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Not all quad bikers are the same: unsupervised cluster analysis identifying injury risk groups among quad bike riders in Dubai, UAE

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ABSTRACT

Objective Quad bike riders in Dubai (UAE) constitute a highly diverse group with varying driving skills and familiarity with the desert environment. In the absence of evidence on the quad bike riders in the region, we attempted to describe the most vulnerable risk groups using routinely collected injury data. This may hopefully inform the most effective injury prevention strategies for the region.

Methods Four-year injury incident reports of 226 patients rescued by Dubai ambulance were grouped into three clusters using two-step cluster analysis in SPSS.

Result The three clusters that emerged were 'Older Tourist-Expatriates' (n=86), 'Prompt Young Emiratis' (n=76) and 'Tightlipped Young Colliders' (n=60). Older tourists were more likely to ride during the daytime and sustained milder injuries due to rollover. Prompt Young Emirati riders who experienced severe head, neck and spine injuries from nighttime rollovers were more likely to call for an ambulance without delay. Tightlipped Young Colliders were very young riders who experienced quad bike collisions or did not report their crash history. One in five riders in Clusters 1 and 3 delayed calling the ambulance by more than 6 hours.

Conclusion Young nationals with severe injuries due to night collisions and rollovers during winter would benefit from increased guardianship, vehicle modification and crowd control interventions. In addition, emergency first aid services for tourists and nationals should be allocated to the major quad biking desert locations in Dubai to relieve the burden on emergency ambulatory care services.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Very few studies describing quad bike riders and quad bike injuries in the Middle East; but presented as one homogeneous rider population.

WHAT THIS STUDY ADDS

⇒ Novel application of unsupervised cluster analysis methods on ambulance trauma records.
⇒ It describes groups of injured quad bikers with distinct aetiology, injury outcome and response to injury.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ It identifies tailored injury prevention interventions for different demographic groups among quad bike riders.
⇒ It advises strategies to optimise emergency care resources in certain injury groups.
⇒ It brings out the issue of delayed health-seeking behaviour among specific groups.

INTRODUCTION

Quad bikes or all-terrain vehicles (ATVs) are four-wheeled side-straddle seated bikes for off-road terrain.[1] Quad biking is one of the Middle East's most popular outdoor recreational sports. It is the preferred ATV for those who have not yet reached the age to drive four-wheel drive vehicles. Children and adolescents in the Middle East frequently ride ATVs or quad bikes, seen in the mean age of injured patients ranging from 23 to 27 years.[2 3] In addition, UAE is known for its diverse population, with expatriates forming 85% of its 9.9 million people in 2020.[4 5] This heterogeneity is further amplified during the tourist season in Dubai, which sees 16.7 million visitors, with almost 40% experiencing desert recreational sports.[6] Thus, desert recreational sport like quad biking has a diverse rider population of varied nationalities, residence and age groups in Dubai.

Among riders, various factors related to the vehicle, terrain, environment and riding habits can influence injuries.[7] Risk factors associated with injury severity include vehicle features like engine size, non-use of rollover protection systems and absence of helmet at the time of the crash.[8–12] Injuries are

influenced by riding practices of age-appropriate vehicle use, using protective gear and riding on public roads or with passengers.[7 11 13–16] Studies have shown that terrain, weather conditions and rural or unsupervised riding locations alter injury severity.[15 17 18]

While several risk factors influenced injuries, quad bike riders exhibiting similar riding practices might show similar crashes or injury outcomes. Likewise, studies have observed that people exposed to different risk factors (exposure clusters) might show varied consequences.[19] In addition to exposure clusters, strong associations between risk factors and their interaction could bring individuals together in groups of similar risk profiles. For example, Haregu identified distinct risk characteristics among those who showed risky road behaviour like jaywalking, and helmet non-users. This study highlighted the heterogeneity in observational data.[19] Sports injury-related observational data or controlled trials also had to acknowledge heterogeneity to avoid spurious results and inferences.[20] This grouping could also be intensified by hidden associations that go undetected by correlation or regression analysis.[21] It is likely that observational injury data collected post-hoc have the limitation of not recording several potential injury risk factors. When identifying risk models, these unmeasured risk factors could hide many strong relationships or associations.[22] Thus, we need to accommodate these unaccounted risk associations and risk clusters when building risk models. Prevention strategies based on results that do not accommodate such clusters or heterogeneity might fall short of showing an impact.[20 23] It is evident that the approach 'one size fits all' prevention strategies might only be effective in specific groups or conditions within a heterogeneous population.[21 23] Thus, analysing evidence without identifying risk groups might miss prevention strategies that significantly impact a subgroup.

