A Comprehensive Review on Risk Factors Affecting the Crash Severity

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ABSTRACT

As a matter of growing machinery life, traffic crashes are considered an inevitable source of injuries and costs around the world. Regarding to increasing traffic accident outcomes, controlling the current status is necessary. In this way, identifying risk factors affecting the crash severity is an essential step toward initiating a convincing solution. The core objective of this study was to categorize the risk factors affecting the severity of crashes. Data needed for this study were gathered through searching Web of Science, Google Scholar, and Science Direct databases using the keywords included fatal and crash, injuries and crash, fatal and traffic accident, and injuries and traffic accident. Based on 83 selected studies for review, factors affecting the crash severity divided into five factors and forty-seven sub-factors. The most prevalent sub-factors were age, sex, safety belts, alcohol and drug use, speed, weather conditions, lighting conditions, time of the day and week, vehicle kind, road condition, collision type and crash location. Many risk factors affect crash severity and determination of the most important ones can be a prelude in reducing the effects. Therefore, the conclusion of this review can assist to traffic safety experts, police and contribute to distinguishing and monitoring the risk factors affecting crash severity transportation agencies.

Keywords: Traffic; Crash Severity; Risk-Factors; Road Transport System

INTRODUCTION

Road transport system is a pivotal structure for economic growth and social progress of a country [1] in which the boosting machinery life and road traffic are combined with road accidents [2]. This common phenomenon is the leading cause of severe injuries, deaths, that burden an enormous financial losses, and serious social effects, especially in low-medium income countries [3]. A road crash could be elucidated as the collision of a vehicle with other metal, body, etc. [4] and this collision type is one of the most important causes of death and injuries in road accidents. The rollover crashes have been identified as the main reason for fatal and severe injuries in road accidents [3]. Rollovers are a type of vehicle crash in which a vehicle tips over onto its side or roof [5].

Historically, road crash outcomes are considered as unpredicted events, but now, they are a great menace for health, worldwide [6, 7], since road accidents are one of the extensive causes of trauma in high-income countries. The injuries resulting from traffic accidents in four-wheeled motor vehicles include of injury to head, chest and lower limbs, whereas in two-wheelers the most important injuries were comprised injury to intracranial and shoulder girdle [8, 9]. Hence, death and injuries could be impending outcomes of traffic accidents. These injuries are divided into two groups namely short-term and long-term disabilities [10]. The short-term disabilities are allocated to returnable harm to physical or mental abilities, and long-term disabilities can be defined as worsening physical or psychological abilities [10]. The reductions in productivity and quality of normal life as well as, the cost of the legal system, and suffer of discomfort are only the minor side effect and social consequence of this pervasive incident [11].

According to the World Health Organization (WHO), road accidents are one of the main causes of fatality in people aged between fifteen to twenty-nine years. Also, the statistical sources revealed that it was the reason of highest mortality among 16-20 years old people during 1995-2005 and among these accidents, the pedestrians and passengers of cars had the highest mortality rate [12]. Additionally, depending on the report of WHO (2004), road deaths accounted for 25% of all deaths from injury [13, 14].

Milad Safari[1], et al., A Comprehensive Review on Risk Factors...

HSE
IJ

Based on WHO report, European and African countries have possessed the lowest and highest mortality rates due to road accidents, respectively [12]. The results of an investigation by Jost *et al.* denote that, approximately 25,000 people died in the European Union (EU) due to road accidents while about 313,000 were severely injured and quite a lot suffered from minor injuries [15]. According to WHO, the road traffic fatality rate per 100,000 population was found 26.6 in the African region [12]. Nowadays, the ratio of road crash injuries per time have been increased to every two and fifty seconds, respectively [16]. thus, WHO has reported more than 1.25 million death annually as a result of these huge amount of traffic accidents and more than 20 and 50 million persons suffer from non-fatal injuries [17]. In 2002, statistics indicated, nearly 90% of the annual disability-adjusted life years (DALYs) and 85% of the deaths in low- and middle-income countries accrued due to the road traffic injuries [18, 19].

