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The Impact of Traffic Law Enforcement Regulations on the Incidence and Severity of Maxillofacial Injuries

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Abstract

Objectives: Road traffic accidents (RTAs) are the main cause of facial injuries in Oman. This study aimed to assess the effectiveness of the new traffic law enforcement regulations (TLERs) on the incidence and severity of maxillofacial injuries in Oman. ***Methods:*** A retrospective longitudinal analytic study was conducted at three tertiary care hospitals in Muscat, Oman. All patients with RTA-related maxillofacial injuries for a five-year period from January 2005 to December 2009 (before the new TLERs) and the five-year period from January 2015 to December 2019 (after the new TLERs) were included in the study. ***Results:*** A total of 1127 patients were included in the study. Of these, 646 (57.3%) patients sustained RTA-related maxillofacial injuries before the implementation of the new TLERs compared to 481 (42.7%) after the introduction of TLERs. There was no significant difference in gender sustained injuries between the two study periods. The incidence of injury before the implementation of the TLERs was 22.7 per 100,000 population, which then reduced significantly to 11 per 100,000 after the new TLERs. Overall, there was a significant

reduction in the mean facial injury severity score from 3.2 to 2.3 before and after the implementation of the new TLERs, respectively. ***Conclusion:*** The findings of this study indicate that the newly introduced TLERs have resulted in a reduction in the incidence and severity of RTA-related maxillofacial injuries. Continuous improvement and reinforcement of TLERs will further help to reduce the burden of these injuries to the society in general and health services in particular.
Keywords: Law Enforcement; Traffic Accidents; Maxillofacial Injuries; Injury Severity Score; Oman.

Advances in Knowledge

- This is the first Omani study, which highlights that the new TLERs were effective in reducing the incidence and severity of RTA-related maxillofacial injuries in Oman.
- The findings of this study would be of interest to other countries to adopt the Omani experience in reducing the incidence and severity of RTA- related maxillofacial injuries.

Application to Patient Care

- The results of this study will help stakeholders and decision-makers to assess, review, and continue improving the current and future road safety strategies.
- The impact of human awareness and behaviour change is important in relation to road safety and further studies need to focus on this area.
- As part of ensuring effective implementation of TLERs, the role of law enforcement should be considered to ensure behavior change and thus improving road safety.

Introduction

Globally, Road Traffic Accidents (RTAs) are ranked as the 11th cause of death and 9th cause of disabilities. In addition, the World Health Organization (WHO) has reported more than 3000 deaths and 30,000 injured or disabled victims per day because of RTAs [1,2] In 2010, the Institute for Health Metrics and Evaluation reported that RTAs were the main cause of death in Oman.[3] Over the past five decades, Oman has experienced significant economical and substructural development that was accompanied by an exponential increase in its population as well as the total number of vehicles.[4] RTAs have a great impact and result in multiple challenges that hinder the progressive development of the country and consume human, financial, and health resources.[1-3,5] Governmental bodies

including; Royal Oman Police (ROP), Ministry of Transport, Ministry of Information and local Municipalities have been playing a big role in controlling and reducing the number and severity of these accidents by utilising communications and information technologies as well as introducing different measures like speed cameras, fines, penalty points, and new and safe highways.[6]

The maxillofacial region has prominent and mobile structures; thus, it is at risk of being injured during RTAs. Such injuries are serious and can cause severe blood loss, airway obstruction, facial deformity, and occasionally death.[3,5,7] Published studies have reported a marked reduction in the number and severity of maxillofacial injuries as an outcome of increased awareness within society and stepping up the traffic law enforcement regulations (TLERs).[5,7,8] In Oman, the implementation of the new TLERs, new road network, and monitoring technologies have shown major improvements and upgrading starting from the end of 2009 to early 2014.[6] Assessing the impact of these measures and regulations on the incidence and severity of maxillofacial injuries is of great importance to establish their effectiveness and to mark the need for their continuous improvements. Therefore, this study was conducted with the aim to assess the incidence and severity of RTAs-related maxillofacial injuries before and after the introduction of the new TLERs in Oman.

Methods

Before the start of the study, ethical approval was obtained from the respective research and ethics committees; Research and Ethical Review & Approval Committee at Centre of Studies & Research (MoH/CSR/20/16596), Research and Ethics Committee at Al-Nahdha Hospital (MOH/ANH/RC/22/20), and Medical Research Ethics Committee at Sultan Qaboos University (MREC #2319).