One solution is to identify the clusters of riders within the data and analyse their risk associations after accounting for heterogeneity.[24] Specifically, cluster analysis is a descriptive statistical technique that identifies groups within a dataset.[25] By doing so, they convert heterogeneous datasets to homogeneous groups and help analyse more multivariate variables. Furthermore, they assist us in making sense of the risk associated with certain groups.[23 25] Additionally, cluster analysis has many applications in developing treatment strategies based on clustered recovery or coping patterns.[26–30] Moreover, it has strengthened health systems by describing the barriers to healthcare access or implementation.[31] In fact, cluster analysis has been widely used to identify causality and risk clusters.[19–22 32] As a result, injury prevention policymakers have accepted that prevention programmes cannot take a universal approach. Consequently, they have identified risk profile of vulnerable groups to tailor high-impact intervention strategies.[23 24 33] Therefore, we adopted cluster analysis to generate effective evidence for injury prevention strategies among quad bike riders in Dubai.

Quad bike riders in Dubai are a highly diverse group, exhibiting varying degrees of familiarity with the desert dunes as well as differing driving skills. Moreover, crashes occur in different environmental conditions and terrains, leading to varied injury outcomes. Consequently, acknowledging and understanding this diversity will help us optimise resources by fine-tuning injury prevention interventions. Therefore, we tried identifying the different injured rider clusters and their unique risk profile to identify the most effective interventions.

In addition, previous studies hypothesised that nationals and tourists could be two distinct vulnerable populations with unique riding habits. As a result, this study was initiated to identify the risk clusters around two different vulnerable populations namely, Emirati nationals and non-nationals. Ultimately, this study aims to identify and describe the various clusters of quad bike riders in Dubai, using 4-year injury records.

MATERIALS AND METHODS

Source

The data sources for quad bike injuries comprised incident reports of injured patients who approached Dubai Ambulance (Dubai Corporation for Ambulatory Services (DCAS)) between 1 January 2017 and 1 January 2021. DCAS data management team extracted the data from the Dubai Ambulance event sheet, activity sheet and Electronic Patient Care Reports. We identified cases from vehicle-related keywords in the case history. DCAS data management team de-identified the extracted data and removed duplicate and missing records. Finally, the variables were checked for outliers. This study was approved by the ethical review board at the Department of Medical and Technical Affairs, Dubai Corporation for Ambulatory Services.

Variables

Demographic variables like age, gender and nationality were included and re-classified. Specifically, age was treated as a continuous variable. The dataset had injured patients from 45 different nationalities. In this regard, Emiratis or nationals were grouped into one category and constituted the most numerous groups for 49.6% of the injured. On the other hand, other nationalities were classified based on the continents, with distinct groups of Asians (excluding Middle East Asians) and Africans forming the next largest group. Following that, Europeans and Americans were grouped together, while nationalities from North Africa and Middle East Asia, constituting the MENA group (table 1). Additionally, when converting nationality into a binary variable, Emirati citizens were named nationals, and all other nationalities were combined as non-nationals. The latter category included expatriate residents, tourists and those from neighbouring countries. However, the database could not differentiate between tourists and expatriate residents.

Table 1 Descriptive characteristics of patients availing emergency care after quad bike injuries in Dubai (2017–2021)

Variable	Number	Percentage
Age		
0–15	56	24.8
16–25	83	36.7
26–35	47	20.8
>35	40	17.7
Nationality		
Emirati	112	49.6
Europe, Americas	38	16.8
Asia, Africa	47	20.8
Middle East and North Africa	26	11.5
Crash mechanism		
Rollover	166	73.5
Collision	27	11.9
Unrecorded	33	14.6
Injured body region		
Head, neck, spine	48	21.2
Limbs	71	31.4
Thorax, other regions	18	8
Skin laceration and abrasion	89	39.4
Time of injury		
16:00 to 20:00	120	53.1
20:00 to 06:00	73	32.3
06:00 to 16:00	33	14.6
Response		
Treated at scene	73	32.3
Referred to emergency care hospital	153	67.7
Season		
Winter (October 01 to March 31)	186	82.3
Summer (April 01 to September 30)	40	17.7