Up to 2% of gross national product (GNP) in middle- and low-income countries is devoted to road accidents that [20-22], the financial cost of corresponded injuries is estimated of US$ 65 billion, more than the total income of these countries in development assistance [23]. If proper actions are not carried out for preventing the road traffic-related injuries, this factor can be enumerated as the 3rd cause of DALYs by 2020 and the 5th cause of death until 2030, bringing about almost 2.4 million dies around the world, ahead of other health difficulties like tuberculosis, malaria, and HIV [7, 18, 22, 24].

Previous studies have shown that behavioural factors have a share of 90% in road accidents which indicates that human factors are the most crucial factor in the occurrence of a road accident [25-30]. With regards to these dramatic reports and increment of the fatal and severe injuries worldwide, controlling traffic accidents is a must for modern communities. In this way, determination of pragmatic solutions are essential for reducing crash severity, highly demands distinguishing the risk factors which affect crashes severity. The purpose of this review was to categorize the risk factors based on their effect on crashes severity with the hope of offering a sufficient and competent tool and insight for police, traffic safety experts, and transportation agencies for predicting and preventing the potential accidents. In the presented review, the risk factors affecting crash severity are categorized into five groups: human, vehicle, road, environment, and accident characteristics factors.

a. Human factors
Human factors are comprised of the driver's age, gender, driving experience, education, income, social status, occupation (e.g., military and police, general staff members, farmers), etc. [30].

b. Vehicle factors
Vehicle factors include vehicle kind (e.g., passenger vehicles, goods vehicles, motorcycles, etc.), vehicle safety status, whether the car is a commercial car, a vehicle overload condition, whether the car has any obligatory third-party insurance, etc. [30].

c. Road factors
Road factors encompass the types of traffic lanes, types and grades roads (ordinary highways, expressways and urban highways), etc. [30].

d. Environmental factors
Environmental factors consist of street-light condition, visibility level, weather conditions, time of the day and week, year and season of the accident, etc. [30].

e. Accident characteristics factors
Accident characteristics factors include number of vehicles involved in the accident [31], crash location (intersection, non-intersection, urban, rural) [27], accident type [32], etc.

To the best of our knowledge, a few studies categorize the risk factors based on their effects on crashes severity, and their content is limited to only presenting the outcomes of the previous studies. Hence, the main objective of this study was to fill this knowledge gap and categorize of risk factors based on their effects on the severity of the crashes.

MATERIALS AND METHODS
Eligibility Criteria
The inclusion criteria for the study included studies on the factors affecting crash severity. The exclusion criteria for this study were abstracts, theses, studies published after 1993.

Information Sources
To do so, a literature review was done for investigating the risk factors based on their effects on crash severity. In this regard, electronic databases including the Web of Science, Google Scholar, and Science Direct were applied for reaping the benefit of relevant studies, and the utilized search terms comprised of 'fatal and crash', 'injuries and crash', 'fatal and traffic accident', and 'injuries and traffic accident'.

Review Process
In the first step of study selection, studies with irrelevant titles were excluded. In the second step, full text of studies were reviewed to include those papers matching the inclusion criteria. Reference management (Endnote X9) were applied for arranging and assessing the titles and as well as for recognizing any duplicate entries.

This study was conducted on the basis of the following steps: collecting some of the factors affecting crash severity by using the many numbers of various

references, categorizing factors, and discussing the most important sub-factors.