This retrospective longitudinal analytic study was carried out at three tertiary care hospitals; Al-Nahdha Hospital, Khoula Hospital, and Sultan Qaboos University Hospital (SQUH), Muscat, Oman. These are the three main hospitals in Oman managing craniomaxillofacial injuries. Data were retrieved from two electronic healthcare systems (Alshifa 3 plus, Ministry of Health, for the Al-Nahdha and Khoula Hospitals and TrakCare® 2018, Unified Healthcare system, InterSystems Corporation, for the SQUH). Data before 2006 were gathered from the trauma log books that were used to manually record maxillofacial injuries before the start of the electronic healthcare systems.

A total of 5444 patients files with a history of RTAs were reviewed. The target patients were divided into two periods. The first period, before the introduction of the new TLERs (January 2005 to December 2009) and the second period, after the introduction of TLERs (January 2015 to December 2019). The study inclusion criteria included all patients who presented to the mentioned three hospitals with the diagnosis of maxillofacial injury as a consequence of RTA during the study periods. Study variables included; gender, age, year of injury, and diagnosis of the maxillofacial injury. All fractures were categorized according to the location of; upper face (frontal bone and skull), mid-face (malar, maxillary, nasal bones, and naso-orbito-ethmoid), and lower face (mandible). Type of injury was also classified into isolated injury when only one facial bone is involved and combined when more than one facial bone is involved. The facial injury severity score (FISS) was chosen to assess the severity of the injury. This index was first created by Bagheri et al[9] and was subsequently used in multiple studies. FISS system categorises facial bones into 3 anatomical regions (upper face, mid-face, and mandible) and each facture line occurring in these areas is given an injury score according to the location, displacement, and severity of the injury. Facial lacerations are also recorded as part of FISS and the final score of FISS is calculated as the sum of each anatomical area sub-scores. Furthermore, the facial injury severity was categorized based on FISS to; mild (1 - 3), moderate (4 - 7), and severe (8 - 15) according to Alasseri et al.[10] A data collection sheet was designed using Microsoft Excel to collect the study data and the statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used for the study variables and the data was expressed in terms of number, percentage, mean, and standard deviation. Chi-square tests were used for significant analysis between the study variables and the periods before and after the implementation of the new TLERs. A statistically significant result was set at $P < 0.05$.

Results

A total of 5444 patients who had maxillofacial injuries were identified during the two study periods; of whom 1127 met the study inclusion criteria of having sustained RTA-related maxillofacial injuries [Figure 1]. The mean age was 30.8 years for the first period (2005-2009) and 27.8 years for the second period (2015-2019) with the difference being statistically significant. Table 1 shows the characteristics and demographic data of the study population.

With regards to the occurrence of the maxillofacial trauma, these injuries were more prevalent among males (78.6% vs 21.4%), however, the difference of gender between the two study periods was not statistically significant [Table 1].

The overall incidence of maxillofacial injuries per 100,000 population during the first and second periods was 22.7 and 11, respectively, which represent a significant reduction of these injuries after the implementation of the new TLERs.

The majority of the encountered maxillofacial injuries before and after the introduction of TLERs were isolated fractures accounting for 72.8% and 94%, respectively. Furthermore, these isolated fractures have shown an increase by 21.2% during the second period after the new TLERs. On the contrary, the opposite happened to the combined injuries with a significant decrease from 27.2% to 6%. This difference in combined /isolated type of injuries between the two periods was statistically significant with a *P-value* of 0.0001 [Table 1].

With regards to the location of the fractures, there was an overall increase in the occurrence of mid-facial fractures in comparison to a reduction in the number of upper and lower facial fractures in both study periods. However, the mandibular fracture was the most frequently encountered diagnosis accounting for 37.4% with the naso-orbito-ethmoid fracture being the least encountered (4%) in both study periods [Table 1].

Although the mean FISS before the introduction of the new TLERs was mild at 3.22 (SD 2.15), this further reduced to a mean score of 2.31 (SD1.71) after the introduction of the new TLERs. This reduction in the mean scores between the two periods was statistically significant (P = 0.0001). There was no statistically significant difference in the mean FISS scores between the genders [Table 2]. The overall FISS categorisation was higher for the mild injuries and low for severe injuries accounting for 68.5% and 2.7%, respectively. However, there was a statistically significant decrease in the percentage of moderate and severe injuries after the introduction of the TLERs [Figure 2 and Table 3].