Incident details, such as date and time of call, were transformed into seasonal and diurnal variables. Specifically, all cases between 1 October and 31 March were classified as wintertime injuries and the rest as summertime quad bike injuries. This classification is based on the outdoor sports season followed by residents in the UAE. Moreover, time of the injury was taken as a continuous variable for cluster analysis and subsequently converted into a categorical variable for descriptive analysis (table 1). The crash mechanism was deduced from a list of keywords in the case history. Among the incident data, 14% of the cases lacked a clearly defined crash mechanism. However, we did not categorise these cases as incomplete records since they still contained other important details regarding injury outcomes and the timing of the injury. In the absence of ICD-10 (International Classification of Diseases, Tenth Edition, Clinical Modifications) diagnostic codes, keyword searches

Table 2 χ^2 analysis showing significant relationships ($p<0.05$) between variables

Variable	Associated variable	χ^2 (P value)
Injured body region	Nationality group	12.443 (0.0189)
	Time of injury	18.758 (0.005)
	Age category	20.488 (0.015)
Time of injury	Nationality group	12.443 (0.0189)

*Following table shows χ^2 value (P value) between variables, only significant relationships are shown.

inferred outcome variables from clinical impressions and case history records reported by DCAS staff (online supplemental table 1). Furthermore, two independent researchers checked these variable codes for validity and misclassification errors. Injury outcomes were grouped based on the affected body region as specified by the International Olympic Committee consensus statement on reporting sports injuries. Consequently, the authors categorised body regions into head, neck, shoulder, thoracic spine, lumbar spine, pelvis and other region classification of the appendages.[34] Finally, we grouped the body regions to meet the less detailed case records.

Analysis

Descriptive statistics of all variables, including frequency distribution and bar charts for categorical variables, were used (table 1). Additionally, the χ^2 test for associations between categorical variables helped identify strong associations among these variables (table 2). In this regard, we followed Clatworthy in planning for and reporting the study.[25] Furthermore, the 'two-step clustering' method, was adopted to identify clusters in the dataset. Variables on injury outcomes and predictors were selected for cluster analysis. The input variables were three categorical variables on injury outcome, crash mechanism and nationality groups. Though two continuous variables of age and time of injury were added, they were omitted from the clustering algorithm due to the lack of variability (online supplemental tables 2 and 3). The reason for choosing the two-step cluster analysis method was that it could handle continuous and categorical data through an unsupervised clustering method, reducing researcher bias.[21 35 36] Initially, the first step of creating pre-clusters was carried out using the log-likelihood method with noise reduction. Subsequently, the second step of identifying the optimum number of clusters was based on the lowest Bayesian information criterion score. In addition, the model fit was assessed using the silhouette coefficient.[36 37] The cluster differences were validated using Pearson's χ^2 analysis and analysis of variance (ANOVA) (table 3). Finally, we described each cluster using the frequency distribution of the input variables on the cluster-split data and tested for normality for continuous variables (online supplemental table 4, online supplemental appendices 1 and 2). For this analysis, IBM SPSS

Table 3 Distribution of variables across the three clusters

Variables	Distribution within each cluster			Pearson χ^2	Asymptotic significance (two-sided)
	Cluster 1 (86)	Cluster 2 (76)	Cluster 3 (60)		
Emirati	0.0%	100.0%	60.0%		
Europe, Americas	32.6%	0.0%	16.7%		
MENA, GCC	25.6%	0.0%	6.7%		
Asia, Africa	41.9%	0.0%	16.7%	169.318	0.000
Less than 16 years	15.1%	31.6%	31.7%		
16–25 years	24.4%	43.4%	46.7%		
26–35 years	31.4%	14.5%	11.7%		
More than 35 years	29.1%	10.5%	10.0%	35.488	0.000
Summer	30.2%	5.3%	16.7%		
Winter	69.8%	94.7%	83.3%	17.410	0.001
Daytime symptom	72.1%	38.2%	36.7%		
Nighttime symptom	27.9%	61.8%	63.3%	26.222	0.000
Rollover	100.0%	100.0%	1.7%		
Collision	0.0%	0.0%	43.3%		
Unrecorded	0.0%	0.0%	55.0%	222.618	0.000
Head, neck, spine	14.0%	32.9%	13.3%		
Limbs	34.9%	27.6%	31.7%		
Thorax, other region	11.6%	2.6%	10.0%		
Skin	39.5%	36.8%	45.0%	16.931	0.050
No delay	82.6%	94.7%	80.0%		
Delay access >6 hours, history	17.4%	5.3%	20.0%	13.302	0.004
				ANOVA f statistics	P value
Median age in years (IQR)	28.00 (16)	18.00 (11)	17.00 (9)	14.961	0.000