RESULTS AND DISCUSSION

In this study, 520 studies were reviewed but only 83 studies were related to the study aim and thus included in the study (Fig. 1).
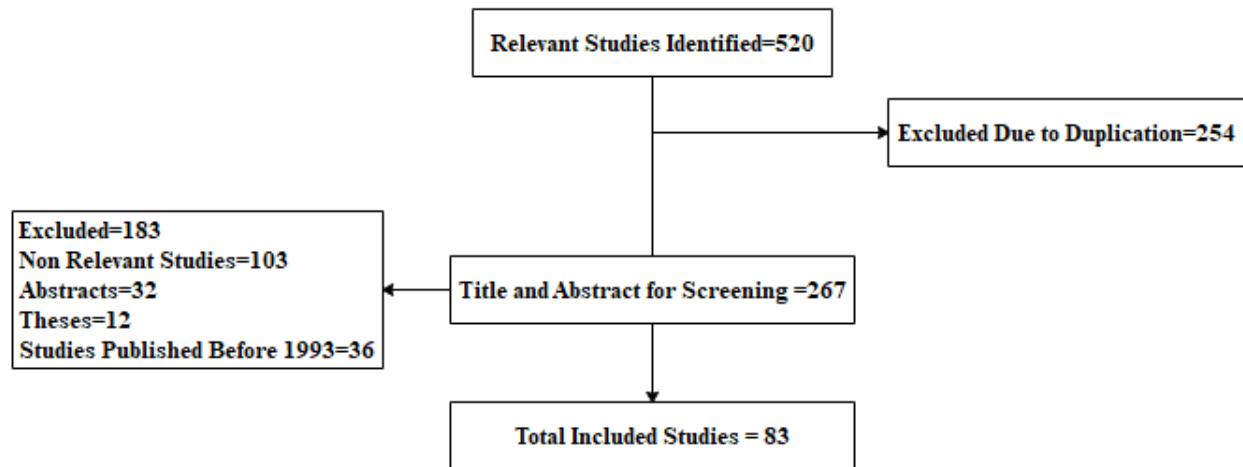

Fig. 1: Bibliographical search and inclusion process

The accumulated data were classified into five factors and 47 sub-factors, and are tabulated in Table 1.

Human Factors

Human factors in traffic safety are the most important issues for analysis. There are, however, complicated associations between traffic safety and human factors [25, 28, 29]. In this study, the human sub-factors of age, sex, safety belts, alcohol and drug use, and speed were identified as the most essential ones.

a. Age

Increased age was a significant factor affecting injury severity caused by road traffic crashes [33]. The old subjects (aged ≥ 65) are the most vulnerable road users, who have the highest risk of mortality after a traffic accident both when driving motor vehicles or as a pedestrian may be due to comorbidity which decreases the probability of recuperation from traumas and driving injuries [27, 34, 35]. For example, Celik and Oktay asserted that older drivers (aged ≥ 65) were twenty times more probable to have fatal injuries [31]. In addition, at Shanghai River-crossing Tunnel, the older drivers (aged ≥ 65) represented a greater risk of severe injuries in traffic crashes than drivers from the other age groups [36]. Regarding to the 15-24 years old working drivers, those who were in more than 65 years old were almost twice (OR: 1.82; 95% CI: 1.11, 3.01) as probable to die or be seriously injured due to a work-related crash [26]. Compared with drivers from the other age groups, drivers at least 65 years (OR: 1.70; 95% CI: 1.03, 3.74) and young drivers (aged ≤ 25 years old) (OR: 1.16; 95% CI: 1.02, 1.43) were recognized to have effects on enhancing the odds of being high individual severity in crashes at intersections [37]. The underlying reasons could be the weak and slow reaction capability [37], sight power, and lack of muscle power which might be responsible for higher involvement of aged drivers in serious crashes [38]. A multivariate logistic regression disclosed that the odds ratio of a fatal injury augmented with age, arriving 4.98 (99% CI: 2.01, 12.37) for vehicle drivers aged over 80 years old than those between 40-49 years [39].

