	Study design	Outcome	Data source	Factors	Most significant factors
Khorashadi *et al*. (2005), US [18]	Cross-sectional	Driver-injury severity (no injury, complaint of pain, visible injury, and severe/fatal injury)	Traffic Accident Surveillance and Analysis System (TASAS) maintained by the California Department of Transportation (Caltrans), Statewide Integrated Traffic Records System maintained by the California Highway Patrol and Caltrans Highway Video Log database	Geometric data, Weather conditions, Road condition, Pavement surface data, Roadway terrain, Driver-related data (such as age, gender, alcohol use), Posted speed limit, etc.	Factors significant in rural: Vehicle occupancy; Excessive speed; First location of collision: interior lanes; Second location of collision: left lane; Single vehicle accident (single vehicle is truck); Number of directional lanes: 2 or 3; Number of directional lanes: 4 or 5; Number of directional lanes: 6 or 7; Highway terrain is rolling; Concrete median barrier; Vehicle model year between 1981 and 1988; Travel time (off-peak traffic between 8:01 a.m. and 3:00 p.m.); Collision year: 1998 Factors significant in urban: When accident caused by another truck; Driver age between 15 and 22; Vehicle move preceding accident; Beyond left shoulder; Left lane; Interior lanes; On/off ramp area; Conventional road (unrestricted access) Inside city limit; Three beam median barrier; Unpaved median; Road condition: construction zone; Raining; Collision type: broadside; Vehicle model year older than 1981; Travel time (afternoon rush hour between 3:01 and 6:30 p.m.).
Mcknight and Bahouth (2009), US [21]	Cross-sectional	Rollover crashes	Field investigators, Police reports	Speed related errors, Attention related errors, Control related errors, and Non-driving related errors	Failing to adjust speed to curves; Loads; Brake condition; Road surfaces; Intersections; Carelessness (general inattention, misdirected attention, falling asleep, and distraction); Control errors (oversteering, understeering, overcorrecting for errors, and minor control errors); Condition of the vehicle
Lemp *et al.* (2011), US [20]	Cross-sectional	Crash severity	LTCCS, FMCSA and NHTSA	Crash variables, Largest truck variables, Vehicle/driver variables	The number of trailers; The truck length; Gross vehicle weight rating (GVWR)
Zhu and Srinivasan (2011a), US [25]	Cross-sectional	Injury severity	LTCCS, FMCSA and NHTSA	Car-level variables, Truck-level variables, Crash-level variables	Alcohol utilize (car drivers); Emotional factors (car drivers); Driver distraction (truck drivers)
Zhu and Srinivasan (2011b), US [26]	Cross-sectional	Injury severity	LTCCS	Truck-occupant characteristics, Truck-driver characteristics, Crash characteristics, Car-driver characteristics, Truck-driver characteristics, Car-passenger characteristics, Vehicle (car) characteristics	Driver behavior characteristics (such as use of illegal drugs, DUI, and inattention); The availability of airbags; The use of seat belt; Car drivers' familiarity with the vehicle and the roadway
Kotikalapudi and Dissanayake (2013), US [19]	Cross-sectional	Crash severity	Truck crash data from the state of Kansas	Driver factors, Road factors, Environment factors and Vehicle-related characteristics	Most significant factors in crash: Failing to give time and attention; Being too fast for existing conditions; Failing to yield right of way Most significant factors in severity of crash: Driver-related contributory causes; Accident class; Manner of collision; Driver being under the influence of