Statistics V.28.0.0.0 was used for frequency distribution, χ^2 analysis, ANOVA and cluster analysis.

We retested the association between variables to understand and explain the risk clusters. To achieve this, the variables that defined the clusters were used for univariate and multivariate regression analysis (table 4). In addition, categorical variables were regrouped into binary variables and added to the regression model. Time of the injury was reclassified into daytime and nighttime injury. Thus, incidents that occurred during the civil daylight period (just before sunrise and immediately after sunset) were classified as daytime injuries. Conversely, they were classified as nighttime injuries. It is important to note that civil daylight includes the time between the sunrise and the sunset, including the civil twilight period. We accounted for the civil twilight period because, despite the sun being below the horizon, people experience considerable visibility during civil twilight. Thus, making

Table 4 Logistic regression models to test association between variables

Dependent variable	Independent variable	P value	OR	Confounders in model	Nagelkerke R square value of model
Delay to access emergency care	Non-national	0.039	3.55 (1.07, 11.82)	Gender, referral, summertime injury, daytime injury	0.171
Nighttime injury	Emirati	<0.001	3.35 (1.83, 6.16)	Emirati National, age less than 36, limb injuries, head, neck and spine injuries, rollover crash mechanism	0.271
	Age <36	0.007	4.17 (1.48, 11.73)		
	Collision crash mechanism	0.05	2.02 (1, 4.07)		
Winter injuries	Non-nationals	0.001	0.25 (0.10, 0.58)	Non-nationals, delay to access emergency, nighttime injuries, age less than 36	0.164

civil daylight a better representative of visibility-related risk, associated with crashes in the desert. To support this categorisation, date-specific civil twilight data were extracted from an online repository. Finally, significant associations in logistic regression were presented, along with ORs and 95% CIs. For these regression models, we used the Nagelkerke R square value to identify goodness of fit.

RESULTS

226 injury incidents involving quad bikes in Dubai were collected over 5 years from 1 January 2017 to 18 February 2021. Notably, the injured quad bike rider's ages ranged from 3 to 63 years, and the majority were males. Moreover, the injured population was predominantly young, with a median age of 22. Among nationalities, half of the injured victims were national Emiratis, with a median age of 17 years. In contrast, the group of non-nationals comprised various nationalities, predominantly South Asians and Europeans (table 1). The median age of non-national quad bike riders was 27.5 years. Furthermore, most injuries occurred during the afternoon and late-evening hours followed by night injuries. Similarly, injuries were unevenly distributed across seasons, with more injuries during winter compared with summer (table 1). In terms of crash types, most riders got injured due to rollover crashes followed by collisions. The resulting injuries were predominantly mild, ranging between skin abrasions and lacerations (39.4%), but also had a significant proportion of limb fractures and those involving head, neck and spine.

An unsupervised two-step cluster analysis divided the injury incident cases into three distinct clusters with cluster quality ranging between poor and fair (figure 1).

The three clusters are presented in table 3. Importantly, crash mechanisms and injury profiles were distinct for each cluster shown by a p value <0.05 for Pearson's χ^2 test between the groups (table 3). The results showed that the clusters were significantly different from each other in relation to injury outcomes, age distribution and nationality. In addition, the time of injury and crash mechanism were also significantly different among the clusters. However, the time of injury was not significantly different between the clusters for most injuries occurring in the afternoon and night.

