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Factors Influencing Pedestrian Traffic Collision in Iran: A Qualitative Content Analysis

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ABSTRACT

Objectives: This study aimed to explore experts' perspectives on the factors influencing pedestrian traffic collisions in Iran.
Methods: This qualitative study was conducted using conventional content analysis with an inductive approach from September 2023 to March 2024. Twenty-six experts were purposefully selected from across Iran. Data were collected through individual face-to-face interviews, guided by a semi-structured interview, developed by a panel of experts and contained open-ended questions. Data analysis was performed manually using the Graneheim and Lundman approach (2004). To ensure trustworthiness, four strategies proposed by Lincoln and Guba were employed.
Results: The results revealed two main categories: direct factors and underlying factors, comprising nine subcategories. Direct factors included five subcategories: driver, pedestrian, roads and streets, vehicle, and geographic factors. Underlying factors included four subcategories: governance factors, social determinants, cultural conditions, and economic status.
Conclusion: The study identified key risk factors associated with pedestrian collisions according to experts' experiences. We recommend further qualitative studies to explore high-risk behaviors among pedestrians and drivers in depth. Additionally, systematic reviews should examine strategies employed by developing and successful countries to prevent or reduce pedestrian collisions.

Keywords: Pedestrian, Traffic collision, Health system, Iran.

Introduction

Traffic collisions pose a serious threat to human life, particularly to vulnerable road users such as pedestrians [1]. According to the World Health Organization (WHO), pedestrians account for 19% of global traffic fatalities, a significant proportion compared to other modes of transportation [2]. In the USA, over 70,000 pedestrians were injured annually in motor vehicle collisions between 2010 and 2020 [3]. In Iran, traffic collision fatalities reached 31.8 per 100,000 population in 2022 [4], yet around 60% of pedestrians disregarding or violating crosswalk rules [5]. Numerous studies have examined pedestrian collision prevention and mitigation strategies [6-8]. Extensive research has also focused on prehospital care and mortality reduction following pedestrian-involved collisions [9-11]. However, most studies have addressed specific aspects of the collisions rather than taking a comprehensive approach. Few investigations have holistically analyzed the contributing factors to pedestrian collisions, resulting in fragmented evidence in the existing literature [10].

A comprehensive analysis of the literature review revealed that most of the previous studies on pedestrian accidents employed quantitative rather than qualitative methodologies. Qualitative studies similar to the present research, which aimed to incorporate the valuable insights of traffic experts, safety engineers, and accident prevention specialists, have been conducted, primarily in underdeveloped nations. Given the escalating rates of pedestrian casualties, particularly in Iran, there is both a critical need and urgency to systematically document and analyze expert perspectives on the causative factors of pedestrian accidents.

Materials and Methods

This qualitative study was conducted using content analysis to explore expert perspectives on factors influencing pedestrian collisions in Iran from September 2023 to March 2024.

The research included Iranian participants who met the following criteria: recognized expertise in pedestrian collision research or prevention, willingness to participate, and ability to provide comprehensive information.

Participants who withdrew during the interview process for any reason were excluded from the study. The remaining participants were recruited until reaching data saturation, through a snowball sampling method based on referrals from the initial 10 interviewers, resulting in 26 participants. Interviews were conducted at locations convenient for participants, primarily workplaces or other preferred settings. To ensure maximum heterogeneity, efforts were made to select interviewees representing diverse professional backgrounds, varying levels of experience, different age groups, both sexes, and distinct work histories (Table 1).

Data were collected using semi-structured interviews based on a guideline developed by the research team. While most interviews were conducted in person, five were administered virtually.

The interviews used open-ended questions to allow new and deeper aspects to emerge. Face-to-face interviews were conducted in Persian in private settings. Two test interviews with semi-structured questions preceded the main data collection. The interviews began with general questions before moving to specific ones. Specific questions started as open-ended, with probing questions used as required:

Primary question: "*In your opinion, what factors contribute to pedestrian* collisions *in the country?*"

Follow-up question: "*Based on your experience, which factors most frequently lead to pedestrian* collisions*?*"

The probing questions such as *"Could you elaborate on this?"* were also posed. Additional methods included member checks and peer debriefing (Triangulation). Data saturation was reached after 21 interviews, and five more interviews were conducted to confirm saturation. Three participants were re-interviewed to clarify ambiguities in transcriptions.

This study was approved by the Ethics Committee of Tehran University of Medical Sciences (code: IR.TUMS.SPH.REC.1402.098). Participants were assured of confidentiality, with all data anonymized using numerical codes.

