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Exploring the Causal Impact of Age and Nighttime Driving on Road Traffic Injuries among Elderly Drivers: A Bayesian LASSO Approach

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ABSTRACT

Objective: To determine the causal relationship between aging and nighttime driving and the odds of injury among elderly drivers.
Methods: In this cross-sectional study, 5460 car accidents were investigated from 2015 to 2016. The data were extracted from the Iranian Integrated Road Traffic Injury Registry System. Pedestrian accidents, motorcycle crashes, and fatalities were excluded from the study. To account for major confounders, Bayesian-LASSO, and treatment-effect cutting-edge approaches were used.
Results: Overall, 801 injuries (14.67%) were evaluated. The results of the univariable analysis indicated that aging and nighttime had adverse effects on the odds of road traffic injuries (RTIs), even after adjusting for the effect of other variables, these effects remained statistically significant. According to a newly developed approach, the overall effects of aging and nighttime were significantly and directly correlated with the odds of being injured for older adults (both $p<0.001$). Our findings indicated that drivers over 75 years old experienced 23% higher injury odds (OR=1.23, 95% CI:1.11 to 1.39; $p<0.001$), while driving at night increased the odds by 1.78 times (OR=1.78, 95% CI:1.51 to 1.83; $p<0.001$).
Conclusion: Aging and nighttime driving are significant risk factors for RTIs among elderly drivers. This highlights the importance of implementing targeted interventions to enhance road safety for this vulnerable population. Furthermore, the use of advanced Bayesian-LASSO and treatment-effect statistical methods highlights the importance of utilizing sophisticated methodologies in epidemiological research to effectively capture and adjust for potential confounding factors.

Keywords: Accident; Traffic accidents; Causal effect; Bayesian estimation; Regularization algorithm.

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Introduction

According to Iranian statistics, road traffic injuries (RTIs) causes 37 fatalities per 10,000 registered vehicles, which is more than four times the global average of nine death per 10,000 motor vehicles. Consequently, the World Bank has designated RTIs in Iran as a significant concern [1]. According to predictions, the proportion of older adults worldwide will be doubled from about 11% in 2000 to 22% in 2050 [2]. The aging rate demonstrates a more rapid growth trend to such an extent in middle and low-income countries (LMICs) that over 80% of older adults will reside in LMICs by 2025 [3]. Older individuals frequently experience vision loss, cognitive dysfunction, and musculoskeletal problems, which make them more prone to road driving difficulties and traffic accidents [4]. Older adults account for a significant proportion of hospitalizations and fatalities from road injuries.

A previous study [5] on the burden of RTIs in Iran found that young adults were more likely to be involved in non-fatal accidents, with the elderly having the highest overall death rates. A similar study from China demonstrated that the mortality rate of road traffic crashes represented a U-shaped distribution by the drivers' age, implying that young and elderly drivers are more likely to be injured or died in motor vehicle crashes. Furthermore, it has been shown that the 75-79 and over 80 years of age groups increased the fatality rate by 5-fold and 3.5-fold, respectively [6]. Due to the high mortality rate among elderly drivers, more research is required to identify the risk factors of road traffic mortalities among this age category.

For a variety of reasons, driving at night has been identified as an adverse prognostic factor for traffic accidents. The epitome of which is reduced visibility late at night [7]. While nighttime driving is hazardous and challenging for drivers of all ages, it is more hazardous for elderly drivers. Older adults have a higher rate of fatal collisions at night, a worse steering accuracy, an increased self-report of being blinded by oncoming headlights, a delayed reaction time after glare, and a lesser identification of traffic signs [8].

Many researchers investigated the relationship between nighttime driving and the risk of RTIs. Despite the abundance of literature on the epidemiology of RTIs among elderly drivers at nighttime, there is a considerable gap in knowledge regarding the causal effect of aging and nighttime driving, particularly in low- and middle-income countries (LMICs) such as Iran. This highlights the need for further research to better understand the factors that contribute to the increased risk of RTIs in elderly drivers and to develop effective interventions to improve road safety for this demographic.