In addition to old subjects, the other age groups are significantly associated with an increment of the severity in the crashes. For example, Kadilar showed that drivers between 46-55 years old were 1.31 times more possible to be involved in a fatal accident than drivers at least 56 years [40]. Theofilatos *et al.* found that drivers with 31-46 years old compared with drivers with the age group of over 60 (OR: 1.47) in outside urban areas and also drivers with age group 18-30 years old (OR: 1.28) and over 60 (OR: 1.72) in inside urban areas have significant relationship with increased severity of an crash [32]. Another source indicated that occupants with age group of over 60 were associated with the declined likelihood of major injuries [43]. Also, it has been reported that at-fault drivers between 25-39 years old involved in a crash augments the risk with more serious injuries than drivers with age group under 25 years old. This enhancement resulted in a rise of serious injury and fatal injury about 13% and 4% respectively, and a decline of 17% of slight injury for at-fault drivers between 25-39 years old. The researchers suggested that for reducing these injuries, it was vital to increase the training and supervision for the vehicle drivers, particularly for whom drive two- or three-wheel vehicles [41]. Rahimof and Sadeghi by providing a

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model found that drivers aged less than 35 years had the highest impact on crashes severity in the freeway [42].

Table1: Risk factors affecting crash severity

No.	Factor	Frequency of sub-factors	Sub-factors
1	**Human**	16	Age [26, 27, 31-37, 39-43], Sex [27, 30, 35, 36, 39, 43-50], Driver's education [40], Driver's occupation [26, 51], Driver's driving experience [52], Distraction [53], Driver's body weight [54], Position in vehicle (driver, front seat, back seat) [33], Having third party insurance [30], Seat belt [35, 39, 40, 48, 55-62], Consumption of alcohol and drugs [39-41, 61, 63-77], High speed [26, 39-41, 52, 63, 78-84], Impairment [53], License status [26, 52], Tailgating [52], Improper overtaking [51].
2	**Environmental**	9	Bad visibility [61], Weather conditions (rain, fog, snow, wind) [3, 48, 51, 63, 68, 76, 85-91], Lighting conditions [30, 43, 48, 51, 76, 77, 81, 92-97], Wind speed (km/h) [98], Temperature [89], Season [87], Crash time [32, 34, 35, 37, 38, 40, 87, 99-101], Day of week [30, 36, 43, 45, 48, 80, 94, 102-104], Month [30, 35, 105].
3	**Vehicle**	6	Type of motor vehicle (passenger vehicle, goods vehicle, 2-wheel vehicle, etc.) [30, 34, 36, 37, 51, 52, 57, 79, 106-109], Vehicle age [48, 110], Vehicle overload [30], Vehicle safety status (defective tires/lights/ mirrors/ brake/ steering wheel) [30], Purpose of vehicle use (private, commercial) [31], Vehicle weight [111].
4	**Road**	11	Type of road (ordinary highways, expressways and urban highways) [30], Road surface conditions (wet/ icy/ unclean road) [36, 40, 76, 95, 97, 112-117], Unpaved shoulder width [51], Number of travel lanes [43, 51], Road alignment (Straight, Curve) [27, 50], Road profile (Level, Grade) [27], Near tunnel entrance/ exit [87], Tunnel length [87], Type of area [41, 51], Length of ramp [76], Road alignment [97].
5	**Accident characteristics**	5	Number and vehicles involved in the accident [31, 43, 79], Crash location (intersection, non-intersection, urban, rural) [27, 32, 34, 37, 43, 56, 77, 79, 80, 87, 97], Accident type (hit fixed object, animal, etc.) [32, 80], Distance from a hospital [61], Collision type (right-angle, sideswipe, front, etc.) [32, 34, 39, 40, 43, 57, 76, 77, 80].

b. Sex

In accordance with the findings presented in the literature, sex is repeated frequently as one of the sub-factors affecting crash severity [30, 39, 43-50]. In spite the fact that women were involved in less severe crashes and were less probable to die in a car crash relative to men drivers, non-fatal injuries as contrary to no outcome happened more often among women drivers [35]. For example, Valent *et al.* unfolded that the risk of entanglement in fatal rather than non-fatal crashes was lower among females than males (OR: 0.65; 95% CI: 0.53, 0.80) [35]. Lu *et al.* found that male drivers insinuate a greater risk of crash severity than female ones (OR: 1.93; 95% CI: 1.18, 3.16) in traffic crashes at Shanghai River-crossing Tunnel [36]. Another study by Kaplan and Prato indicated that the greater occupational risks for bus drivers belong to women bus drivers and the severity of corresponded bus crashes was lower in male bus drivers in comparison with their female counterparts, especially for light injury crashes [27].