Discussion

Sultanate of Oman is the second-largest country inland space and third in population size of the Gulf Cooperation Council (GCC) countries.[11] The income from oil revenue coupled with guided government policies in development, has moved Oman to a prestigious position at many levels and was ranked as the most "improved nation" in the world in terms of development during the past five decades.[3,12] With this rapid development there was a rapid rise in population and infrastructure and accordingly, there was also a remarkable increase in the number of drivers and registered vehicles. The Omani population has increased from 2.8 million in 2009 to 4.6 million by the end of 2019. Similarly, the number of registered vehicles and drivers increased from 840 thousand cars and 84 thousand registered drivers to 1.7 million cars and 1.5 million drivers by the end of 2009 and 2019, respectively.[11,13-15]

The Omani government through multiple governmental bodies including the ROP has over the past 10 years worked to further improve and enhance the road network and safety.[6,14] A national road safety committee was created in 2011 and the 18th of October was announced as an annual day of traffic safety. Furthermore, traffic safety symposia are held annually starting from 2011 that also feature traffic safety competitions focusing on school audiences. Major media and reporting campaigns were conducted throughout the years promoting and focusing on road safety issues and utilising all media platforms aimed at increasing awareness within the society, delivering educational programs, and behaviour changes with relation to road safety.[6] Furthermore, ROP annually participate and conduct activities as part of the GCC traffic week that focus on raising the public awareness and educating the public on issues related to road safety.[6,16] Furthermore, the Scientific Research Council of Oman has allocated annual road safety research funds and facilitated a liaison and consultancy agreement to enhance traffic safety with the British Research and Transportation Centre.[6] To tie-up with the move towards better road safety in Oman, the new TLERs were reintroduced gradually from late 2009 to early 2014. These regulations were equally applied and strictly reinforced across Oman. The TLERs included strict traffic law regulations and penalties, road and speed monitoring technologies, and others including traffic rehabilitations and regular traffic awareness campaigns.[6,14,15] This study which addresses the impact of the new TLERs regulations on maxillofacial injuries was undertaken five years post implementation of the new regulations ensuring proper adoption, implementation, and public awareness.

This is the first study in Oman and the second in GCC countries that was conducted to assess the impact of TLERs on maxillofacial injuries. The present study looked at two 5-years periods before and after the introduction of the new TLERs, which was unique in covering a longer period before and after implementing TLERs when compared to the reported study by Alasseri et al.[10] The result of this study showed that the incidence of RTAs-related maxillofacial injuries per 100,000 population has dropped from 22.7% to 11% after the introduction of the new TLERs. This finding is in line with other published work indicating that more stringent traffic law regulations resulted in a significant reduction of RTAs and their related injuries.[8,10,17-20]

The present study showed a male predominance concerning RTA-related maxillofacial injuries during both study periods (mean 78.6%). This finding is similar to previously published regional and international studies that reported men being commonly involved in RTA accounting for almost up to 80% of these injuries.[9,10,18-20] Such high prevalence was attributed to the fact that men are more empowered in society, involved in more outdoor activities, and more likely to be involved in reckless driving compared to female drivers.[10,20] Furthermore, our reported mean age of the involved patient was 29.9 years, which is very much similar to the findings of published studies concluding that this age group is associated with increased self-dependence, high activity, and social interactions that may increase their susceptibility to reckless driving and more road usage.[9,10,17-20]

Regarding the location of the injury, published data from Saudi Arabia reported that most maxillofacial injuries were in the lower face with no reported occurrence in the upper face during both study periods, before and after the implementation of the Saher law enforcement system.[10] Our findings are in contrast to the work of Alasseri et al in that before the implementation of TLERs, lower face and mid-face injuries have an equal occurrence of 38.2% each and after the TLERs adoption, most of the injuries were of mid-face accounting for 57.3% followed by lower face at 36.4%. This study also reports the occurrence of upper face injuries before and after the implementation of TLERs with a statistically significant reduction in the occurrence of upper face injuries during the second study period. This important finding is in line with other published studies.[17-21] If we consider the injury location-based on the International Classification of Diseases (ICD-10) diagnosis, the mandible was the most commonly involved maxillofacial bone at both study periods, and this finding is supported by other published scientific data.[9,10,17,20,21]