The most crucial requirement for developing a causal estimate is appropriately selecting significant confounders. Generally, the critical confounders are already known in limited studies, and the selection of these confounders among many covariates has recently become the subject of scholarly discussion. The Kitchen Sink strategy, which selects all covariates as confounders and uses their presence in assessing causal effect, is perhaps the most straightforward known method [9]. When the number of covariates is very large, this method is unjustifiable, because it affects the efficiency of the model [10]. When there is a large group of variables, the Least Absolute Shrinkage and Selection Operator (LASSO) selects the best predictor and discards the rest [11].

Another challenge for statisticians that could be resolved with the help of the Bayesian framework is setting the appropriate confounders in the presence of missing and sparse data. For frequency approaches, the advantage of the Bayesian methods has been proven, even with a non-informative prior [12]. In response to this challenge and as another novelty of the study, we proposed the Bayesian Lasso, which accounts for sparse data problems and appropriately selects significant confounders. Thus, this study aimed to report both the adjusted effects of aging and nighttime driving on older adults' injuries as well as the causal effects using a new statistical method that can account for all significant confounders as well as the dispersion of sparse data.

Materials and Methods

In this cross-sectional study, the data were extracted from the Integrated Road Traffic Injury Registry System (IRTIRS) for elderly drivers [13]. As a national research program, the IRTIRS development started in 2017. The World Health Organization, the Iranian Ministry of Health, the Iranian Traffic Police, and the Iranian Forensic Medicine Organization were in charge of this multi-method study. The Ministry of Health and Medical Education, in collaboration with other interested organizations, and the Road Traffic Injury Research Center affiliated with Tabriz University of Medical Sciences have taken steps to develop the information registration system to create an integrated data collection system.

Without using any samples, all 5561 traffic accidents involving elderly drivers that were reported to IRTIRS from March 2015 to March 2016 were gathered. Accidents involving motorcycles, and bicycles, as well as fatal crashes, were excluded. Following data screening, 101 records (1.82 %) were excluded due to missing information. People aged 65 years and older were considered to be elderly. The injured elderly was investigated and compared in the following age groups: i) 65-69 years, ii) 70-74 years, iii) 75-80 years, and iv) over 80 years. The study design was approved by the Institutional Review Board (#IR.TBZMED.REC.1398.1244) of Tabriz University of Medical Sciences (Tabriz, Iran).

The data was analyzed using two different statistical methods. First, logistic regression was used to investigate the risk factors of RTIs among elderly drivers and to compare our findings with those of other studies. This method can calculate the crude and adjusted impact of study parameters on the odds of injury. Then, we utilized a recently developed statistical approach, a hybrid of Bayesian LASSO and treatment effect, to identify significant confounders and adjust their confounding effect [14]. Selecting the most significant confounders is critical in the presence of several confounders to avoid a biased estimation of the exposure effect. LASSO, an advanced statistical method, performs automatic variable selection in the dataset [15]. The Bayesian form of LASSO also handles uncertainty in variable selection [16]. The data were analyzed using STATA software (version 17: 2021, Stata Corp LCC, USA). In univariable analysis, a p-value less than 0.05 was accepted as the statistical significance level, and $p<0.1$ was used to select the variables to include in the multivariable regression model. In univariable analysis, the results were presented as odds ratios (ORs), and in multivariable regression analyses, as adjusted odds ratios (aORs).

Results

From March 2015 to March 2016, IRTIRS registered 384,614 traffic accidents. The elderly drivers accounted for 5561(1.45 %) of the causalities in motor-vehicle to motor-vehicle injury crashes. The injury rate among this population was 14.67%.

The univariable analysis revealed that the Bayesian Lasso method with narrow credible intervals produced more precise odds ratio estimates. In the presence of sparse data, the issue was even more obvious. To give an example, the estimated 95% confidence interval for the commuting area and road type based on logistic regression was unexpectedly large (interval lengths ranged from 8.5 to 53.21). However, the same results were acceptable in the Bayesian framework (interval lengths ranged from 0.46 to 1.19).