c. Seatbelt

Many papers have highlighted the fact that utilization of seatbelts decreases traffic crashes injury or death, and also lack of seatbelt usage increases the likelihood of more severe crashes [40, 55-60, 62] and the failure of seatbelts usage lead to an enhanced injuries among drivers (OR: 13.27; 95% CI: 9.39, 18.74), for fatal injury and (OR: 2.49; 95% CI: 2.17, 2.86), for non-fatal injury [35]. Seatbelt utility is considered as one of the significant factors influencing the severity of an

injury of single-vehicle crashes for goods transport vehicles [48]. The conditional percentage of fatal and severe injury when the occupants appropriately used a seatbelt and when the seatbelt was not worn was 24% and 45%, respectively [48]. Due to the lack of seatbelts application has served a 24% greater likelihood of sustaining an injury, and an 80% higher likelihood of death [61]. As a proof of this fact, the investigation of Be´dard *et al.* showed that in comparison with no belt circumstances, employing three-point safety belts were protective against deadly injuries (OR: 0.46; 99% CI: 0.39, 0.53) [39].

d. Consumption of Alcohol and Drugs

Alcohol and drug-impaired driving have been recognized as a significant factor in defining the probability and severity of highway crashes [64]. Alcohol has been indicated to augment the probability of risky driving habits and affect the driver's capability to control the motor vehicle [70].

Many authors have considered alcohol and drug-impaired driving as one of the risk factors affecting crashes severity in recent years [40, 65-67, 69, 71-75]. The study of Abegaz *et al.* showed that driving after alcohol consumption was a significant reason of alcohol-impaired drivers were more probable to sustain severe injuries relative to non-drunk drivers (*p*-value: 0.017) [63]. The study of Zhu and Srinivasan (2011) showed that alcohol-impaired car drivers were involved in severe high accidents [77]. For example, driving under the influence of alcohol was related to the 19% to 23% increase in the likelihood of serious

injuries and fatal traffic accidents [61]. Alcohol consumption was found the important and associated positively with injury severity (*p*-value: 0.001). It caused a reduction of serious and slight injury by 3.44% and 16.20%, respectively and an augment of 19.64% of fatal injury [41]. An increased likelihood of traffic injuries by 14.80% due to alcohol usage [76]. Drivers who possessed more than 0.30 (OR: 3.16; 99% CI: 1.96, 5.09) blood alcohol concentration (BAC) were associated with an augmented odds of mortality [39]. When alcohol or drugs were involved, the risk of serious injuries or mortality was about 3% greater, and the risk of no injury was 20% lower in single-truck crashes [68].

e. High Speed

Driving speed not only is one of the crucial factors that influence the severity of a crash but is also associated with the chance of being involved in a crash [83]. High speed as one of the risky behaviours affecting crashes severity has been the focus of research attempts in recent years [26, 39, 52, 63, 79-82, 84]. For instance, the motor vehicle driving at speeds +111 km/h have three times more risky than driving at speeds –56 km/h [40]. With no doubt, speeding is in close relation with the severity of injuries; for instance, it reduced slight injury by 23.72% and increased serious and fatal injuries by 14.06% and 9.66%, respectively for speeding drivers in traffic accidents on two-lane highways [41].

Environmental Factors

Environmental factors are the deterministic factors affecting the severity of crashes (Table 1). In this paper, the sub-factors of weather conditions, lighting conditions, time of the day and, the day of the week were identified as the most important sub-factors.