The data were analyzed using Graneheim and Lundman's method, which involved three stages: preparation, organization, and reporting [12]. Each interview was reviewed immediately after completion to obtain a comprehensive understanding. Initial coding was derived from participants' own terminology. Similar codes were grouped into subcategories, which were then organized into broader categories based on shared characteristics. All classifications underwent iterative refinement through research team discussions until a consensus was reached on the final nomenclature.

In the next phase, four strategies proposed by Lincoln and Guba and triangulation were utilized to enhance the trustworthiness. Five additional interviews were conducted with collision-involved individuals (pedestrians and drivers). Member checking, peer debriefing, constant comparison, and triangulation were implemented to ensure robustness (Table 2).

Results

Three experts could not participate in the interviews due to work commitments. The study included 26 participants in 31 interviews, yielding an average interview duration of 58.50 minutes with a standard deviation of 32.36 minutes. Most participants were

Table 1. Characteristics of traffic experts (n=26)

No	Working history (years)	Age (years)	Responsibility	City	Education	Time	Sex
1.	18	60	Member of a research center	Rasht	PhD in Social Medicine	1:45	F
2.	15	56	Faculty member	Rasht	PhD in Nursing	2:10	F
3.	30	65	Member of a non-governmental organization	Rasht	Master's degree	1:50	M
4.	25	55	Member of a research center	Tehran	Specialist in Preventive and Social Medicine	1:40	M
5.	20	52	Faculty member	Shiraz	Epidemiologist	42	M
6.	23	55	Municipality staff	Tehran	PhD in Management	60	M
7.	20	48	Member of the Disaster Department	Yazd	PhD in Health Services Management	45	M
8.	25	52	Member of Municipal Transportation	Isfahan	Diploma in Experimental Sciences	1.42	M
9.	20	48	Emergency dispatch staff	Mashhad	PhD in Health in Disasters and Emergencies	56	M
10.	18	43	Member of the Emergency Department	Shiraz	PhD in Health in Disasters and Emergencies	22:32	F
11.	22	47	Member of Traffic Police	Tehran	Master of Police Studies	40	M
12.	26	50	Member of the Disaster Department	Tehran	Master of Medical Education	35	F
13.	25	58	Faculty Member of Shahid Beheshti University	Tehran	PhD by research in injury epidemiology	45	F
14.	22	48	Member of the Safety Department	Tehran	PhD student in Road and Transportation	65	M
15.	20	45	Safety expert in the road technical section	Tehran	PhD in Civil Engineering	45	M
16.	24	47	Safety Expert Road Maintenance Organization	Tehran	Master's degree	35	M
17.	3	34	Road Maintenance Organization/ transportation expert	Tehran	PhD student in Road and Transportation	25	M
18.	15	42	Member of Road Safety Commission	Tehran	Bachelor's Degree in Healthcare Management, Master's Degree in Medical Informatics	35	F
19.	25	46	Member of the Road Safety Commission	Tehran	Ph.D. in Urban Planning and Geography	25	M
20.	20	46	PhD student in Traffic Safety Management	Tehran	Iranian Traffic Police (RAHVAR)	45	M
21.	28	52	Safety and Traffic Accident Department, Ministry of Health	Tehran	PhD in Social Medicine	21:22	M
22.	28	53	Road Maintenance and Transportation	Rasht	Mechanical engineer	75	M
23.	22	55	Pre-hospital emergency	Tehran	Emergency medicine specialist	22:26	M
24.	20	49	Road technical section, Iran Road Maintenance and Transportation Organization	Tehran	Safety expert	21:20	M
25.	20	59	Trauma Research Institute, Guilan University of Medical Sciences	Rasht	Professor of Neurosurgery	45	M
26.	30	56	Faculty member, Shahid Beheshti University of Medical Sciences, Tehran	Tehran	PhD in Health in Disasters and Emergencies	1:53	M

M=Male; F=Female

male (n=20), aged over 45 (n=23), with more than 20 years of work experience (n=21). Eighteen participants held doctoral degrees, and 16 had specialty qualifications (Table 1).

Two main categories and nine subcategories emerged. The first main category was direct factors which included these subcategories (driver, pedestrian, roads and streets, vehicle, and geographical factors). The second main category was underlying factors which included (Governance factors, social determinants, cultural conditions, and economic status) (Table 3).

Here are the reported findings:

1- Direct Factors

This category was termed "direct factors", and comprised elements that primarily caused pedestrian collisions at the scene. One or more of these factors were identified as direct causes of incidents.

Table 2. Strategies for achieving trustworthiness in the study.