Based on the results of the univariable logistic regression, 12 variables were identified for inclusion in the multivariable logistic regression, namely, driving age, lightning, crash mechanism, human factor, collision type, commuting area, road design, road defect, vehicle type, vehicle safety, driver's sex, and driver's seatbelt-wearing status. The univariable Bayesian Lasso results, however, included weather and the aforementioned 12 variables.

Considering the aim of this study and also based on univariable and multivariable analyses, aging and nighttime were identified as the risk factors for injuries caused by road traffic among older adults. Multivariable Bayesian lasso analyses showed that the odds of being injured in a car accident were 1.15 times (aOR=1.15, 95% Cred. I: [1.07-1.40]) higher for people aged 70-74, 1.16 times (aOR=1.16, 95% Cred. I: [1.01-1.38]) higher for people aged 75-79, and 1.30 times (aOR=1.30, 95% Cred. I: [1.12-1.62]) higher for people aged 80 and over. For nighttime crashes, the odds of injury rate increased by 2.18-fold (aOR=2.18, 95% Cred. I [1.97-2.46]). Elderly drivers were 1.32 times more prone to be injured in clear/cloudy weather than inclement weather conditions (Table 1).

The odds of injuries in single-vehicle crashes were 2.62 times higher than those in multiple-vehicle crashes (aOR=2.62, 95% Cred. I: [2.12-3.06]). The multivariable analysis also revealed that the odds of being injured in the presence of human factors increased by 42% (aOR=1.42, Cred. I: [1.38-1.61]) (Table 1).

When compared to side-swipe collisions, head-on collisions, followed by fixed-object collisions, increased the odds of older people being injured by 3.72 (95% Cred. I: 2.93-4.28) and 3.16 (95% Cred. I: 2.75-3.51) times, respectively (Table 1).

The commuting area had a significant effect. It was found that rural roads were more dangerous for elderly drivers than urban ones (aOR=4.22, 95% Cred. I: [3.51-4.59]). The findings also demonstrated that two-way roads had a high odds of causing injuries in the event of a collision (aOR=1.34, 95% Cred. I: [1.25-1.54]) (Table 1).

Heavy vehicles and lack of safety equipment increased the odds of an elderly injury in a traffic accident by 1.36-fold (aOR=1.36, 95% Cred. I: [1.14-1.64]) and 2.10-fold (aOR=2.10, 95% Cred. I: [1.86-2.35]), respectively (Table 1).

Elderly men had 2.02 times more odds of being injured in a traffic accident than women (aOR=2.02, 95% Cred. I: [1.71-2.32]). For older individuals involved in car accidents, not wearing a seatbelt increased the odds of injuries by 14% (aOR=1.14, 95% Cred. I: [1.11 to 1.29]) (Table 1). More details about the frequency and odds ratios of all crucial factors are presented in Table 1.

The results of multivariable logistic regression and Bayesian Lasso regression indicated that the latter was superior when judging with Bayesian Information Criteria (BIC). It was observed that multivariable Bayesian Lasso regression outperformed its counterpart (BIC [multivariable Bayesian Lasso regression]=2841.434 versus BIC [multivariable logistic regression]=4237.075), which was 49.03% lower in Bayesian LASSO.

The present study employed the newly presented method to estimate the causal effect of aging and nighttime driving. The overall effects of aging and nighttime were significantly and directly correlated with the odds of being injured in older adults (both $p<0.001$) (Table 2). For older adults over 75 years of old, the odds of injury increased by 23% (95% CI: [1.11 to 1.39]; $p<0.001$). As indicated in Table 2, evaluating the causal effect of nighttime driving revealed that older adults had 1.78 times higher odds of being injured in a traffic collision at night (95% CI: [1.51-1.83]; $p<0.001$).