Reference	Study design	Outcome	Data source	Factors	Most significant factors
					alcohol; Truck maneuver; Traffic control device; Surface condition; Being too fast for existing conditions; Being trapped; Damage to the truck; Light conditions
Islam and Hernandez (2013), US [16]	Cross-sectional	Injury severity	National Automotive Sampling System General Estimated System (NASS-GES) crash database maintained by NHTSA	Human-related factors, Vehicle-related factors, Road and environmental-related factors, Crash mechanism-related factors	Age group between 55 and 65; High-speed; Not wearing a seat belt; Licensed drivers working or residing in the state of Texas; Curve sections; Dark conditions; Summer months; Departs from the roadway
Qin *et al.* (2013), US [23]	Cross-sectional	Crash severity	Large truck crashes were recognized via a large-truck flag assigned by the Wisconsin Department of Motor Vehicles and were recovered from the online Wisconsin crash database through the WisTransportal System	Human factors, Highway and traffic conditions, Accident characteristics, Environmental factors	Drugs; Speed; Rule violation; Reckless behavior; Visibility; Darkened roadways and areas without street lights
Islam *et al.* (2014), US [17]	Cross-sectional	Injury severity	The original police reported crash database	Driver characteristics, Vehicle characteristics, Temporal characteristics, Roadway characteristics, Accident characteristics, Land use characteristics, Environmental characteristics	Most significant factors in single-vehicle crashes in rural locations: Driver fatigue; African American drivers; Single unit trucks; Off peak (12:01 a.m. - 7:00 a.m.); PM peak; Wet surface; Ooverturned; Hitting fixed object; Shopping/business. Most significant factors in multi-vehicle crashes in rural locations: Male drivers; Driver fatigue; Hispanic drivers; Multiple unit trucks; Tire defect; Off peak (6:01 p.m. - 12:00 p.m.); Wet surface; State road; Rear end accidents; Open country. Most significant factors in single-vehicle crashes in urban locations: The W 26K trucks; Tire defect; Fog or mist; Roadway curves; Off-road accident. Most significant factors in multi-vehicle crashes in urban locations: Male drivers; Caucasian drivers; The W 26K (26,000 lbs) trucks; Roadway vertical grades (upgrade or downgrade); Darkness without light indicator; Rear end accidents
Dong *et al.* (2014), US [13]	Cross-sectional	Crash frequency	The Tennessee Roadway Information System (TRIMS)	Traffic factors, Geometric design of roadway intersections	Traffic volume; Truck percentage; Lighting condition; Intersection angle
Islam (2015), US [15]	Cross-sectional	Injury severity	NASS-GES crash database	Weather condition, Months of the year, Light condition, Trailing unit when the crash occurred, Vehicle role, Orientation of vehicle at the time of crash, Vehicle maneuver just prior to impending crash, Driver's attention level, Occupants' use of available vehicle	Distracted and sleepy driving; Male occupants; Drivers residing or working in the state of Texas; Not wearing a seat belt; Dark driving conditions; Time of day; Curved road segments; Wet surface conditions; Tire related defects; Semi-trailer involved in multi-vehicle crashes; Departing roadway; Rear-end collision; Head-on collision; Vehicle rollover; Speeding

Reference	Study design	Outcome	Data source	Factors	Most significant factors
				restraints, Location of the occupants in the vehicle, Gender of the occupants, Drivers' working/residing place according to license record, Vehicle maneuver during pre-crash situation, Time of the day, Speed, Number of vehicles involved in the crash, Road surface condition, Alignment of highway section	
Osman *et al.* (2016), US [22]	Cross-sectional	Injury severity	The High-way Safety Information System (HSIS)	Roadway characteristics, Traffic characteristics, Environmental characteristics, Temporal characteristics, Work zone characteristics, Crash characteristics	Daytime; No control of access; Higher speed limits; Rural principal arterials
Teoh *et al.* (2017), US [24]	Case–control	Crash risk	Field inspection, The Safety and Fitness Electronic Records (SAFER) system maintained by FMCSA (2012)	Characteristics of crash-involved trucks, Inspection violations, Driver characteristics, Carrier crash risk factors	Out of service (OOS) brake violations; Higher historical crash rates; Operating on a short-haul exemption
Dong *et al.* (2017), US [14]	Cross-sectional	Crash severity and frequency	The Tennessee Department of Transportation (TDOT) crash records information system	Traffic characteristics, Driver characteristics, Vehicle characteristics, Environmental characteristics, Geometric characteristics	Most significant factors affecting crash severity and frequency: Truck percentage; Annual average daily traffic (AADT); Driver condition; Weather condition Most significant factors affecting crash frequency: Driver age; Speed limit; Location type; Most significant factors affecting crash severity: Seat belt wearing; Light condition; Terrain type
Al-Bdairi and Hernandez (2017), US [10]	Cross-sectional	Injury severities	The Oregon Statewide Crash Data System provided by the Oregon Department of Transportation (ODOT)	Month of the year, Median type, Roadway surface condition, Driver license status, Vehicle manoeuvre just before impending crash, Participant level action, Participant level safety equipment use, Alcohol not a factor, Speed not a factor, Roadway characteristics, Number of vehicles involved in the crash	Large-truck drivers who are not licensed in Oregon; Median type; Fatigued drivers
Moomen *et al.* (2019), US [27]	Cross-sectional	Effective factors Truck crashes	Crash data was obtained from the CARE package from 2005 to 2015. Grade data and vertical alignments were obtained from WYDOT for two-lane highways in Wyoming.	Driver characteristics, Environmental factors, Collision characteristics, Roadway characteristics	Driver gender; Age; Weather; Lighting; Road conditions; Number of crest curves; Crash type; Number of driveways; Day of week and posted speed limit
Behnood *et al.* (2019), US [28]	Cross-sectional	Injury severity	Using the data from large-truck crashes in Los Angeles over an eight-year period (January 1,	Drivers' characteristics; Driver actions; Truck's characteristics; Crash characteristics; Crash time; Weather and environmental conditions;	Middle-aged drivers; Making a left turn; Time-of-day; Time-period; Daylight; Wet-road condition indicator and the rain indicators; Truck age