No	Trustworthiness criteria	Description
1	Credibility	Through member review, peer review, continuous comparison, and triangulation, credibility was ensured. Transcribed texts and summaries of the first four interviews were shared with participants via email or face-to-face meetings. During the interview, LKA asked participants to provide reflective comments on any possible misunderstandings. Extracted codes were compared by both LKA and E.H.R. The interviews were transcribed and the first and final codes and categories were checked by an AOT expert familiar with the qualitative research. To increase credibility, triangulation was used. Perceptions of those participants who were in charge of important organizations, departments, etc. plus other stakeholders were all gathered to gain a more in-depth understanding of the issue. Constant comparison was done through frequent returns to the data in the analysis stage, which helped to form categories and subcategories. The main researcher participated in all stages of data collection, and analysis.
2	Confirmability	An attempt was made to listen to all the interviews several times and all of the participants' statements were transcribed word by word so that any qualitative researcher carrying out the interviews again can achieve the same results. The interviews were conducted by the same researcher who implemented them because engaging other researchers could cause misinterpretation and misunderstanding in the content of the interviews.
3	Transferability	To confirm the transferability of the study, findings were given to other qualitative researchers. The demographic characteristics of all the participants were recorded with maximum detail so that the transferability of the study in similar environments could be increased and the researchers could have a good model for their study method.
4	Dependency	To confirm the dependency of the study, the codes, categories, and subcategories, were given to other qualitative expert researchers. Their opinions were used in the naming categories and sub-categories. Necessary revisions and corrections were made.

A- Drivers

Law-breaker Driver: Participant: *"I have unfortunately seen this scene many times: a pedestrian running on the crosswalk. This is a tragedy! It means that a defenseless pedestrian must run to claim his/her legitimate right... or timidly cross the line"* (P4).

Distracted Driver: One participant explained: *"You may have heard or seen drivers looking ahead but not truly paying attention to the road; they are lost in thoughts about their loans, worried about paying tuition for their child, or their marriage preparations and dowry"* (P22). *"This distraction could indeed affect their interactions with other road users, including pedestrians and motorcyclists"* (P6).

Driver with Little Knowledge and Experience: *"These drivers fail to recognize streets are also pedestrian spaces"* (P21). *"Whether on rural, secondary, or forest roads, they lack proper caution awareness and disregard speed limits"* (P15).

B- Pedestrian

Participants believed that pedestrians possess characteristics that make them susceptible to collisions.

Careless Pedestrian: Pedestrians possess a high degree of freedom, allowing them to enter the roadway from any point, unlike vehicles restricted to designated access points. As one participant noted: *"If a pedestrian wants to cross a bridge, he/she might prefer taking the risk rather than walking the extra 500 meters to reach it"* (P21).

Vulnerable Pedestrians: *"...children may not have reached a mature mental level yet, it is possible that they suddenly find themselves in the traffic paths. In addition, they cannot accurately judge vehicle speed, distance, or arrival time"* (P25).

Pedestrians with Little Knowledge: *"Education level matters... the passerby is important... there is an old man with Alzheimer's, he has forgotten everything he has learned, and he stops by the side of the road..."* (P9).

C- Streets and Roads

The statements of the participants indicated that our streets and roads are not managed properly, which contributes significantly to pedestrian collisions.

Improper Road Maintenance: *"Well, we have many dangerous roads that remain hazardous despite officials' awareness"*. *"I feel that everyone knows everything, but no one seems to roll up their sleeves to make an impactful move. I emphasize again that this requires strong, authoritative intervention. I really emphasize this. You see, if the leadership and the president intervene directly, the result will be better"* (P13).

Non-standard Road Construction: The participants' statements primarily revealed significant road geometry and design issues. In urban areas, streets are excessively wide (often lacking boulevards or pedestrian islands), while crossings remain dangerously narrow, creating unsafe pedestrian conditions. Rural roads present different challenges, frequently passing through residential areas despite having insufficient width to ensure pedestrian safety.

These observations were summarized by participants' key remarks: *"We must design road geometry to physically prevent pedestrians from entering the roadway where feasible"* (P14).