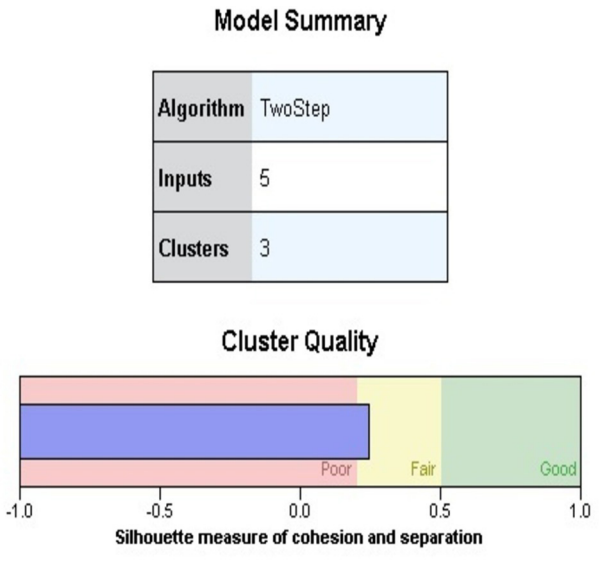

Figure 1 Cluster model quality of fit using silhouette measure of cohesion and separation.

The three clusters that emerged were named as follows: 'Older Tourists-Expatriates' (Cluster 1, n=86), 'Prompt Young Emiratis' (Cluster 2, n=76) and 'Tightlipped Young Colliders' (Cluster 3, n=60). The first cluster (Cluster 1) comprised injured patients from Europe, USA, Canada, South Asia, the Middle East and North America (other than Emiratis nationals), neighbouring Gulf Countries and Africa. Notably, injured riders of Cluster 1 were significantly older than the other two groups, with a median age of 28 years (Median 28; IQR 16). Moreover, patients in this group were from various nationalities and could either be tourists or expatriate residents. Interestingly, these older riders were getting injured both in summer and winter months and more during the daytime from 06:00 to 16:00 (online supplemental appendix 3). In comparison to the other groups, a significant proportion of Cluster 1 injuries were injured during the day (76%) predominantly due to rollover incidents. Consequently, they ended up with a wide range of injuries, mostly mild skin lacerations and limb fractures.

In contrast, the second cluster of 'Prompt Young Emiratis' was comprised of Emirati nationals of a younger age group with a median age of 18 years (Median 18; IQR 6) (online supplemental appendix 2). Notably, these riders experienced quad bike rollover incidents similar to Cluster 1 riders but were least likely to delay calling for an ambulance. However, this group of young riders suffered from a disturbingly higher proportion of severe head, neck and spine injuries (33%) and limb injuries (28%) sustained in the afternoon and night (online supplemental appendix 3). On the other hand, the third cluster of 'Tightlipped Young Riders' was the smallest yet distinct group of very young riders with a median age of 17 years (Median 17; IQR 22) (online supplemental appendix 2). Importantly, this group was injured mainly during the night and experienced injuries from vehicle collisions and rollovers (online supplemental appendix 3). What sets this group apart is their tendency to be tightlipped, as they do not share their experience relating to crash mechanisms. As a result, this group had a sizeable proportion of patients whose injury risk factors and crash mechanisms were not recorded. Furthermore, another disturbing health behaviour was the delay in calling the ambulance. Almost 20% of injured patients in Cluster 3 and Cluster 1 notably delayed calling the ambulance by more than 6 hours. This is concerning, especially considering that 45% of riders in Cluster 3 experienced injuries affecting the head, the neck, spine and extremities.

Logistic regression models helped further understand the risk associations that influenced the clustering. Specifically, non-nationals were 3.55 times more likely to delay calling ambulance by over 6 hours compared with Emiratis (table 4). Similarly, nationality had an important role in predicting the times of injury. Emirati nationals were more likely to get injured at night. This inference comes from the analysis showed that the OR for Emiratis experiencing night injuries was significantly higher by 3.35 times when compared with non-nationals (table 4). In addition, the same model observed that nighttime injuries were two times as likely to be collisions than rollovers.

Furthermore, the logistic regression revealed that Emirati nationals were more likely to be injured in the winter compared with non-nationals (table 4). In conclusion, the logistic regression models showed strong associations between nationality, time of injury and delay in accessing emergency care. In addition, younger age groups and collision crashes were found to be strongly associated with nighttime injury.