Assessing the severity of trauma is an important tool to estimate the risks of injury, survival probability and outcome prediction, plan for emergency and definitive treatment, predict health cost, and hospital length of stay (LOS).[10,21,22] For this purpose, many trauma severity scoring systems have been proposed and adopted over the past few decades.[21] The Abbreviated Injury Scale (AIS), the Injury Severity Score (ISS), and the Trauma and Injury Severity Score (TRISS) were among the first trauma severity scoring systems that were adopted in the 70's and 80's and have since undergone various revisions and updates.[23-26] In 1997, Osler et al revised the ISS system and proposed the New Injury Severity Score (NISS) that overcame the problem of ISS making it more simple and accurate to record.[27]

The main drawback of these trauma systems is that they were primarily designed to assess general trauma and in particular survival but not the disability, prognostic outcome, cost of treatment, or LOS.[10,21] Proper assessment of the maxillofacial trauma severity requires accurate recording of the injury type, location, functional abnormalities, and disability implications.[9,10,22,23] To address this area of trauma, newer severity scoring systems like Maxillofacial Injury Severity Score (MFISS) by Zhang et al in 2005, Facial Injury Severity Score (FISS) by Bagheri et al in 2006, and Maxillofacial Injury Severity Score (MISS) by Shi et al in 2008 were introduced.[9,23,28] Recently published work by Chen et al comparing four different maxillofacial trauma severity scoring systems showed that the MFISS was a better scoring system of maxillofacial injury severity and is regarded as a reliable system in assessing trauma severity, treatment plan, prognosis prediction, outcome, and assist maxillofacial trauma epidemiological and clinical studies.[22] However, MFISS has inherent multiple deficiencies that also exist within the other severity systems like inability to accurately record the severity of mid-face fractures and functional impairments.[22,23] MFISS is also a more complex system and demands multiple data entry than FISS. Accordingly, for the purpose of this study, we have used the FISS to evaluate trauma severity pre- and post- implementation of the new TLERs without the need for the outcome, prognosis, or treatment need analysis. Furthermore, the FISS was a simple system to use, requires far less data entry in comparison to the MFISS and MISS systems, and has been validated as a reliable system for recording maxillofacial trauma severity.[6,7,21]

FISS is a simple maxillofacial severity scoring scale that was designed and introduced by Bagheri et al in 2006 for maxillofacial trauma research purposes and has been used in multiple international studies to record maxillofacial trauma severity.[9,10,22] Our study showed that there was a statistically significant reduction in FISS from 3.2 to 2.3 before and after the implementation of the new TLERs, respectively which contradict the findings of Alasseri et al who reported that their mean FISS changed from 3.2 to 3.5 after the introduction of the Saher system.[10] Although their sample size was small, they showed that FISS injury subtype scores have reduced and the overall incidence of RTA-related maxillofacial injuries has also reduced from 58.9% to 41.4% after the implementation of the new traffic regulations in Saudi Arabia.[10] Our study findings are in line with the published work that highlighted the overall benefits of the enforcement and adoption of the strict traffic law regulations in reducing the incidence of RTA-related trauma.[7,8,10,17-20] Many developed countries including North America and Europe have succeeded in reducing the incidence of RTAs from over 30% to 3-8% over a few decades by investing in human education, research, and strict traffic regulations.[7,8,16,20,29,30] Previously published data from different GCC countries reported that 51-63% of the maxillofacial injuries are RTA related, representing the major aetiological factor in these injuries. These reports have recommended that collaborative work needs to be taken to reduce this relatively high incidence by adopting multiple measures that focus on improving public awareness, education, road network and safety, and more strict traffic regulations.[16,17,20,31] The present study has demonstrated the benefits of adopting the set recommendations that have led to a significant reduction in incidence of RTA-related maxillofacial injuries in Oman from 53 and 63%, as reported by Bakathir et al and Al-Hashmi et al in 2008 to 19.5% and 22.6% before and after the introduction of the TLERs, respectively.[16,31] Furthermore, the significant increase in isolated maxillofacial fractures with the significant decrease in combined injuries indicate a great achievement and success which has made Oman a role model within the GCC in the implementation and reinforcement of TLERs.

