Original Article

An Epidemiological Analysis of Injuries among Cyclists and Clinical Characteristics of them: A Single-Center Experience from Northwest of Iran

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Abstract

Background and Objectives: The most common cause of death and serious disability in cyclist's crashes is traumatic brain injury. The The present study aimed to provide accurate statistics and information on traffic accidents based on epidemiologic characteristics and outcomes of cyclists' injuries in East Azerbaijan province-Iran, based on International Classification of Diseases ICD-10 and International Classification of Diseases 9th Revision, Clinical Modification (ICD-9-CM) guidelines. **Materials and Methods:** This cross-sectional study was conducted in Tabriz, Iran, on 317 cyclists who sustained an injury through road traffic accidents. Multivariable Cox regression, reported as hazard ratios (95% confidence interval), quantified the association between explanatory variables such as age, gender, and anatomical regions with mortality. **Results:** The present study included 317 trauma patients with an average age of 34.72 (SD= 24.14) years old; 89.6% of the patients were male. Collision with truck or van, pick-up, and automobiles collisions (42.9%) were the most common counterpart vehicle used [V13]. The most common anatomical regions affected by the cyclists were head injuries (72.2%) (S00–S09). The highest proportion of injuries incurred by cyclists was superficial (46%) [S00-T00]. Closure of skin and subcutaneous tissue of other sites were the most clinical modification provided for the patients (54.1%) (86.59). The obtained regression coefficient showed that age increased the odds ratio of mortality by 0.02. **Conclusions:** Men were the most injured group. Head injuries were the most common injuries. Skin and subcutaneous tissue sutures commonly require surgery. Also, the chance of mortality increases with age. All cyclists need to wear a helmet to reduce head-impairing injuries.

Keywords: Epidemiology, Cycling, Injury, Iran

Introduction

The World Health Organization (WHO) established road traffic injuries as the eighth leading cause of death for all age groups, with 26% of data corresponding to cyclists and pedestrians. Additionally, 3% of traffic collisions involve cyclists, resulting

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in an estimated 50,000 deaths around the world annually. In 2019, 16,884 cyclists were injured in reported road traffic accidents. Of which, 4,433 were died or seriously injured.[1] The majority of cyclist sufferers are adults, with approximately 10% being children. Cycling accidents increase as children grow older, with 10 to 15 year-old riders being more at risk than other age groups.[2] Studies have ascertained that cyclist injuries account for 1.2 million medical center visits, 580,000 emergency department visits, 23,000 hospital admissions and 900 death annually in the U. S.[3]

Some one-year research in an Iranian province demonstrated that 4.9% of the injured children in urban and sub-urban regions transmitted to emergency departments were cyclists, of whom 55% had head injuries.[4] In another study in Iran in 1994, of 2304 traffic injuries which transmitted to emergency departments, 8.2% were cyclists and 21% of them had head injuries (representing 6.7% of all traffic-related head injuries).[5]

One of the most prevalent agents for visits to emergency departments is traffic injuries.[6] Unlike car accidents, the body is exposed directly to the external surrounding in two-wheeler accidents. Because cycles and motorcycles use only two wheels for balance, they can easily turn over. In addition, they have a high probability of injuries due to the influence of road surfaces and the environment. As a result, fatal damage such as head and limb injuries may be caused.[7,8] In fact, cyclists besides pedestrians are the most susceptible road users because of their lack of protection and comparatively greater likelihood of experiencing severe injuries or death after a crash.[9]

One of the most common injuries sustained by cyclists is head injury, ranging from a cut on the cheek to traumatic brain injury. Injuries to the head, in particular, are important fraction of injuries pertinent to cycling.[9,10] Other prevalent injuries include knee difficulty, buttock pain, and neck or shoulder pain. In a study of 132 contributors, Weiss demonstrated that cyclists suffered buttock pain (32.8%), knee difficulty (20.7%), neck or shoulder pain (20.4%), groin benumb (10%), and palmar pain (10%).[11] In a recent Australian study of linked police and hospital data for cyclists in motor vehicle collisions, 34% of hospital-admitted cyclists had a head injury, and 15% had a serious head injury.[9] Using a helmet may decrease the risk for head injuries by 85%. A meta-analysis study of cycle helmet effectiveness showed that cycle helmets reduce the risk of head injuries by 60% and brain injuries by 58%.[10]