DISCUSSION

Cluster analysis revealed three distinct groups of quad bike riders with different injury profiles in Dubai. We found that Emirati riders are relatively younger with a tendency to ride at night and in winter. In addition, younger riders sustain severe injuries due to collisions and rollovers. In contrast, older non-nationals are more likely to stick to daytime driving and more likely to sustain milder injuries following rollovers. We found that risk factors like nationality, age and crash mechanisms significantly differ between the clusters, in addition to their distinct injury profiles. Therefore, such clustering analysis helps to identify the risk groups and the most likely strategies for injury prevention.

Age was the most distinguishing feature among clusters of injured quad bike riders. This is similar to studies on road traffic injury that showed clusters with distinct age distributions.[19 21] Consequently, this observation may explain why younger age rider groups are more prone to head injuries following collisions (Cluster 3). Moreover, logistic regression models showed a strong association between age and nighttime riding. Age influencing risky riding behaviour was reported by Haregu *et al*, who observed a considerable influence of age on helmet usage.[19] In addition to risk aversion, age is known to influence the propensity to injury, especially in complex environments. For instance, young riders were more likely to sustain injuries in a complex driving environment like night, or unfavourable weather conditions, where middle-aged riders could navigate more safely.[21] While understanding the influence of age as a risk factor for injury, we must refrain from assuming that young age is synonym to lack of experience. In fact, riding experience was a significant factor associated with quad bike crashes with riders with less than 1 year of experience reporting the highest crash rates among 1546 workplace riders in Australia and New Zealand. This risk was further reduced when novice riders were trained on hazard perception by experienced riders.[12] Therefore, it is essential to undertake further studies to explore the effects of age, experience and the adverse weather conditions in the desert with injury in the Middle East region.

Regarding crash mechanisms and visibility synergy, logistic regression showed a close association between nighttime riding and collision crashes. This observation should be accepted carefully, as classifying time into binary variables might remove nuances or unaccounted time-related risk factors. This residual confounding might show associations that may not accurately reflect true relationships. Despite this, our study found a few observations related to nighttime injuries. Our cluster analysis revealed that collisions occurring at night were associated with injuries to the head and neck (Clusters 2 and 3), in contrast to rollover incidents during daylight hours (Cluster 1). This could be attributed to riding at night in conditions of low visibility, thereby creating a complex risk environment, particularly in challenging terrains such as the desert. In support of this, a cluster analysis of driver injury in roadway intersections noted that injury severity increased during the night compared with the daytime. The authors of this study attributed the result to lower visibility, fatigue and driving under intoxication.[21] Consequently, this observation calls for a more in-depth study among quad bike desert riders to test the synergy between visibility, fatigue, intoxication and desert terrain.

Additionally, we have observed mild skin injuries occurring among older non-nationals, especially when riding during the daytime. This reduction in injury severity could be attributed to 'risk compensation' in unfamiliar weather conditions, especially among drivers unfamiliar with desert terrains. For example, Li hinted that such risk compensation is observed whenever drivers were less likely to experience a collision in adverse weather conditions, such as during snow or rain.[21] Similarly, risk compensation was also observed when inexperienced motorcycle riders attempted to avoid dangerous roads and high-risk situations.[22] In addition, the higher safety measures by tour operators through short, guided rides might have contributed to injury prevention among tourists in Dubai.

Finally, the most enigmatic group (Cluster 3) did not divulge the crash mechanism despite showing a wide range of injury outcomes. However, the group was younger and also had a higher risk of delaying calls to the ambulance. Ambulance staff described the group as the one with riders who tend to move away from the injury site and walk into the ambulance outpost. Unfortunately, this group of riders, who delayed calls for healthcare were found suffering from severe injuries to the head, the neck, the spine and limbs (44%) that would have benefitted by prompt care. It is also disturbing to note that non-nationals were at a higher odds of delaying calling an ambulance than nationals.