This retrospective analysis had a few limitations and inherent drawbacks including missing and limited sources of data, failure to record other associated injuries which would serve as an additional measure of injury severity. This national study is not fully comprehensive as it lacks data from other smaller maxillofacial surgery units namely; Armed Forces Hospital, and the three regional Hospitals in Sohar, Salalah, and Ibri that started managing maxillofacial trauma after 2016. Further studies

incorporating detailed maxillofacial trauma assessment, treatment, outcome, cost, and LOS will be important in assessing the impact of RTA-related maxillofacial injuries on the healthcare system in Oman.

Conclusion

In summary, the new Omani TLERs were effective in reducing the incidence and severity of RTA-related maxillofacial injuries. However, additional work is required for continuing improvement and reinforcement of TLERs to further reduce the incidence of these injuries and subsequently decrease the burden of the RTA-related injuries in Oman. The impact of this study should help all stakeholders assess and review current and future road safety strategies. The role of human awareness and behaviour are important in relation to road safety and further studies need to focus on this area.

Authors' Contribution

AH, AB and AA conceptualized and designed the study. AA obtained the ethical approval for the study. AH, AB and SH supervised the work. AA, KH and SR collected the data. AA and AB drafted the manuscript. MI edited the manuscript. All authors approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Table 1: Characteristics and demographic data of the study population.

Characteristics and demographic of the study variables				
Variables	**2005-2009**	**2015-2019**	**Total**	***P-value***
% RTA-related maxillofacial injuries from the total injuries	19.5%	22.6%	20.7%	
Gender [no. (%)]				
Male	516 (80%)	369 (76.9%)	885 (78.6%)	0.213
Female	130 (20%)	112 (23.1%)	242 (21.4%)	
Total	646	481	1127	0.0001
Age [years]				
Mean	30.8	27.8	29.9	0.0001
Minimum	1	2	1	
Maximum	83	63	83	
Diagnosis [no. (%)]				
Fracture of malar and maxillary bones	121 (18.7%)	151 (31.4%)	272 (24.1%)	0.0001

Fracture of mandible	247 (38.2%)	175 (36.3%)	422 (37.4%)	
Fracture of nasal bones	112 (17.3%)	93 (19.3%)	205 (18.2%)	
NOE fracture	14 (2.1%)	30 (6.2%)	44 (4%)	
Fracture of frontal bone	152 (23.5%)	32 (6.6%)	184 (16.3%)	
Location of Injury [no. (%)]				
Upper face	152 (23.6%)	30 (6.3%)	182 (16.2%)	0.0001
Mid-face	247 (38.2%)	276 (57.3%)	523 (46.4%)	
Lower face	247 (38.2%)	175 (36.4%)	422 (37.4%)	
Injury type [no. (%)]				
Isolated	470 (72.8%)	452 (94%)	922 (81.8%)	0.0001
Combined	176 (27.2%)	29 (6%)	205 (18.2%)	

Table 2: Comparison between facial injury severity scores before and after the implementation of the new traffic law enforcement regulations in relation to age and gender.

	Year / Gender	No.	Mean	Std. Deviation	*P-value*
Age	**2005-2009**	646	30.9	13.3	0.0001*
	2015-2019	481	27.8	12.5	
	Male	885	29.4	12.7	0.312
	Female	242	30.4	14.2	
FISS Score	**2005-2009**	646	3.2	2.15	0.0001*
	2015-2019	481	2.3	1.71	
	Male	885	2.87	2.01	0.237
	Female	242	2.69	2.09	

Table 3: Facial injury severity score before and after the implementation of the new traffic law enforcement regulations.

Year	**Sex**	**FISS Groups [no. (%)]**			**Total**	***P-value***
		Mild	**Moderate**	**Severe**		
2005-2009	Male	310 (60.1%)	189 (36.6%)	17 (3.3%)	516 (100%)	
	Female	76 (58.5%)	49 (37.7%)	5 (3.8%)	130 (100%)	

	Total	386 (59.8%)	238 (36.8%)	22 (3.4%)	646 (100%)	0.0001
2015-2019	Male	289 (78.3%)	75 (20.3%)	5 (1.4%)	369 (100%)	
	Female	97 (87.4%)	12 (10.8%)	2 (1.8%)	111 (100%)	
	Total	386 (80.4%)	87 (18.1%)	7 (1.5%)	480 (100%)	0.0001
Total		**772 (68.6%)**	**325 (28.9%)**	**29 (2.6%)**	**1127 (100%)**	**0.0001**

FISS Scores: Mild (1-3), Moderate (4-7), and severe (8-15).