Table 1. The distribution of the explanatory variables for elderly drivers' injury based on the Iranian Integrated Road Traffic Injury Registry System (2015-2016).

Variable		Total n (%)	Injury n (%)	Univariable analyses		Multivariable analyses	
				Logistic regression OR[a] (95% CI[b]); *P*-value	Bayesian LASSO[c] OR[a] (95% Cred[d]. I)	Logistic regression aOR[e] (95% CI[b]); *P*-value	Bayesian LASSO aOR[e] (95% Cred[d]. I)
Driver's age (Year)	65-69	2922 (53.51%)	388 (13.27%)	Reference	Reference	Reference	Reference
	70-74	1542 (28.24%)	242 (15.69%)	1.28 (1.18 to 1.38); *p*=0.028	1.22 (1.11 to 1.36)	1.17 (1.06 to 1.53); *p*=0.010	1.15 (1.07 to 1.40)
	75-79	697 (12.76%)	112 (16.68%)	1.34 (1.20 to 1.49); *p*=0.045	1.32 (1.21 to 1.43)	1.19 (1.01 to 1.64); *p*=0.037	1.16 (1.01 to 1.38)
	≥80	299 (5.47%)	59 (19.73%)	1.57 (1.36 to 2.18); *p*=0.002	1.47 (1.32 to 2.06)	1.49 (1.12 to 2.12); *p*=0.009	1.30 (1.12 to 1.62)
Lightning	Day	4249 (78.72%)	491 (11.55%)	Reference	Reference	Reference	Reference
	Night	1148 (21.27%)	271 (23.60%)	2.36 (2.01 to 2.79); *p*<0.001	2.24 (1.90 to 2.50)	2.21 (1.85 to 2.62); *p*<0.001	2.18 (1.97 to 2.46)
Crash day	Weekday	4019 (73.60%)	593 (14.75%)	1.03 (0.86 to 1.22); *p*=0.768	1.12 (0.97 to 1.32)	-	-
	Weekend	1441 (26.39%)	208 (14.43%)	Reference	Reference		
Weather	Clear/cloudy	123 (2.27%)	15 (12.19%)	1.18 (0.69 to 2.06); *p*=0.535	1.46 (1.25 to 1.67)	-	1.32 (1.19 to 1.57)
	Inclement weather	5273 (97.72%)	747 (14.16%)	Reference	Reference		Reference
Crash mechanism	Single-vehicle crash	364 (6.71%)	128 (35.16%)	3.63 (2.89 to 4.57); *p*<0.001	2.96 (2.62 to 3.37)	2.78 (2.08 to 3.72); *p*<0.001	2.62 (2.12 to 3.06)
	Multiple-vehicle crash	5059 (93.28%)	657 (12.98%)	Reference	Reference	Reference	Reference
Vehicle factor	No	5359 (99.22%)	758 (14.14%)	Reference	Reference	-	-
	Yes	42 (0.77%)	7 (16.66%)	1.21 (0.54 to 2.74); *p*=0.641	1.18 (0.91 to 1.55)		
Human factor	No	1293 (23.90%)	147 (11.36%)	Reference	Reference	Reference	Reference
	Yes	4117 (76.99%)	627 (15.22%)	1.40 (1.16 to 1.70); *p*=0.001	1.44 (1.24 to 1.65)	1.33 (1.03 to 1.99); *p*<0.001	1.42 (1.38 to 1.61)
Collision type	Side-swipe collision	617 (12.62%)	32 (5.18%)	Reference	Reference	Reference	Reference
	Head-on collision	324 (6.62%)	87 (26.85%)	6.71 (4.35 to 10.34); *p*<0.001	4.65 (4.91 to 5.32)	4.25 (2.80 to 6.47); *p*< 0.001	3.72 (2.93 to 4.28)
	Rear-end collision	2601 (53.20%)	262 (10.73%)	2.05 (1.40 to 2.99); *p*<0.001	1.10 (1.02 to 1.31)	1.98 (1.59 to 3.19); *p*< 0.001	1.02 (0.92 to 1.29)
	Side-swipe collision	1256 (25.69%)	184 (14.64%)	3.14 (2.13 to 4.63); *p*<0.001	2.85 (2.32 to 2.90)	3.06 (2.28 to 4.66); *p*<0.001	2.71 (2.27 to 2.91)
	Fixed-object collision	91 (1.86%)	18 (19.78%)	4.51 (2.41 to 8.43); *p* <0.001	3.24 (2.86 to 3.67)	3.19 (0.61 to 7.35); *p*=0.603	3.16 (2.75 to 3.51)
Commuting area	Urban	4695 (86.17%)	583 (12.41%)	Reference	Reference	Reference	Reference
	Suburban	716 (13.14%)	190 (26.53%)	2.55 (2.11 to 3.07); *p*<0.001	1.58 (1.13 to 1.94)	1.96 (1.57 to 2.45); *p*<0.001	1.15 (0.99 to 1.38)
	Rural road	37 (0.67%)	21 (56.75%)	9.26 (4.80 to 17.84); *p*<0.001	6.27 (4.74 to 8.15)	4.97 (2.39 to 10.36); *p*<0.001	4.22 (3.51 to 4.59)
Road type	Freeway	151 (2.78%)	27 (17.88%)	2.61 (0.32 to 20.96); *p*=0.366	2.74 (2.18 to 3.37)		
	Expressway	1290 (23.81%)	166 (12.86%)	1.77 (0.23 to 13.72); *p*=0.584	2.52 (2.22 to 2.82)		
	Main street	3094 (57.12%)	396 (12.79%)	1.76 (0.23 to 13.58); *p*=0.587	2.46 (2.15 to 2.77)	-	-
	Side street	245 (4.52%)	20 (8.16%)	1.07 (0.13 to 8.63); *p*=0.952	1.09 (0.93 to 1.39)		
	Main road	523 (9.65%)	128 (24.47%)	3.89 (0.50 to 30.20); *p*=0.194	2.79 (2.37 to 3.28)		
	Side road	100 (1.84%)	36 (36.00%)	6.75 (0.84 to 54.05); *p*=0.072	3.35 (2.97 to 3.82)		
	Alley	13 (0.24%)	1 (7.69%)	Reference	Reference		