a. Weather Conditions

Based on the literature, the weather conditions comprised of rain, fog, snow, wind, etc., are the most significant environmental sub-factors affecting the severity of crashes [3, 48, 68, 76, 85, 88-90]. For instance, it has been reported that the risk of "fatal injuries" (95.5%) and "injuries" (65.9%) under unfavourable weather was probably lower than those happened under favourable weather conditions [87]. It could be due to the driver's tendency to driving more warily under unfavourable conditions [82]. The findings of Osoro *et al.* indicated that traffic crashes during rainy weather (OR: 2.90; 95% CI: 1.30, 6.50) were associated with a severe injury because it reduced visibility and increased slippery roads which caused reduced ability to control the vehicle by drivers [91]. Anarkooli *et al.* found that rainy weather conditions decreased the likelihood of no injury and slight injury by 6% and 26%, respectively while it augmented the likelihood of killed or seriously injured (KSI) by 27% [51]. It has been revealed that driving in

rainy weather conditions were significantly associated with severity of crash injury compared with the driving on a clear or other weather condition (*p*-value: 0.001) [63]. The results of Jung *et al.* showed that the most severe traffic crash was 1.79 times more probable to happen as rain precipitation intensity for fifteen minutes was getting stronger, which implies that vehicle drivers tend to understand the risk of a vehicle driving by the rain precipitation less sensitively [86].

b. Street-light Conditions

The street-light conditions are divided into three categories including natural daylight, favourable street lighting at night, and no street lighting at night. In accordance with the literature review, the street-light conditions are further significant environmental sub-factors which could be responsible for the severity of traffic crashes [76, 77, 81, 92-94, 96]. For instance, it has been reported that in the case of street-light shortage or no street-light conditions, traffic crashes will have a greater risk of being involved in severe-injury crashes relative to traffic crashes happened under daylight [97]. The likelihood of KSI injury of single-vehicle rollover crashes was augmented under dark light condition by 34% but, vice versa, it decreased the likelihood of slight injury by 37% [51]. Even though, the daylight and good lighting had a higher risk of severe injury relative to poor street lighting (OR: 0.58; 90% CI: 0.33, 1.02) for private vehicles due to the fact that drivers often drive slower and safer in poor lighting conditions [48]. The findings of Zhang *et al.* indicated that driving in poor street lighting conditions had a great proportion of severe crashes [30]. Islam and Hernandez concluded that the road traffic crashes that took place under dark highway segments raised the likelihood of fatal injuries by 11.5% and incapacitating injuries by 10.4% [95]. This likelihood in trucks crashes transporting hazardous materials was augmented under both dark-unlighted and dark-lighted conditions by 371% and 292%, respectively [43].

c. Crash Time

The time of a crash is classified into three-time intervals including daytime (10 am - 5 pm), night time (8 pm - 7 am), and peak time (7 am - 10 am or 5 pm - 8 pm) [37]. Many studies have referred the time of crash as a significant factor associated with crashes severity [34, 38, 99-101]. As an example, the greater odds of death in happened crashes from 1 am to 5 am, has been reported, compared with those happened from 6 am to 11 am, among pedestrians, car drivers, motorcycle and moped riders [35]. Still, the risk of fatal and non-fatal injuries during day-time are likely 46.7 and 1.8 times greater in comparison with the night-time, respectively [87] and Kadilar declared the less likelihood of fatal traffic crashes during day-time relative to twilight crashes [40], Furthermore, another

source reported more serious crashes tend to happen at night and traffic crashes which had 19% greater risk of fatal or serious injury and extensive damage than traffic crashes happened during daytime [37]. The corresponded odds ratio was higher in outside urban areas (0.82) than the urban areas (0.72) [32].

d. Day of the Week

Several studies have designated the day of the week as another deterministic factor which contributed to the severity of crashes [45, 80, 94, 102-104]. For instance, Yau showed that the ratio of severe and fatal injuries in crashes of goods vehicles were variable among the weekdays ('Monday-Thursday': 29%, 'Friday-Sunday': 42%) [48], and compared with weekend crashes, hazardous materials truck crashes happening during days of week were found to be more severe (the probability of involvement in a crash with major injuries augmented by 91%, while the probability of involvement in a crash with no injuries reduced by 51%). The higher traffic volume during weekdays could be a plausible reason behind the highlighted accidents among weekdays [43]. Yau also stated that crashes involving motorcycles that occurred during weekends ('Monday-Thursday': 29%, 'Friday-Sunday': 42%) had a greater proportion of fatal and serious injury. This may be because of risky driving practices and increase of motorcycles on weekends [48]. Confirming the results of this study, weekdays (OR: 0.68, 95% CI: 0.49, 0.97) were less probable to be involved in serious or fatal crashes than weekends at Shanghai river-crossing tunnel [36].