Table 3. Results of participant data analysis on factors affecting pedestrian deaths and injuries in Iran

Category	Subcategory	Selected codes	Some outstanding primary codes
1. Direct factors	Driver	Lawbreaker	Disregarding the rules, Disrespecting pedestrian rights, Evading the law, being Uncommitted to duties, Not adhering to duties, Not having a driving license, Disobeying driving rules, Not ingraining traffic rules, Carelessness, and disregarding traffic rules.
		Distracted driver	Thinking about something other than driving, Distractions, Listening to music, Forgetting to turn on the lights, Inattention, Paying little attention to the road, Lack of attention, Listening to the radio, Talking on a cell phone, talking to the front seat passenger, Thinking about the installments.
		Driver with little knowledge and experience	Not knowing the road signs, Lack of awareness of his rights, Being unfamiliar with the driver's duties, Ignorance, Inexperienced driver, Lack of knowledge of the driver's duties, unawareness, Inadequate training.
	Pedestrian	Careless pedestrian	The street as a place of recreation, Crossing the freeway, Not using the pedestrian crossing, Not using the pedestrian bridge, Not using the underpass, Jumping over the fence, Not using the safe crossing, Crossing disregarding the green light, Disregarding traffic signs.
		Vulnerable pedestrian	Not showing a quick reaction in the elderly, Vulnerability of children and elderly passers-by, Low perception of risk in children, Hearing and vision problems in the elderly, Movement problems in the elderly Poor five senses, and impaired perception of danger in the elderly and children, Insufficient safety of children and the elderly to pass through urban areas, Slow movement due to physical weakness, diabetes and discopathy in the elderly, Different levels of caution of pedestrians in different age groups and occupations.
		Pedestrians with little knowledge	Insufficient training, lack of information Changing behavior, not seeking training, Lack of awareness of their rights and licenses, Lack of awareness of the difference between highway, freeway, and main road, Not knowing about the blind spot of the car, level of education, Lack of sufficient information and training for the pedestrian, High influence of passerby's ignorance on the occurrence of risky behavior, Ignorance and risky behavior, illiteracy, Low literacy.
	Roads and streets	Improper road maintenance	Unclear border between city and villages, rural areas close to the city, dispersion, continuity, strip-like and not having a specific location, Failure to improve Collision-prone areas, Developing residential areas and our roadside villages, Road passing through residential areas, interference of urban and rural roads, interference of pedestrian lines, commercial, residential and farms on roadside, schools near the main streets, shopping centers and residential areas near ring roads, weekly local markets on roadsides, incorrect calculations in pavement construction.
		Non-standard road construction	Vast streets, narrow passages, leave dangerous roads as they are, small widths of rural roads, inappropriate roads, lack of pedestrian bridge and fence in the middle of roads, non-specialized roads for users, not installing the speed reducers, road is not safe when marked crosswalks are improper and need repair, roads without protection permitting pedestrians to pass, no guardrails, not using different colors on the road, developing roads from one lane to two and disregarding people's need to cross the width of road, not designing the roads for pedestrians, not specializing pedestrian and bicycle crossing lines in the country, non-smart roads, reducing the effect of speed bumps by installing them anywhere, not installing traffic signs, defective and low-quality cameras.
	Vehicle	Non-standard vehicle	Poor quality vehicle, low-quality braking system, Poor quality of the bumper, lack of warning system, lack of specialized car bumper, inadequate lighting system, lack of good sensors, lack of pedestrian warning sensors, abundance of scrap cars, aging cars.
		Traditional car manufacturing	Lack of safety material for the passenger in the car, the gradual decline of car technology in the country, low-quality domestic cars trend due to the high cost of foreign-made cars, not using smart safety tools and in-car systems, taking no measure to improve the quality of domestic cars.
	Geographic factors	Time of Collision	Evening or night, twilight hours, early morning, near sunset, and, dark air, quiet hours of the night, more pedestrian Collisions in winter near sunset and ending time.
		Bad weather conditions	Low visibility in bad weather conditions, weather conditions such as slippery and fog leading to more pedestrian Collisions, slippery roads, icy roads, rain, storms, slippery street, unfavorable weather conditions, rainfall in the north of the country causes the driver's visibility to decrease without having a driver, pedestrian traffic Collisions increase in the north due to rain and low visibility, cause of pedestrian Collisions is different in desert and mountainous areas, environment where Collisions occur (flood, lightning, storm, very hot, etc.)