Limitations

The data used for cluster analysis were from patients who availed the Ambulance services in Dubai following quad bike crashes. Notably, the dataset mainly comprised the profiles of quad bike riders who sustained moderate to severe injuries. However, these ambulance data missed out the profiles of riders with mild injuries, who usually constitute a sizeable proportion of quad bike injuries. Despite this limitation, this suboptimal classification might still benefit interventions intending to reduce severe injuries in the region. Moreover, the classification of injury outcomes by ambulance staff is based on clinical impressions only, which might lead to further misclassification errors. The ICD-10 Diagnostic codes could have helped minimising this error, but unfortunately, it is not yet the norm in DCAS database. Additionally, the poor linkage of the DCAS database with emergency departments at Dubai hospitals also exerted further limitations to the study regarding the final injury outcomes. As such, this study should be considered an exploratory study.

Furthermore, the results from this study cannot be generalised to regions where the tourist riders are known to be less in numbers. In contrast, quad bike riders in other areas might represent Clusters 2 and 3 more than Cluster 1. For example, contrary to our findings, Qatar reported fewer national riders when compared with non-nationals.[2] Therefore, we recommend undertaking similar studies in other countries with identical desert ecosystems dominated by local riders. Despite the heterogeneity in nationalities, the study results still represent injuries in a desert ecosystem with extreme summers and mild winters.

Recommendations

Using cluster analysis, we were able to identify distinct groups of injured riders with specific risk environment, risk outcomes, motivators and barriers. Using cluster analysis may help increase the effectiveness of interventions aiming to control quad bike injuries. The findings of this study may help policymakers to determine the most effective intervention measures and to fine-tune the implementation reach.

The cluster that requires maximum attention would be that of 'younger drivers' who drive at night and tend to suffer from collisions (Cluster 3). To avoid collisions, these drivers need more mentoring and support provided through crowd control mentors at night, especially in the winter season. Injury prevention messages should be designed and disseminated regularly using social media. These messages may include caution against using quad bikes on paved roads or with larger four-wheel drive vehicles.[16] The messages should also inform riders that quad bikes have a very high propensity to rollover, where riding over a small rock, tyre rut, tuft of grass or across a moderate embankment can result in a rollover.[7] This risky environment occurs when young children and adolescents come out to the desert with older family members at night-riding parties. This group of young riders might also benefit from special safety training courses on navigating the desert dunes during adverse weather conditions and low visibility. Powerful headlights and reflective clothing must be made mandatory for this group. Awareness of emergency call number and trust in the legal-health system could address the delay in accessing emergency care following crash, among nationals and non-nationals.

To reduce head and neck injuries, helmet use has to be enforced with assistance from guardians and family members both, during day and night. In addition, young riders might need training on 'active dismounting' and 'active riding techniques' to avoid rollover injuries.[1 13 38] Finally, first aid posts or trained tour operators at riding camps and parks could handle milder skin injuries that almost constitute 40% of emergency calls (Cluster 1). This can save resources of ambulance care to be used for more severe injuries requiring transport to trauma hospitals.

The two groups of non-national riders (Clusters 1 and 3) could be tourists and expatriate residents who are less familiar with driving in the desert terrain. Terrains with a graduated level of difficulty should be made available to the tourists and riders to familiarise themselves with the vehicle and the tricky desert terrain. For example, a beginner might be allowed to ride on level ground or shallow dunes, while the riders who are more competent could be taken to more challenging dunes and desert bowls. Tour operators should not provide new riders with vehicles of super engine capacity. The current practice of a tour guide leading the group is beneficial in reducing injuries and should be encouraged in all driving spots. In addition, tour companies and tour mentors should be trained and equipped with first aid kits to reduce the burden on emergency ambulance services, such as DCAS in dealing with minor injuries. Thus, tour companies can continue to be an active stakeholder in reducing injuries and hastening recovery.

CONCLUSIONS

The study showed three risk clusters among quad bike riders in Dubai—Older Day Riding Tourist—Expatriates (Cluster 1), Prompt Young Emiratis (Cluster 2) and Tightlipped Young Colliders (Cluster 3). Younger riders showing severe injuries due to night collisions and rollovers, especially during winter, could benefit from increased supervision, vehicle modification and crowd control. Emergency care for tourists and citizens suffering from minor/mild injuries could be delegated to trained tour operators or first aiders.

Cross-sectional studies and retrospective secondary data analysis may help identify risk factors associated with quad bike injuries. However, it is well known that these initial findings are insufficient to design effective intervention measures. Moreover, the impact might be questionable as risks are known to cluster. Thus, identifying clusters of risk factors would help identify the target

population and fine-tune the interventions in these groups.

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