Male gender and older age have shown to be associated with cyclist/motorcyclist involvement in road traffic accidents and greater injury severity.[9,12] However, the relationship between age and death in some age groups (e.g., children or adolescents) wait for clarification.[13,14] Both genders[3] have been at increased risk of more severe injuries.[12] Although alcohol depletion is related to risky behavior while cycling,[15] previous studies targeting the relationship between this factor and injury severity or fatality are inconclusive.[16,17] The commission of contraventions is reportedly related to injury severity or death, but only in cycle collisions with a motor vehicle, not in other accidents.[18] Environmental elements can also play a major role as explanatory variables in fatal outcomes. Traffic lane characteristics, for example, crossroads as opposed to open roadways, are usually associated with an increased risk of crash but not necessarily with more severe injuries.[19] Road surface and adverse weather conditions appear to be related to the probability of accidents, but their association with injury severity or death also requires clarification. Prior studies have found both them directly associated with injuries or death,[18] and others found no relationship between them.[20] Time of the day was associated with conspicuity, which, in turn, was related to accidents rates. Nonetheless, the association between time of the day and injury severity has not been shown clearly. A direct association with severity has been described during daytime[20] and during nighttime,[19] with some analyses finding no association at all.[21]

In the causal model, protective methods such as cyclists' helmets,[22] cycling pathways, and visibility aids are used. Protection methods such as cycle helmets, designated cycling paths, and visibility aids have been employed to prevent cycling casualties. Some jurisdictions have also introduced social interventions such as helmet legislation, and promotional programs to increase helmet use. Conversely, many countries, such as Iran, have not implemented these measures to reduce cycling injuries.[22] Therefore, based on the existing conditions, lack of accurate statistics, and information on traffic accidents in this province, epidemiologic characteristics and outcomes of cyclists' injuries were investigated in Northwest Iran based on ICD-10 and ICD-9-CM guidelines.

Materials and Methods

Study population

This study was a cross-sectional study that followed STROBE guidelines.[23] The participants were 317 motorbike riders and cycle passengers referred to Imam-Reza hospital, Tabriz, East Azerbaijan Province in Iran due to road traffic accidents from March 2013 until March 2018. All cyclist-related injured patients admitted to Imam Reza Hospital or those who died after arrival were studied.

As the largest referral center for trauma and the emergency medical service's policy to transfer the majority of trauma patients to this center, it is estimated that the patients who visited our center are a representative sample of the entire injured population of Tabriz.

Data source and sampling

Injured motorbike riders and cyclists were detected by regular surveillance of the hospital information system (HIS) during the study period to identify all riders and cycle passengers who suffered injuries daily. Road cyclists who residing in East-Azerbaijan province were eligible to be included in the present study. Assaulted cyclist patients were excluded from the study. The participants involved all the hospitalized patients in the emergency department or other wards of the hospital during the study period. All 317 records were evaluated for data

collection. After a patient was released, hard copied records were transferred to the medical records unit, where trained staff and custom extracted information regarding external causes of the injury, injury diagnosis, and outcome of hospitalization. Data were then coded using ICD-10 coding system and entered to an electronic database.

Data were extracted from the HIS database. A self-administered questionnaire was made accessible from March 2013 to March 2018. After a patient was screened on admission, information regarding identity and baseline demographics was collected.

The explanatory variables

The independent variables included in our study are gender gender (male or female), age, type of injury and anatomical regions, length of hospital stay, hospitalization unit, and finally, ICD-10 chapter 19 codes provided in Table 1.

Outcome

The final variable for this study was death from motor vehicle traffic crashes. Injured cyclists and riders that were adjusted according to ICD-10 codes chapter 20 which involved V10-V19, and clinical services that are delivered to injured cyclists and passengers modified based on ICD-9-CM.[24] Moreover, the final status of injured cyclists included: recovered entirely, permanent disability, and death were being defined as a dependent variable.

Statistical methods

Variables with normal distribution were described with mean and standard deviation (SD), and the variables with nonnormal distribution by median and inter-quartile range (IQR). The normal distribution of data has been assessed by the Shapiro-Wilk test with a significance level of 0.05. Cox regression is a widespread regression model to use as a time-distance prediction from exposure to the event. Semi-parametric Cox distribution was used to predict cyclist's mortality. Hazard-ratio (HR) index is an estimable indicator in Cox regression. In the multivariable analysis, an Enter strategy with ($P < 0.1$) was used. Adjustments were made to variables including gender, age, type of organs, injuries to the cyclists and passengers in collision with vehicles, or objects. The Proportional Hazard assumption[25] was evaluated by Shoenfield residuals' test which denoted that the assumption was stated in the global test ($P = 0.085$) and all individual variables tests ($P < 0.05$). All statistical tests were two-sided, and a p-value of less than 0.05 was considered significant, HR = 1 was regarded as nonsignificant. All statistical analyses were conducted using Stata, version 16 (Stata Corp., College Station, TX, licensed to Tampere University).

Ethical considerations

The protocol of study had been approved by the Tehran University of medical sciences' ethics committee. Privacy consideration of recorded data in HIS has been preserved throughout the study. Participants' written informed consent was ignored because this was a non-interventional study using anonymized patient data.