Road design	One-way road	1420 (26.31%)	176 (12.39%)	Reference	Reference	Reference	Reference
	Two-way road	3977 (73.68%)	586 (14.73%)	1.22 (1.02 to 1.46); *p*=0.030	1.19 (1.14 to 1.33)	1.38 (1.14 to 1.68); *p*=0.001	1.34 (1.25 to 1.54)
Road defect	No	5263 (97.51%)	722 (13.71%)	Reference	Reference	Reference	Reference
	Yes	134 (2.48%)	40 (29.85%)	2.68 (1.83 to 3.91); *p*<0.001	1.94 (1.45 to 2.98)	1.41 (0.91 to 2.19); *p*=0.131	1.39 (1.14 to 1.73)
Vehicle type	Light	4717 (86.72%)	650 (13.77%)	Reference	Reference	Reference	Reference
	Heavy	722 (13.27%)	131 (18.14%)	1.39 (1.23 to 1.70); *p*=0.002	1.68 (1.34 to 2.04)	1.11 (0.89 to 1.39); *p*=0.332	1.36 (1.14 to 1.64)
Vehicle safety equipment	No	4171 (76.84%)	669 (16.39%)	2.16 (1.73 to 2.69); *p*<0.001	2.21 (1.78 to 2.74)	2.17 (1.73 to 2.72); *p*=0.001	2.10 (1.86 to 2.35)
	Yes	1257 (23.15%)	102 (8.11%)	Reference	Reference	Reference	Reference
Drivers' sex	Male	5273 (96.57%)	789 (14.96%)	2.57 (1.42 to 4.63); *p*=0.002	2.11 (1.75 to 2.34)	1.94 (1.06 to 3.56); *p*<0.001	2.02 (1.71 to 2.32)
	Female	187 (3.42%)	12 (6.41%)	Reference	Reference	Reference	Reference
Driver's level of education	Illiterate	228 (4.46%)	56 (24.56%)	2.86 (1.86 to 4.42); *p*<0.001	2.65 (1.75 to 4.18)		
	Primary	712 (13.93%)	123 (17.27%)	1.84 (1.27 to 2.65); *p*=0.001	1.69 (1.19 to 2.42)	-	-
	Nonacademic	3740 (73.17%)	472 (12.62%)	1.27 (0.92 to 1.76); *p*=0.151	1.33 (0.98 to 1.82)		
	Academic	431 (8.43%)	44 (10.20%)	Reference	Reference		
Drivers' job	Jobs with high income	4372 (88.25%)	525 (12.82%)	1.08 (0.63 to 1.87); *p*=0.775	1.11 (0.87 to 1.49)	-	-
	Jobs with middle income	448 (9.43%)	77 (17.18%)	1.64 (0.92 to 2.97); *p*=0.098	1.56 (1.37 to 1.79)		
	Jobs with low income	134 (2.70%)	15 (11.19%)	Reference	Reference		
Driver's seatbelt usage status	Used	2670 (48.90%)	254 (9.51%)	Reference	Reference	Reference	Reference
	Not used	2790 (51.98%)	547 (19.60%)	2.32 (1.98 to 2.72); *p*<0.001	1.20 (1.03 to 1.40)	1.88 (1.75 to 2.04); *p*=0.016	1.14 (1.11 to 1.29)