Vehicle Factors

As presented in Table 1, the increase in crash severity is associated with vehicle factors. Among the vehicle sub-factors, the type of vehicle is the most important because of its high repetition in the previous studies. Type of vehicle encompasses passenger vehicles, goods vehicles, and vehicles on two-wheels. A large number of previous studies has been asserted that the type of vehicle is significantly associated with the severity of crashes [34, 57, 79, 107, 109]. It has been reported that goods vehicles indicated a greater proportion of severe crashes than others [30, 36]. The findings of Shawky *et al.* exposed that truck involvement traffic crashes have a greater likelihood of fatal Rear-End (RE) crashes [52]. It has been revealed that while truck is involved in RE crashes, the likelihood of vehicle driver fatality augmented from 0.3% to 6.1% relative to its likelihood under regular situations. The chance of vehicle driver injury also augmented from 37.1% to 44.9% [106]. According to the report of Jafari Anarkooli *et al.*, if a light truck vehicle is involved in the rollover crashes, the likelihood of KSI augments by 31.0%, while the chance of slight injury outcome reduces by 57.6%. The study also stated that, if rollovers involved heavy

vehicles, the likelihood of sight injury and KSI would increase by 5.9% and 4.6%, respectively. An effective precautionary master plan for light-truck and heavy vehicles, which are more susceptible to a rollover, is to develop rollover prevention system to reduce the risk of rollover traffic crashes [51]. It has been reported that compared with light vehicle, two-wheel vehicle (OR: 3.63; 95% CI: 2.53, 5.75) and heavy vehicle (OR: 0.13; 95% CI: 0.11, 0.23) had important effects on the severity of injuries [37]. The findings of Islam *et al.* denotes that compared with passenger cars, light trucks (particularly SUVs and pickup trucks) were more probable (almost two times) to be involved in fatal injuries of rollover crashes. A possible explanation lies in the fact that light truck has less stability in comparison with passenger cars [108].

Road Factors

Road factors are the most crucial factors affecting the severity of crashes. As can be seen in Table 1, the condition of road surface is the most important sub-factor related to the road conditions.

a. Road Surface Conditions

Road surface conditions which include wet, icy, and unclean surface are considered as extra essential sub-factors of road affecting the severity of traffic crashes [76, 112-117]. In spite the fact that drivers in rainy conditions decrease their speed, the injuries could have lower severity level. The results of Wang *et al.* indicated that traffic crashes which happened on wet road surface had a higher potential for serious injury or fatal outcome compared with traffic crashes happened on a dry road surface. It has been reported that compared with dry road surface (OR: 0.63; 95% CI: 0.41, 0.95), wet road surface had a higher effect on the severity of injuries [36]. It has been reported that dry pavement crashes in rural areas decreased the probability of no injuries, but augmented the probability of fatalities by 55.0%, incapacitating injuries by 57.9%, non-incapacitating injuries by 31.5%, and probable injuries by 33.0%. However, dry pavement crashes in urban areas decreased the chance of probable injuries by 86.7%. In keeping with these studies, dry surface condition crashes in urban areas augmented the probability of fatalities by 35.4%, incapacitating injuries 62.6%, and non-incapacitating injuries by 27.8% [95].