Category	Subcategory	Selected codes	Some outstanding primary codes
2- Underlying factors	Governance factors	Absence or non – non-compliance with laws and regulations	Not considering the role of the pedestrian in the laws, lack of deterring laws, non-observance of the law, lack of enforcement guarantee of the laws, inadequate fines, lack of laws to fine pedestrians, lack of tools at the disposal of the police to apply fines to pedestrians, poor laws, lack of rules and regulations for pedestrians, driver not being fined for crossing the pedestrian lane, not taking the rules seriously by the police, failure to properly implement the law where it should be implemented.
		Poor management and planning	Not reaching the end of many projects, taking a long time for a proposal to be implemented, lack of planning, poor implementations and not being properly implemented, hasty decisions, lack of physical support and a process for pedestrians, insignificant and secondary look at pedestrian Collisions in the past, not having a plan and not being able to implement a comprehensive operational plan for safety in the country, not considering authorities as a major problem in the country, not insisting on implementation, not fulfilling the duties of the municipalities, current challenges of not knowing the current situation, not following the approvals of the commission, not following the notification plan, not actualization of integration of the institutions in our country, lack of proper speed management, lack of a powerful centralized unit.
	Social Determinants	Working and living conditions of people	People's daily life, people for whom life is not worth crossing the pedestrian bridge, divorce, delinquency, increasing people's psychological problems and its impact on the transportation and traffic industry, social pressure, stealing traffic signs due to economic problems, decreasing psychological safety, increasing mental concerns in the last few years, abnormal behavior due to financial problems, normality of issues, indifferent citizens of the society, lack of NGOs.
		Social indifference	no attitude in society, normalization of many things in the country, feeling no responsibility toward people, lack of sensitivity, people jumping on the bandwagon, people's distrusting in others, easy death of people, regarding people's demand inappropriate in the structure of our country, lack of national determination, poor understanding of danger in the country.
	Cultural conditions	Poor citizenship culture	No culture-building measure for drivers, poor traffic culture, people's lack of traffic culture as the cause of pedestrian collisions, women's avoidance of using reflective strips due to poor culture, danger of religious ceremonies and festivals on held the side of the roads, short-term effects of advertising, use of black veils (*Chador*) rooted in rural context and culture, special respect to dark color and considering it holy in the country, poor literature.
		Inadequate traffic culture	Delay in education in the awareness of parents, not prioritizing education, poor performance of media in education, not specifying the organization in charge of traffic education, lack of traffic education in textbooks, role of people with low education in decision-making, discontinuous education, poor education, not teaching the traffic principles to children, increasing children school drop-outs, decreasing trauma education in health centers.
	Economic status	Imbalance of household income and expenses	Family poverty, prioritizing other living expenses over buying a new car, busy and stressful lifestyle causes disregarding priority and reckless behavior in driving and crossing the street, parents are not aware of human responsibility, the influence of livelihood, corruption, and family environment on the behavior of the passerby in macro-perspective, chain effect of the personal, family and work economic conditions of the passerby on the decision to cross the street, some families do not accept reflective strips for its payment, reduced power of buying 04 poverty of the society, lack of financial resources of people, unemployment.
		Macroeconomic insta-bility	Reduced country's GDP, non-implementation of projects that have been identified due to the lack of financial resources, economic sanctions, credit problems, waiting for the commission's expert approvals to be implemented until forecasting the next year's budget of the municipality, failure to fulfill duties road officials due to economic problems, sanctions and lack of financial resources, financial problems to supply equipment and provide training, economic crises as a reason for the increasing pedestrian Collisions following extortion, economic problems and their impact on the transportation industry, economic pressure on people.Q

However, another participant concluded that "*this confirms most roads are neither pedestrian-friendly nor safe*." (P1). This collective feedback underscores systemic failures in pedestrian infrastructure planning.

D-Vehicles

Non-standard Vehicles: "*The issues of vehicle quality, particularly braking systems, significantly impact collision rates*" (P6). "*If it is necessary to visit the car system, it may be time to replace the pads, but the economic constraints often prevent necessary repairs*" (P5).

Traditional Car Manufacturing: "*The third challenge... in our country, car technology is decreasing day by day. Gradually, the doors of technology are closing on us. Day by day, we are distanced from safe vehicles and are forced toward lower-quality domestic cars. Imported vehicles? We cannot afford them! Thus, we are moving towards unsafe automobiles*" (P16).

E-Geographic Factors

Most of the participants acknowledged that the weather conditions and the hours of the day significantly influence pedestrian collision risks.

Time of Collisions: "*Pedestrians who leave the house for a walk early in the morning are more prone to collision risks due to reduced driver's vision at dawn*" (P2).

Bad Weather Condition: "*... weather conditions, well, it is known that slippery surfaces and fog can increase pedestrian collision risks*" (P14).

2- Underlying Factors

The second category of factors named "underlying factors", comprises indirect influences that typically remain hidden contributors to pedestrian collisions. These factors only become apparent through in-depth collision analysis. The category includes four subcategories: Governance factors, social determinants, cultural factors, and economic conditions.

A-Governance Factors

Participants identified governmental factors as having an indirect influence on pedestrian collisions. This subcategory comprises two distinct elements:

Absence or Non-compliance of Laws and Regulations: "*We do not have sufficient manpower. We don't have adequate police presence to control traffic, and devices such as surveillance cameras don't seem to be very deterrent*" (P21).