Reference	Study design	Outcome	Data source	Factors	Most significant factors
			2010 to December 31, 2017).	Roadway attributes; Heterogeneity in the means of random parameters.	
Wang *et al.* (2019), China [29]	Case study	Crash injury severity	A sample of 2695 heavy truck crashes occurring on four mountain expressways in Jiangxi and Shaanxi (China) between 2006 and 2015 was analyzed.	Geometric factors, Driver characteristic, Crash factors, Truck characteristics, Environmental characteristics.	Driving experience; Rear-end collision; Brake failure; Truck mechanical condition; Low visibility (foggy, rainy, or snowy); Road design curved (neither too sharp nor too long)
Al-Bdairi *et al.* (2020), US [30]	Cross-sectional	Crash severity	The crash data pertaining to ROR crashes involving large trucks in Oregon between 2007 and 2014 were utilized.	Factors contributing to ROR crashes in both models: Driver fatigue, Dry roadway surface condition, Dark with street lights, Colliding with a ditch, Seatbelt not used, The presence of horizontal curves, Exceeding the posted speed, Driving too fast for the conditions. Factors contributing to ROR crashes on urban roadways: Crashes occurring on vertical curves, Urban areas with a population density of between 10,001 and 25,000 and losing control of a vehicle. Factors contributing to ROR crashes on rural roadways: Young drivers between 20 and 45 years, Female drivers, Overturning crashes.	Driver fatigue; Dry roadway surface condition; Dark with street lights; Colliding with a ditch; Seatbelt not used; The presence of horizontal curves; Exceeding the posted speed nor driving too fast for the conditions; Crashes occurring on vertical curves; Urban areas with a population density of between 10,001 and 25,000; Losing control of a vehicle; Young drivers between 20 and 45 years; Female drivers; Overturning crashes
Ouedraogo *et al.* (2020), US [31]	Cross - sectional	Crash severity specifically with interest on heavy vehicles	A monthly truck-related crash dataset for January 2010, December 2018 was used (rural freeways in Ohio)	Speed limit change impact, Weather condition	Raising speed limits; Winter weather conditions
Uddin *et al.* (2020), US [32]	Cross-sectional	Injury severity	Crash data from the state of Ohio between 2011 and 2015 available from the Highway Safety Information System.	Driver characteristics, Crash characteristics, Vehicle characteristics, Roadway characteristics, Temporal characteristics.	Rural, rear-end and sideswipe crash parameters; Weather conditions; Roadway visibility; During normal condition: Dark-lighted; Speed limit (45 to 60 mph); 4 or more lanes; Asphalt; Time (7 a.m. to 9:59 a.m.); During rainy condition: Daylight; Speed limit (≥ 65 mph); Interstate Snowy condition: Urban; Curve; Truck trailer; Time (4 p.m. to 6:59 p.m.)
Azimi *et al.* (2020), US [33]	Cross-sectional	Injury severity	The data contained large truck rollover crashes that occurred between 2007 and 2016 in the state of Florida.	Roadway attributes, Vehicle attributes, Driver attributes, Temporal attributes, Heterogeneity.	Lighting conditions; Driving speed; Roadway conditions; The presence of horizontal curves; Driving speed between 20 - 49 mph; Hazardous material release; Not wearing a seat belt; Diver action; Driver condition
Liu *et al.* (2020), US [34]	Case study	Injury severity	Dataset containing 7,976 crashes involving large trucks is collected from HSIS in North	Driver characteristics, Roadway characteristics, Environmental related characteristics.	Speed limit over 50 mph; Driving under the influence of alcohol or drugs; Rural roadways; Dark light condition; Grade roadway