Accident Characteristics Factors

A search in the literature showed that accident characteristics are also involved in the rise of the crash severity. Hence, five sub-factors of this element are presented in Table1. In this study, the collision type and crash location are considered as the important sub-factors due to their high frequency in the previous studies.

a. Collision Type

Collision type includes right-angle, sideswipe, front; etc. which based on the previous studies serves a considerable effect on the severity of the crash [32, 34, 40, 57, 76]. For example, the findings of Hassan and Al-Falah showed that compared with other collision points, head-on collisions had greater odds (1.12 times) of being involved in fatal crashes [80] and It has been revealed that head-on collisions were the most severe in traffic crashes involving trucks and cars. This assertion is instinctively reasonable due to the substantial differences in the size of two vehicles, weight and, the relative speed of impact regarding the opposing directions of two vehicles movement [77]. While in RE collisions, the likelihood of major injuries has been reduced by 142% and the likelihood of no injuries was found to augment by 84%. This finding is intuitive since RE collisions mostly cause vehicle structural damages [43]. Also, the sideswipe collision as one of the collision types, have a considerable effect on the severity of the crash. Confirming this issue the findings of Be´dard *et al.* indicated that in comparison with front collision, the driver-side collision had a greater risk (twice) of being involved in a fatal accident [39].

b. Crash Location
A significant association has been found in the literature between the crash location and the severity of crashes [34, 37, 56, 77, 79]. For example, it has been reported that an intersection-related traffic crash has a lower chance of causing fatal and serious injuries in comparison with non-intersection-related traffic crashes [80, 97]. This issue is also highlighted for bus crashes so that the intersection-related bus crashes augmented the likelihood of incapacitating, severe non-incapacitating, and light injuries by 7.0%, 27.5%, and 6.6%, respectively, and slightly decreased the likelihood of fatal injuries by 0.7%. Although this finding respects the fact that collision type in intersections causes greater severity of injury, the risk of fatality remains comparatively low, because of low speed at the intersections [27], and non-intersection-related vehicle crashes were 1.77 times more probable to cause fatal and severe injuries [32]. Type of highway and tunnel features also significantly associated with the severity of crashes. The study results of Ma *et al.* pinpoint an enhanced injury among occurred crash in the tunnel entrance and tunnel exit, compared with traffic crashes happened inside the tunnels and the underlying reason could be the sudden change in geometry, weather, and light conditions near the tunnel entrance and tunnel exit which may disturb drivers' concentration and cause more severe crashes [87] and it has been revealed that highway hazardous material truck crashes happening on non-interstate highways, the probability of major injuries reduced by 113% and the probability of no injuries augmented by

47% for the vehicle occupants. This could be due to the lower volume of traffic on non-interstate highways [43].

CONCLUSIONS
In the presented work, a review on the risk factors affecting crashes severity has been conducted. In this review, by applying a wide variety of references, risk factors affecting the severity of crashes categorized into five factors and 47 sub-factors. Afterwards, based on the literature review, the sub-factors that have an important effect on the severity of crashes were discussed. The limitations of this study are including:
- In this review, studies that were written in English were included.
- Papers were included in this study if they specifically investigated risk factors affecting the severity of crashes

In the light of aforementioned points, this study proposes the following ways to reduce deadly accidents:
- Restricting driving for the aged people.
- Increasing driver training program for women.
- Increasing driving financial penalties when using alcohol.
- Institutionalizing the culture of using the seatbelt.
- Increasing the utilization of speed controller cameras.
- Using speed humps and raised platforms.
- Traffic safety training to drivers when driving in unfavourable weather conditions.
- Providing sufficient lighting on roads and streets.
- Decreasing night-time driving, as much as possible.
- Designing safer vehicles to reduce injuries in the case of the collision.

Safety experts, police, and transportation agencies can reap the benefit of this article by identifying and controlling the risk factors affecting the severity of crashes.

ETHICAL ISSUES
Ethical issues have been completely observed by the authors.

CONFLICT OF INTEREST
There is no potential conflict of interests for each author, concerning the submitted paper. The local ethical review Committee of the Tabriz University of Medical Sciences approved the study (IR.TBZMED.REC.1396.1103).

AUTHORS' CONTRIBUTIONS
All authors equally help to write this manuscript.

Milad Safari[1], et al., A Comprehensive Review on Risk Factors...

HSE
IJ

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Milad Safari[1], et al., A Comprehensive Review on Risk Factors...

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