Results

General description

Three hundred seventeen patients with cyclist injuries were admitted to the referral center within the study period. Most of the injured people were men (89.6%). The mean age of patients was 34.72 (SD = 24.14) years (ranging from 1 to 93 years). 49.5% of the patient hospitalized in trauma unit and surgery unit 24.9 % in the second place [Table 2].

The case fatality rate was 8.2%. Moreover, the death ratio in the result of injured cyclists in men was 1.41 times higher than women. Furthermore, 26 injury-related deaths were recorded during the study period which resulted in 8.2% in-hospital mortality rate. Forty seven persons (15%) were recovered entirely. However, 240 patients (75.7%) were permanently disabled, and the deceased cyclists were mostly male (87%) and adult (81%). The median length of hospital stay was 4 days, and the IQR range was between 1 and 75 days.

Type and anatomical regions

The most common anatomical regions of injuries were the head; other causes of injuries were the abdomen,

Table 1: Injury, poisoning and certain other consequences of external causes

Codes	Anatomical region
S00-S09	Injuries to the head
S10-S19	Injuries to the neck
S20-S29	Injuries to the thorax
S30-S39	Injuries to the abdomen, lower back, lumbar spine and pelvis
S40-S49	Injuries to the shoulder and upper arm
S50-S59	Injuries to the elbow and forearm
S60-S69	Injuries to the wrist and hand
S70-S79	Injuries to the hip and thigh
S80-S89	Injuries to the knee and lower leg
S90-S99	Injuries to the ankle and foot
T00-T07	Injuries involving multiple body regions

Table 2: Demographic data, and mortality rate of injuries among cyclists

Characteristic	*n* (%)
Mean age (years)	34.72±24.14
Hospital stay duration (days)	6.07±8.05
Mortality	26 (8.2)
Gender	
Male	284 (89.6)
Female	33 (10.4)
Hospitalization unit	
Trauma	157 (49.5)
Intensive care unit	2 (0.6)
Face and jaw	32 (10.1)
Operation room	17 (5.4)
Urology	19 (6.0)
ENT	11 (3.5)
Surgery	79 (24.9)

ENT: Ear, nose, and throat

lower back, lumbar spine, and pelvis subsequent parts. Furthermore, displacement, ligament elongation, and muscle elongation (S03-T03**)** were the cyclists' major trauma regarding cyclists' pedals [Table 3].

Cyclists most frequently sustained upper extremities injuries (63.4%) and the lower extremities (36.6%). Overall injuries based on types are shown in Table 4. Most of the cycle injuries resulted from accidents with pick-up, truck or van, and automobiles. The clinical characteristics of the patients, the code of clinical services were delivered to them are shown in Table 4.

Table 3: Frequency distribution of anatomical regions of injuries and types of injuries among cyclists based on International Classification of Diseases

Codes: Anatomical regions	*n* (%)
S00-S09: Injuries to the head	229 (72.2)
S10-S19: Injuries to the neck	3 (0.9)
S20-S29: Injuries to the thorax	15 (4.7)
S30-S39: Injuries to the abdomen, lower back, lumbar spine, and pelvis	37 (11.6)
S40-S49: Injuries to the shoulder and upper arm	7 (2.2)
S50-S59: Injuries to the elbow and forearm	7 (2.2)
S60-S69: Injuries to the wrist and hand	2 (0.6)
S70-S79: Injuries to the hip and thigh	7 (2.2)
S80-S89: Injuries to the knee and lower leg	9 (2.8)
S90-S99: Injuries to the ankle and foot	1 (0.3)
S00-T00: Superficial	46%
S01-T01: Open	6.6
S02-T02: Fracture	9.4
S03-T03: Displacement/ligament elongation/muscle elongation	18.2
S04-T04: Crush	19.8

Risk factors for mortality

The obtained regression coefficient showed that the HR of death in females was 0.75 times less than inmales. Age increased the odds ratio of mortality by 0.02. The mortality odds ratio of patients with injuries to the abdomen, shoulder, and pelvic was 0.61, and extremities 0.85 lower than others. An increase in the pedal cyclist in collision with or involved in the car caused an increase in the odds ratio of mortality but it was not significant [Table 5].

Discussion

This study supports the existence of an association between individual factors such as age, gender, and anatomical regions with mortality.