Reference	Study design	Outcome	Data source	Factors	Most significant factors
			Carolina between 2005 and 2013.		configuration; Roadway segments with traffic control
Li *et al.* (2020), US [35]	Cross-sectional	Severity of large truck crashes	Crash data collected from the Texas Crash Records Information System (CRIS) from 2011 to 2015.	Crash contributing factors, Lighting conditions, Roadway functional system, Traffic control, Lane width and shoulder width, Types of curbs, Location of first harmful event, Median type, Weather characteristics, Road alignment.	Driving under the influence of drugs/alcohol; Fatigue; Urban interstate highway; Urban other principal arterial; Crash occurred off-road
Haq *et al.* (2020), US [36]	Cross-sectional	Injury severity	10 years of crash data (2007–2016) on I-80 in Wyoming.	Rural and urban locations, Time of day, Lighting conditions, Roadway classification, Weather conditions.	Age and gender of occupants; Truck driver occupation; Driver residency; Sideswipes; Presence of junctions; Downgrades; Driver improper actions; Curves; Weather conditions; Behavior characteristics (such as impaired driving, use of alcohol or illegal drugs, seatbelts not being used, fatigue, and dangerous driving)
Behnood *et al.* (2020), US [37]	Cross-sectional	Crash-injury severity	Crash data from Los Angeles.	Truck's characteristics, Drivers' attributes, Crash characteristics, Driver actions, Weather conditions, Crash time, Roadway attributes.	Young drivers; Colliding fixed objects; Intersection related crashes; Crash time; Traffic signs and signals; The truck right of way; Broadside crashes; Rear end crashes; Collisions with fixed object and parked vehicle; Daylight indicator
Rahimi *et al.* (2020), US [38]	Cross-sectional	Injury severity	The dataset consists of crashes from March 2011 to March 2012 provided by the Iranian Traffic Police.	Driver's education, Crash characteristics, Advanced braking system deployment, Presence of curves on roadways, High speed-limit.	The education of truck drivers; Collision with fixed object / collision with animals; Truck weight; The number of lanes in each direction; Weather conditions
Yuan *et al.* (2021), China [39]	Cross-sectional	Fatal crash severities	Dataset (from 2012 to 2016) from the Fatality Analysis Reporting System (FARS) was used for analysis.	Environment characteristic, Roadway characteristic, Vehicle characteristic, Driver characteristic (age, gender, previous crash and traffic conviction histories, driving violation behaviors), Collision characteristic.	Adverse weather conditions; Rural areas; Curved alignments; Tractor-trailer units; Heavier weights; Various collision manners; Driving violation behaviors; Fatigue (carelessness); Weather conditions; The season; The day of week; Light conditions; Time period; Vehicle age (between 5 and 10 year)
Hosseinzadeh *et al.* (2021), US [40]	Cross-sectional	Crash injury severity	The data was extracted from suburban crash data between 2011 and 2014 in eight provinces of Iran: Isfahan, Qom, Qazvin, South Khorasan, Kerman, Mazandaran, Khuzestan, and the eastern district of Tehran.	MV truck-involved crashes, Truck-drivers at fault, MV truck-involved crashes, Non-truck drivers at fault and SV truck crashes.	Unsafe lane-changing; Deviation to the left

As indicated in Table 3, there are 23 factors involving large truck crashes, of which some factors are repeated several times. As shown in Table 4, 10 factors are the most common in large truck-involved crashes including speed, age, location, collision type, seat belt wearing, light condition, vehicle technical condition, time, road surface condition, and accident type.