Poor Management and Planning: "*The respected government officials in all three branches procrastinate the projects and duties and neglect their role in addressing this issue*" (P8).

B-Social Determinants

According to the participants, social determinants increase pedestrian collision risks by fostering vulnerability among pedestrians. These factors indirectly elevate exposure to danger, with two key subcategories emerging:

Working and Living Conditions of People: "*Assume that people have a lot of social tensions; well, they will be mentally preoccupied. Probably prioritizing basic survival needs over safety concerns. A pattern which is consistent with Maslow's hierarchy of needs*" (P15).

Social Indifference: "*In developed countries, when someone commits a violation, the public do not remain indifferent... here it is the opposite. There is no social pressure if someone commits a violation*" (P4).

C- Cultural Conditions

This subcategory comprises two elements: optional codes called the poor citizenship culture and inadequate traffic culture.

Poor Citizenship Culture: "*There is this culture in Iran when the driver sees a passerby, they often move faster and honk*" (P9).

Inadequate Traffic Culture: "*Without childhood traffic education, proper behaviors won't become ingrained. We must educate this new generation differently - perhaps by involving them in enforcement roles*" (P8).

D- Economic Status

Participants identified both micro- and macroeconomic conditions as significant underlying contributors to collisions.

Imbalanced Household Income and Family Expenses: "*When the economic status is bad and families struggle to afford basic necessities such as annual clothing purchases, safety considerations become secondary*" (P22).

Macroeconomic Instability: "*Above all, financial resources are usually inhibitors. Projects that, even if some points are started experimentally, remain incomplete due to resource constraints, and unfortunately, we are witnessing such deaths*" (P19).

Discussion

The findings of the present study indicated that pedestrians face multiple collision risks, which are categorized as: direct factors and underlying factors.

1- Direct Factors: This factor included driver, pedestrian, roads, vehicle, and geographic/environmental factors, which are discussed below (Figure 1):

An exploration of participant statements indicated that drivers can directly cause traffic collisions through various factors, including traffic law violations, visual distractions, and lack of knowledge or experience. Previous studies support these findings, showing that violations of traffic laws [13], visual distractions [14], and conversations with front-seat passengers significantly impaired driver performance [15]. Furthermore, research confirmed
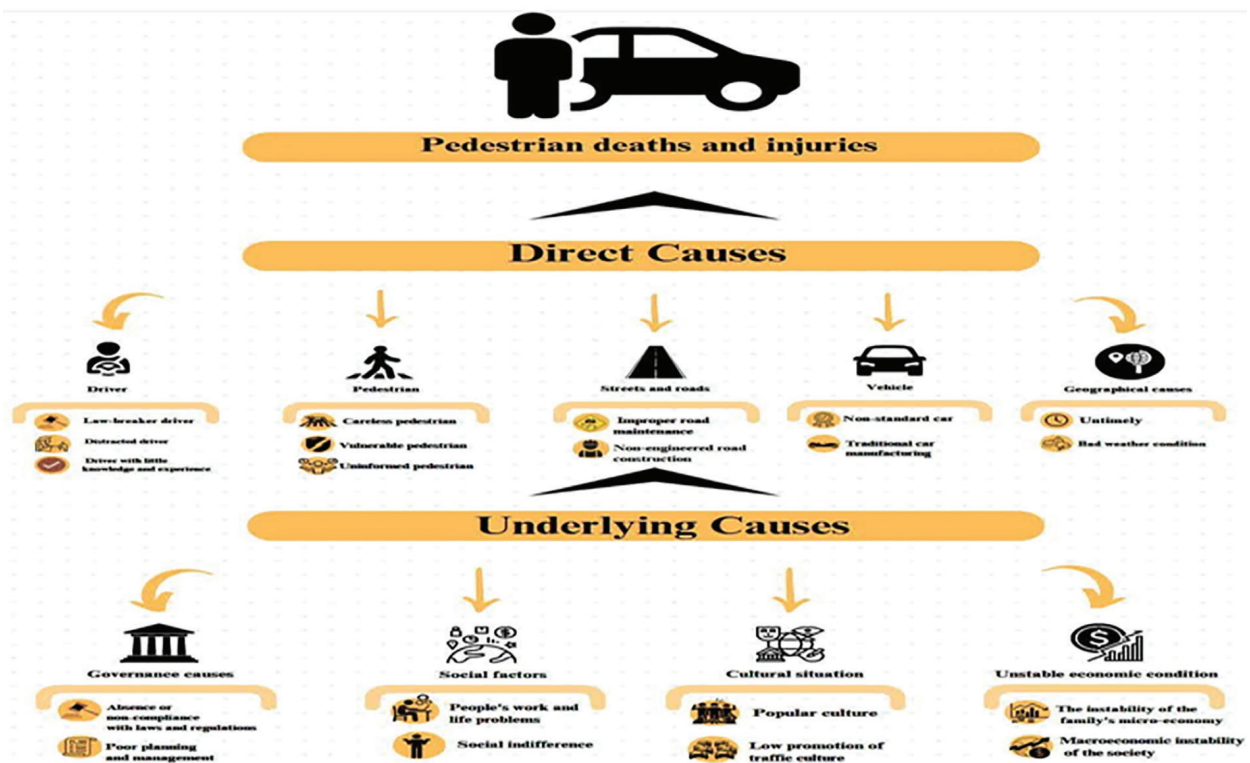
Figure 1. Direct and underlying factors affecting pedestrian deaths and injuries in Iran.