We performed a detailed medical investigation of 317 cyclists involved in road traffic accidents; 89.6% of them were males. In Björnstig *et al.,* in Sudan, men comprised 52% of the injured people.[26] The men are more eager to use cycles as transportation tools and vehicles than women. While they have risky behaviors, the women have a conservative role, and this is a possible explanation of why more cycle-related injuries occur in men. Besides, because of cultural issues, most women in Iran do not use cycles as a vehicle, so it is one of the main reasons this ratio is high in men compared to women in Iran. For example, the male population spends more time and, distance cycling and exposure degrees show higher mortality in transportation.[27] Even though, preceding studies have recommended that male cyclists tend to perceive fewer obstacles to cycling and have more positive attitudes to cycling compared to women.[28]

Regarding the multivariate analysis, age increased the mortality odds ratio by 0.02. In this regard, Montoro *et al*.[29] and Scott-Parker *et al*.[30] have found young road users, markedly

Table 4: Injuries cyclists sustained in collision with vehicles, or objects according to codes of International Classification of Diseases-10, and prevalent clinical services which are delivered to cyclists based on modified codes

Codes	Definition	*n* (%)
V10	Pedal cyclist in collision with or involved in pedestrian or animal	3 (0.9)
V11	Pedal cyclist in collision with or involved in pedal cycle	2 (0.6)
V12	Pedal cyclist in collision with or involved in two or three wheeled motor vehicles	28 (8.8)
V13	Pedal cyclist in collision with or involved in car (automobile, pick-up, truck or van)	136 (42.9)
V14	Pedal cyclist in collision with or involved in heavy transport vehicle or bus	16 (5.0)
V15	Pedal cyclist in collision with or involved in other nonmotor vehicle	1) 0.3)
V17	Fixed or stationary object	6 (1.9)
V18	Noncollision transport accident	121 (38.2)
V19	Other or unspecified transport accident	4 (1.3)
01.24	Other craniotomy	41 (11.3)
38.93	Venous catheterization, not elsewhere classified	10 (5.3)
39.27	Arteriovenostomy for renal dialysis	8 (3.7)
54.11	Exploratory laparotomy	9 (4.4)
54.98	Peritoneal dialysis	9 (4.4)
76.75	Closed reduction of mandibular fracture	10 (5.3)
76.76	Open reduction of mandibular fracture	11 (6.9)
86.59	Closure of skin and subcutaneous tissue of other sites	120 (54.1)
93.54	Application of splint	9 (4.4)

Table 5: Factors associated with mortality rate using Cox regression

Variables	Subgroups	Hazard ratios	95% CI
Gender	Male (reference)	-	-
	Female	0.75	0.17-3.28
Age		1.02	1.01-1.04
Type of organs	Head and neck (reference)	-	-
	Abdomen, shoulder and pelvic	0.61	0.14-2.69
	Extremities	0.85	0.18-4.09
Injuries to the cyclists and passengers in collision with vehicles, or objects	V13 (reference)	-	-
	V18	0.47	0.15-1.45
	V19	1.11	0.44-2.77

CI: Confidence interval

those who were under the age of 25, as a critical target for risky behaviors on the road, between diverse empirical and comparative studies. Studies such as the one performed by Martínez-Ruiz *et al.* (2014)[31] showed that Young cyclists are at greater risk of injury due to physiological and physical differences and lower risk perception. Some age groups are also more exposed to traffic-related risks than others, especially middle-aged people who comprise the workforce.[32] It is noteworthy that the higher risk in elderly people is not clarified by greater exposure to traffic. In addition, patients beyond 50-year-old were at the highest ranking for spine, pelvis, and femoral neck fractures.[33]

Our study showed that head and abdominal injuries are common among cyclists. In Hejazi's study, there was a statistically significant association between the injured organs and the cause of death in the injured cyclists.[34] Autopsy results suggested that head injuries developed in the second and third phases of the accidents had a great importance for pedestrians and cyclists. The head and neck region was the most injured (27.4%).[33] Yavuz *et al.* reviewed skull fractures and intracranial lesions due to traffic accidents and stated that the presence of skull fractures lowered the incidence of intracranial lesions by decreasing the intracranial compression.[35] Many bruises or fractures of the lower limbs that occurred due to the bumper crash were also prevalent injuries in the nonprotected group.[36] Head injuries may relate to the nonwearing of helmets while journey on E-bikes is consistent with Suzhou's study where only a 9% helmet wearing rate among E-bikers was noted.[37] The most likely reasons for the higher probabilities of traumatic brain injury for nonmotor transportation accident victims referred to hospital are (i) the probability high case fatality rate among these susceptible road users, with deaths from head injuries incurred in high energy collisions, particularly with motor vehicles occurring at the scene, before arriving hospital, or in the emergency department: (ii) Some traumatic brain injury may have been comparatively slight concussions, incidental to more severe fractures or other injuries that led to hospital admission.

Limitation

The data analyzed is not likely to fully represent all road traffic injuries. The major strength of this study is the use of data from the national datasets to quantify exposure-based rates of cycling injuries resulting in death or hospital inpatient treatment. Further specific studies must be done to gain new insights based on more extensive national databases.

Conclusions

Men were the most frequently injured group. Head injuries were the most prevalent cause of hospitalization. Moreover, wearing a helmet is necessary to prevent injury and death regarding cyclists. The chance of cyclists' mortality increases with age.

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Conflicts of interest

There are no conflicts of interest.

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