[a]OR: Odds Ratio; [b]CI: Confidence Interval; [c]LASSO: the Least Absolute Shrinkage and Selection Operator; [d]Cred: Credible Interval; [e]aOR: Adjusted Odds Ratio

Table 2. The causal effect of age and nighttime on elderly drivers' injury.

Variable	OR[a] (95% CI[b])	*P*-value
Age	1.23 (1.11 to 1.39)	<0.001
Nighttime	1.78 (1.51 to 1.83)	<0.001

[a]OR: Odds Ratio; [b]CI: Confidence Interval; Age was considered as an age category with two levels; i) under 75 and ii) equal or over 75 years old

Discussion

The purpose of this study was to assess whether aging and nighttime driving increased the probability of injury due to road traffic accidents among elderly people. The structure of the result was designed hierarchically in two steps. First, the crude and adjusted impacts of these covariates on the odds of elderly injury were estimated using univariable and multivariable regression models. In the second step, the causal effects of aging and nighttime driving were estimated using the newly developed statistical method.

The results of the first step indicated that aging and nighttime driving in univariable analysis had significantly positive effects on the odds of injury in elderly drivers. Although this effect size was somewhat moderated by adjusting the effect of other confounders in multivariable models, the effects remained statistically significant.

As far as we know, no previous studies have evaluated the causal effect of aging and nighttime driving on injuries in older adults. Although previous studies simply employed some traditional statistical methods, they reported consistent findings [1, 17, 18]. Ages 70-74 were found to have the highest fatal crash rates, peaking at age 85 and older [18]. Our existing knowledge suggests that rather than an increased propensity to get into collisions, older drivers had more odds of experiencing severe injuries, particularly medical complications and chest injuries. A growing body of literature found a relationship between aging, typical age-specific disorders, and driving ability [4, 19]. Although physical and mental decline is expected with age, people with a typical clinical diagnosis of cognitive decline, such as those with Alzheimer's or moderate cognitive impairment (MCI), experience greater reductions in driving performance [20, 21]. Therefore, age-related physical and mental impairments have a significant impact on driving performance in older adults.