that younger and less experienced drivers were at higher risk of collisions, with increasing driving experience, the level of risk decreased [16]. Thus, the development and implementation of targeted laws, policies, and countermeasures are strongly recommended [15].

Pedestrian negligence, vulnerability, and lack of knowledge are other direct factors that endanger pedestrian safety. While pedestrian negligence occurs universally, damages and payments are addressed differently. England's traffic law, for instance, imposes shared responsibility on both pedestrians and drivers regardless of fault [17]. Regarding the vulnerability of pedestrians, Holm and Jaani reported that children, as pedestrians, were one of the most vulnerable groups of road users, particularly children walking alone [18]. Sex and age significantly influence risk patterns: aerial camera studies revealed that male pedestrians commit more violations than females, with younger pedestrians demonstrating riskier behaviors such as shorter waiting times and reduced environmental awareness while crossings [19]. These patterns correlated with injury rates, as female pedestrians experienced fewer collisions [20]. Besides, elderly pedestrians, though typically more cautious, face elevated risks due to inadequate nighttime lighting in smaller urban areas—a danger compounded by dark clothing and visual impairments [21].

Among other direct factors responsible for pedestrian collisions, road, and street conditions emerged as critical direct factors in pedestrian collisions, with participants highlighting inadequate

maintenance and substandard construction. Some previous studies confirmed these findings [22-24]. Similarly, a positive correlation was found between pedestrian collisions and the safety of road infrastructure. Besides, the length of state roads, unclassified streets, parking areas, and the number of bus stops had a positive relationship with pedestrian collisions [25]. In Iran, a qualitative study identified insufficient pedestrian safety infrastructure as a key concern [26]. Further investigations revealed that three variables had a remarkable effect on zebra crossing usage and reduced collisions: guardrail installation, the number of road lanes, and the width of the zebra crossing [27]. Highlighting the pedestrian crossing positively influenced driver's behavior in reducing the speed [28]. Collectively, these findings underscored the vital role of road design, including street layouts, parking zones, sidewalk width, installation of roadside signs, and bus stop placement in pedestrian safety. Civil engineers must prioritize these infrastructure elements to mitigate collision risks [25].

The vehicle itself was also identified as a direct factor affecting pedestrian collisions. Participant statements highlighted two key concerns: non-standard vehicles and outdated manufacturing practices that fail to keep pace with global technological advancements These findings aligned with existing research demonstrating how vehicle technology could significantly reduce pedestrian collision risks [29, 30]. Yue Abdel-Aty's study reported that modern vehicle technology is particularly effective in situations where pedestrian

crossing intentions are ambiguous. In this scenario, the vehicle's warning system changed the braking process from the "dreaded slow hard-reaction braking" to "comfortable soft fast-reaction braking" [29]. Modeling data further revealed that increasing the speed of reduction systems and lowering vehicle weight could significantly improve the performance of speed reduction systems during pedestrian collisions. The average maximum speed reduction capability has shown notable progression, increasing from 7.48 m/s in 2018 to 9.36 m/s in 2021 [31], suggesting continuous improvements in speed reduction system efficacy in recent years.

Environmental conditions emerged as the final category of direct factors influencing pedestrian-vehicle collisions, as evidenced by participant statements. Several studies confirmed the effect of day and night hours and weather conditions on pedestrian collisions [32-34]. Similarly, Alogaili and Mannering specifically identified notable variations in the severity of pedestrian injuries between daytime and nighttime incidents, with nighttime collisions resulting in more severe injuries [33]. Besides, bad weather conditions, such as rain, fog, snow, and wind, compromise the driver's visibility and elevate collision risks [35]. A Scottish study examining injury severity determinants at both physically controlled and human-controlled intersections further confirmed that weather, road, location, vehicle, driver behavior, and time characteristics collectively affected the severity of injury [34]. Nevertheless, various findings suggested that good weather conditions might increase the likelihood of pedestrian collisions [36], highlighting the complex relationship between environmental factors and pedestrian safety.