Table 3: General factors contributing to large truck–involved crashes based on results of studies included

Factor	Reference number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Frequency
Speed			*	*				*	*	*			*	*	*			8
Age		*	*						*						*			4
Location	*		*	*					*		*	*	*	*	*			9
Collision type			*					*			*		*					4
Seat belt wearing							*		*				*		*			4
Light condition								*	*	*	*	*	*		*			7
Terrain type			*												*			2
Vehicle technical condition				*							*		*			*		4
GVWR					*						*							2
Time	*	*	*								*		*	*				6
Road surface condition		*		*				*			*		*					5
Carelessness				*			*	*										3
Distraction				*		*							*					3
Sleeping				*									*					2
Sex											*		*					2
Median type			*														*	2
Fatigue											*						*	2
Weather condition			*								*				*			2
Alcohol consumption						*	*	*										3
Use of medicines							*			*								2
Traffic volume												*			*			2
Truck percentage												*			*			2
Accident type			*						*		*		*					4

Table 4: The most frequent contributing to large truck-involved crashes based on results of studies included

Factor	Reference number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Frequency
Speed			*	*				*	*	*			*	*	*			8
Age		*	*						*						*			4
Location	*		*	*					*		*	*	*	*	*			9
Collision type			*					*			*		*					4
Seat belt wearing							*		*				*		*			4
Light condition								*	*	*	*	*	*		*			7

Vehicle technical condition				*				*		*			*	4
Time	*	*	*					*		*	*			6
Road surface condition		*		*			*		*		*			5
Accident type				*				*		*		*		4

DISCUSSION

This review has documented a few sound papers that were surveyed factors relating to large truck-involved crashes. However, no decisive conclusions can be provided about factors affecting large-truck crashes. Ten identified factors were discussed in the following sections. According to Table 4, factors that have been studied several times in included papers are speed (fortheen times), age (nine times), location (thirteen times), collision type (nine times), seat belt wearing (six times), light condition (thirteen times), vehicle technical condition (seven times), time (eleven times), road surface condition (eleven times), and accident type (four times).

High-speed in large truck-involved crashes may lead to greater levels of injury severity [18-20, 41, 42]. Based on the findings by Khorashadi *et al*., the severity of a driver's injury can be significantly influenced by excessive speed [18]. It has also been reported that failing to adjust speed to curves remarkably is associated with the rollover of the large trucks [14]. In addition, another study has been indicated that speed limits of ≤ 72 km/h is associated with a higher frequency of the large truck-involved crash than the speed limits of ≥ 80 km/h [26].

Driver age has a significant effect on the frequency of large truck-involved crashes [12, 26]. Khorashadi *et al.* verified that drivers' age between 15 and 22 are significantly associated with an increase of visible injury [18]. It has been revealed that the occupants (i.e., both drivers and passengers) with the age group between 55 and 65 are also more susceptible to be severely injured. This might also be associated with the physiological power and injury-sustaining ability of older individuals [19].

It has been revealed that location type has significant effects on the frequency and severity of large truck-involved crashes [11, 26]. Khorashadi *et al.* reported that interior lanes and left lane (in rural) and beyond the left shoulder, left lane, interior lanes, on/off ramp area, conventional road, inside city limit (in urban) have a significant effect on injury severity [18]. According to the findings of Osman *et al.*, rural principal arterial augmented the chance of "serious injury" relative to "no injury" outcomes [22]. Also, it has been indicated that intersections have an important effect on large truck crashes [14, 22]. This might also be associated with high speeds during turning [14] and other studies revealed that road curve sections are significantly associated with severe injury [19, 21, 23].

It has been found that collision has a significant role in increasing the severity of truck crashes. For instance, the study of Khorashadi *et al.*indicated that broadside collision type has an important effect on increased injury severity [18]. The findings of Islam (2015) showed that rear-end collisions augment the probability of incapacitating injuries by 22.2%, as well as, head-on collisions increase the probability of fatalities by 11.5% [15].

A seat belt is a passive vehicle safety feature designed to minimize the severity of injuries sustained by drivers and passengers in the event of a crash. It has been reported that seat belts significantly influence the severity of crashes involving large trucks [17, 19, 23, 26]. Failure to wear a seat belt result in an 11.5% more probability of being involved in a traffic accident with non-incapacitating injury consequences [23].