According to the findings of the previous studies, driving at night was riskier [22, 23]. Driving in the daylight provides better visual prospection and gives more time to detect obstacles and avoids hazards. All these factors make drivers more cautious and ready to take the required precautions to lower the chance of severe collisions. Speed, intoxication, fatigue, and poor night vision were all been reported as the leading contributing factors to the increased risk of nighttime crashes [24]. A substantial majority of fatal nighttime crashes were caused by driving too fast and drinking too much. Poor vision in low-light conditions was correlated with poor recognition of traffic signs. Poor lighting reduces the reading distance of road signs, leaving less time to react to their information. This effect is especially pronounced in elderly drivers who drive at night [22].

The findings of this study indicated that older drivers, especially those over 75 years old, must undergo routine physical and medical examinations. This is because road safety requires the integration of complex visual, motor, and cognitive capabilities. Night driving restrictions for elderly drivers with impaired night vision should be considered necessary. The license restrictions on nighttime driving seem to effectively reduce road traffic injuries among elderly drivers. When driving in difficult conditions, most elderly drivers know their limitations and adjust their driving accordingly. Still, some cannot recognize their visual impairments and continue to drive in dangerous situations. For drivers over the age of 75, night driving ability and night vision tests should be compulsory, while renewing their driving license.

This study had some strengths. First, as far as we know, it was the first study, which implemented a new statistical approach to the dataset. Second, estimating the causal effect of the parameters based on evident and reliable scientific documentation helps policymakers, healthcare providers, and law enforcement in making more accurate prioritization decisions to implement essential health-promoting measures. The main limitation of this study was that it only considered the data from 2015 to 2016 due to restricted access to data until 2022. Although we made an effort to include all crucial and relevant confounders, the retrospective nature of this study limited its scope.

Based on the results of our study, increased age, and nighttime driving were significant risk factors for road traffic injuries among elderly drivers. This highlighted the importance of implementing tailored interventions to enhance road safety for this vulnerable population, such as restricting nighttime driving or providing additional training and assistance for elderly drivers. Furthermore, the use of advanced statistical methods such as Bayesian LASSO and treatment effect highlighted the importance of utilizing sophisticated techniques in epidemiological research to precisely capture and adjust for potential confounding factors.

Declaration

Ethics approval and consent to participate: The study was conducted following the Declaration of Helsinki and approved by the Institutional Review Board (#1396.465) and the ethics committee (#IR.TBZMED.REC.1398.1244) of Tabriz University of Medical Sciences, Iran. Participation in the study was voluntary for everyone, and their anonymity was respected. The participants were assured that their personal information would remain confidential and not be disclosed. All procedures were performed following the relevant guidelines and regulations. Written informed consent was obtained from all the participants included in the study.

Consent for publication: All authors read and approved the final manuscript to be published and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriate.

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Authors' Contributions: Conceptualization and study design: HSB; Investigation: MAJ; Data management: HSB, MAJ, and FJ; Methodology: HSB, MAJ, and FJ; Software, analyses, and interpretation of the results: MAJ and FJ; Validation: HSB, and MAJ; Writing and reviewing the draft: HSB, MAJ, and FJ; Writing, reviewing and editing: STH, MG, MR, KSH, HS.