2- *Underlying Factors:* Analysis of participant statements revealed four subcategories of governance factors, social determinants, cultural conditions, and economic status.

The absence of governance factors manifests through two subcategories: non-compliance with traffic regulations and poor management and planning. In several studies, the speed limit law had a significant impact on pedestrian safety [37-39]. The research performed by Mukherjee and Mitra further confirmed the importance of legal measures in speed management in urban areas of India [23]. The results of the present study also suggested how infrastructure design, including the construction of urban streets, parking allocation, the width of sidewalks, and the placement of signage and bus stations fundamentally influenced pedestrian safety. These findings underscored the necessity for transportation authorities to prioritize pedestrian-oriented infrastructure planning to effectively reduce collision risks [25].

Social determinants emerged as significant underlying factors, comprising two subcategories socioeconomic conditions (working and living circumstances) and social indifference. This collective indifference toward pedestrian safety concerns indirectly contributes to increased collision risks. A study reported that family and social determinants such as the size of the household, immigration, and the parent's physical disability were associated with an increased risk of pedestrian injury [40]. Complementary studies revealed that pedestrian safety concerns extend beyond physical infrastructure. Participants emphasized crucial social dimensions, particularly the need for driver respect toward pedestrians and comprehensive safer environment design, alongside economic challenges such as insufficient traffic signage and lighting. These findings highlighted the multifaceted nature of pedestrian safety, where social attitudes and infrastructure jointly influence outcomes.

Educated pedestrians demonstrated the capacity to both identify safety hazards and propose practical solutions [41]. However, improving road safety requires broader societal transformation. A crucial step involves shifting public attitudes toward traffic violations - community members should actively report witnessed infractions to authorities. Strategic partnerships with sponsors could help cultivate this collective responsibility.

The economic dimension remains equally critical, as illustrated by the dilemma of motorcyclists who recognize the need for helmets but lack purchasing power. This paradox highlights how safety awareness alone proves insufficient without addressing underlying economic constraints. Effective collision reduction strategies must therefore incorporate: (1) targeted social support for low-income populations and (2) enhanced employment opportunities to improve economic conditions. Only through this dual approach, combining safety education with economic empowerment, can sustainable improvements in pedestrian safety be achieved.

Cultural factors, with two subcategories of citizenship culture and traffic culture, indirectly contribute to pedestrian collisions by shaping both driver and pedestrian behaviors. In an exploratory study on the influence of beliefs on the behavior of passers-by, it was found that pedestrians who attribute events to divine control, luck, and fate, demonstrated riskier attitudes and behaviors when crossing the streets [42]. These findings underscored the necessity of recognizing cultural variations across nations and developing targeted interventions to address these deep-rooted beliefs.

Several studies indicated that education could be effective in pedestrian safety [43-45]. In a study on the effect of education on elderly pedestrians, a miniature simulation device, used for education, improved street-crossing decisions and behaviors [43]. However, the evidence remains contradictory. While pedestrian collision reduction strategies ranged from vehicle speed control to pedestrian behavior modification, active speed measures had

the greatest benefit, whereas pedestrian education programs had the least effect [46].

Economic instability emerged as the final underlying factor, identified by participants as significantly impacting both household and societal levels while contributing to traffic collisions. In research performed by Roll and McNeil, higher traffic-related injuries were observed in pedestrians with below-average incomes, particularly affecting African Americans, local Natives, and other minority communities [47]. Several studies indicated that the death risk due to road collisions in low-income countries was higher than that of high-income ones, underscoring their need for greater safety resources and attention [48-50]. These findings emphasized the necessity of prioritizing pedestrian safety improvements, especially in school areas where many minority groups and the poor live [51].

Declaration

Ethical approval and consent to participate: This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Tehran University of Medical Sciences (code: IR.TUMS.SPH.REC.1402.098). Written informed consent was obtained from all participants prior to their involvement in the study.

Consent for publication: Hereby the authors declared that informed consent was obtained from all participants, and the participants were aware of the study's purpose, potential risks, and benefits.

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Authors' Contribution: All authors contributed to the conception and writing the main manuscript. EH analyzed the data, AA and JH prepared tables. All authors reviewed the manuscript.

Availability of Data and Materials: All data generated or analyzed during this study are included in this article.

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