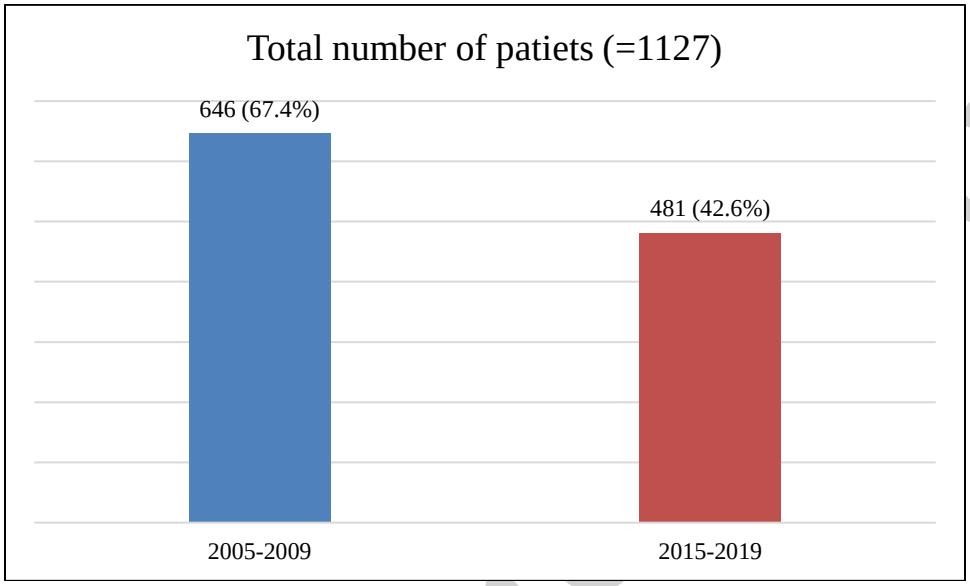

Figure 1: RTA-related maxillofacial injuries before and after the implementation of the new traffic law enforcement regulations.

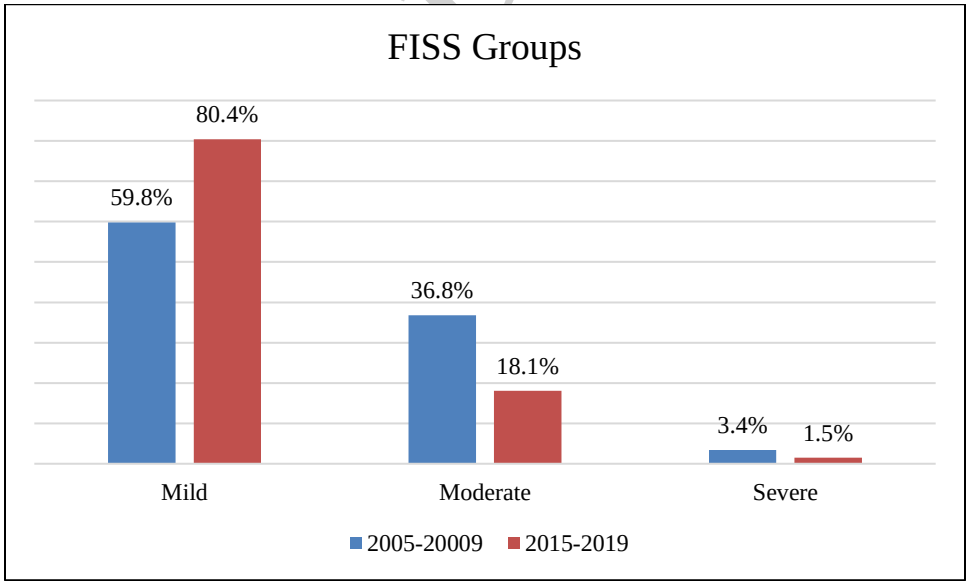

Figure 2: Facial injury severity score group categorization before and after the implementation of the new traffic law enforcement regulations.