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References

1. Sadeghi-Bazargani H, Ayubi E, Azami-Aghdash S, Abedi L, Zemestani A, Amanati L, et al. Epidemiological Patterns of Road Traffic Crashes During the Last Two Decades in Iran: A Review of the Literature from 1996 to 2014. *Arch Trauma Res*. 2016;**5**(3):e32985.
2. In: World Health Organization. WHO Facts about ageing 2014. Available from: http://www.who.int/ageing/about/facts/en/. [The web page does not exist]
3. Officer A, Schneiders ML, Wu D, Nash P, Thiyagarajan JA, Beard JR. Valuing older people: time for a global campaign to combat ageism. *Bull World Health Organ*. 2016;**94**(10):710-710A.
4. Falkenstein M, Karthaus M, Brüne-Cohrs U. Age-Related Diseases and Driving Safety. *Geriatrics (Basel)*. 2020;**5**(4):80.
5. Bhalla K, Naghavi M, Shahraz S, Bartels D, Murray CJ. Building national estimates of the burden of road traffic injuries in developing countries from all available data sources: Iran. *Inj Prev*. 2009;**15**(3):150-6.
6. Zhang J, Lindsay J, Clarke K, Robbins G, Mao Y. Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accid Anal Prev*. 2000;**32**(1):117-25.
7. Plainis S, Murray IJ, Pallikaris IG. Road traffic casualties: understanding the nighttime death toll. *Inj Prev*. 2006;**12**(2):125-8.
8. Jones PR, Ungewiss J, Eichinger P, Wörner M, Crabb DP, Schiefer U. Contrast Sensitivity and Night Driving in Older People: Quantifying the Relationship Between Visual Acuity, Contrast Sensitivity, and Hazard Detection Distance in a Night-Time Driving Simulator. *Front Hum Neurosci*. 2022;**16**:914459.
9. VanderWeele TJ. Principles of confounder selection. *Eur J Epidemiol*. 2019;**34**(3):211-9.
10. Greenland S, Pearce N. Statistical foundations for model-based adjustments. *Annu Rev Public Health*. 2015;**36**:89-108.
11. Kang J, Choi YJ, Kim IK, Lee HS, Kim H, Baik SH, et al. LASSO-Based Machine Learning Algorithm for Prediction of Lymph Node Metastasis in T1 Colorectal Cancer. *Cancer Res Treat*. 2021;**53**(3):773-83.
12. Agresti A. An introduction to categorical data analysis. JohnWiley & Sons. Inc, Publication. 1996.
13. Sadeghi-Bazargani H, Sadeghpour A, Lowery Wilson M, Ala A, Rahmani F. Developing a National Integrated Road Traffic Injury Registry System: A Conceptual Model for a Multidisciplinary Setting. *J Multidiscip Healthc*. 2020;**13**:983-96.
14. Wilson A, Reich BJ. Confounder selection via penalized credible regions. *Biometrics*. 2014;**70**(4):852-61.
15. Tibshirani R. Regression shrinkage and selection via the lasso. *J R Stat Soc Series B Stat Methodol*. 1996;**58**(1):267-88.
16. Hans C. Model uncertainty and variable selection in Bayesian lasso regression. *Statistics and Computing*. 2010;**20**:221-9.
17. Sadeghi-Bazargani H, Samadirad B, Moslemi F. A decade of road traffic fatalities among the elderly in north-West Iran. *BMC Public Health*. 2018;**18**(1):111.
18. Toups R, Chirles TJ, Ehsani JP, Michael JP, Bernstein JPK, Calamia M, et al. Driving Performance in Older Adults: Current Measures, Findings, and Implications for Roadway Safety. *Innov Aging*. 2022;**6**(1):igab051.
19. Murphy SA, Babulal GM, Roe CM. The Importance of Advancing Research on Aging and Driving. *Geriatrics (Basel)*. 2021;**6**(1):7.
20. Anstey KJ, Eramudugolla R, Chopra S, Price J, Wood JM. Assessment of Driving Safety in Older Adults with Mild Cognitive Impairment. *J Alzheimers Dis*. 2017;**57**(4):1197-205.
21. Barco PP, Baum CM, Ott BR, Ice S, Johnson A, Wallendorf M, et al. Driving Errors in Persons with Dementia. *J Am Geriatr Soc*. 2015;**63**(7):1373-80.
22. Gruber N, Mosimann UP, Müri RM, Nef T. Vision and night driving abilities of elderly drivers. *Traffic Inj Prev*. 2013;**14**(5):477-85.
23. Jahanjoo F, Sadeghi-Bazargani H, Asghari-Jafarabadi M. Modeling road traffic fatalities in Iran's six most populous provinces, 2015-2016. *BMC Public Health*. 2022;**22**(1):2234.
24. Niemann S, Achermann Sturmer Y, Cavegn M. SINUS-Report 2009: Safety Level and Accident Occurrence in Road Traffic 2008. Swiss Council for Accident Prevention; Bern, Switzerland. 2009. [Germany]