Light condition is recognized as an important factor in the severity and frequency of crashes involving large trucks [18-22, 26]. Crashes that happen at night are found to have augmented severity (relative fatality risk of 1.90). Because of lower traffic density at night, large-truck drivers have a much inclination to speed, thereby increasing the risk of more severe injury. Improvement of lighting conditions can noticeably decrease the crash severity and increase traffic safety [26]. Dark conditions lead to a 50.3% greater probability of fatalities since other vehicles might be entirely blinded by such uncomfortable driving conditions [23].

Safe vehicles play a serious role in preventing crashes and decreasing the probability of serious injury [27]. The study of Teoh *et al.* indicated that any out-of-service vehicle defect enhances crash risk by 362% [24]. Tire defect and brake condition are significantly associated with the severity of crashes, and large truck rollover crashes [14, 21]. Also, tire-related malfunction enhances the probability of incapacitating injury by 5.2%, shows the lack of vehicle maintenance resulted in weight imbalance and uncontrolled driving situations [23].

Time is significantly associated with occurrences and severity of crashes involving large trucks [11-13, 21, 23, 24]. For instance, Khorashadi *et al.* found that travel time (off-peak traffic between 8:00 a.m. and

3:00 p.m. and afternoon rush hour between 3:00 and 6:30 p.m.) is an important factor in enhancing complaint of pain [18]. Besides, off-peak (6:00 p.m. to 12:00 p.m.) enhances the likelihood of major injury in rural multiple-vehicle crashes while off-peak (00:01 a.m. to 7:00 a.m.) enhances the likelihood of major injury in rural single-vehicle crashes [21].

Road surface condition is important for safe driving, particularly in undesirable weather conditions such as snow or rain. Road surface condition has a significant effect on the occurrence and severity of crashes involving large trucks [12, 14, 18, 21, 23]. For instance, wet pavement condition is enhanced by 9.4% of the probability of possible injuries due to undesirable driving and braking on slippery road circumstances for other motor vehicles and the braking features of large trucks [23].

Five types of accidents including when an accident is caused by another truck, departs from the roadway, vehicle rollover, hitting a fixed object, and off-road accidents were considered in this study. Accident type plays a critical role in the severity of crashes [13, 19, 21, 23]. Around 99.9% of crash incidences in which a large truck departs from the roadway will suffer a higher degree of injury severity, while 0.1% will less severe injuries [19]. Also, in accident type such as vehicle rollover the probability of incapacitating injuries enhances by 9.6%, which are complicated in temperament for crashes involving multi-vehicle [23].

RECOMMENDATIONS

This study proposes the following ways to reduce crashes involving large trucks:

Making speed hump and speed table for reduced speed [43].

Installation of speed cameras [44].

Enhancing economic penalties for reducing speed.

Reducing speed in intersections, road curved sections, on/off ramp areas.

Increasing vehicle strength to reduce the severity of injuries.

Using intermediate barriers in preventing head-on collisions.

Maintaining a safe following, distance for reducing rear-end collisions.

Increasing financial fines for failure to wear a seat belt.

Providing favourable lighting for streets and roads.

Timely replacement of tires.

Regular inspection of brake conditions.

Improving the quality of the road standards [45].

Slowing down speed and no more brakes on slippery roads.

CONCLUSIONS

This study presented a review on factors affecting crashes involving large trucks by including ۳۱ papers. Factors that were repeated four times or more were discussed. Results showed that key factors are including speed, age, location, collision type, seat belt wearing, light condition, vehicle technical condition, time, road surface condition, and accident type. From the viewpoint of this study, speed, location, and light condition seem to be the most frequent factors in crashes involving large trucks. Our results can help the traffic police, transportation agencies, and safety experts in knowing and controlling the factors affecting crashes involving large trucks.

ETHICAL ISSUES

The local ethical review Committee of Tabriz University of Medical Sciences approved the study (IR.TBZMED.REC.1396.1103).

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHORS' CONTRIBUTIONS

Milad Safari: Writing and original draft preparation. Khaled Zoroufchi Benis: Review and editing. Seyed Shamseddin Alizadeh: Methodology, writing, review and editing. Homayoun Sadeghi Bazargani: Review and editing. Mohammad Shakerkhatibi: Methodology, writing, review and editing.

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