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Other Conditions

Pediatric golf cart trauma: Not par for the course☆,☆☆,★

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ABSTRACT

Introduction: Golf cart trauma in southeast Georgia represents a significant source of morbidity in the pediatric population. We believe these events are related to the introduction of new state legislation that allows local authorities to govern golf cart operation.
Methods: We performed a retrospective review from 2010 to 2016 of children involved in golf cart traumas (n = 46). We recorded age, gender, Glasgow Coma Scale score (GCS), Injury Severity Score (ISS), location of event, and patient position during event. Outcomes included injury type and length of stay (LOS).
Results: The most common position in a golf cart was a passenger (52.2%). Events varied regionally and correlated with stringency of local legislation. Skull fractures afflicted 48% (n = 22) of children and traumatic brain injuries (TBIs) were noted in 35% (n = 17) of patients. TBIs (LOS = 4.6 days, p = 0.006) and abdominal injuries (LOS = 8.5 days, p = 0.017) lengthened mean hospital stay. Increasing ISS was associated with an increased probability of sustaining a TBI (OR 1.295, p = 0.004). Younger children were more likely to sustain a skull fracture (OR 1.170, p = 0.034) while older children incurred more orthopedic injuries (OR 1.217, p = 0.045).
Conclusion: Skull fractures and TBIs are common following pediatric golf cart trauma. Georgia's varying municipality legislation likely contributes to the growing frequency of this trend.
Level of Evidence: Retrospective study, IV.

Golf carts as recreational vehicles have increased in popularity and usage with minimal increase in meaningful legislation and safety features. Although initially designed for low speeds on the green, their utility has expanded 130% to farm, home and leisure purposes [1]. With this growth, golf cart related trauma has become more common with many of those injured being children. McGwin and colleagues identified nearly 50,000 injuries in a 3-year period involving golf carts with the highest rate of injury noted in 10 to 19-year-olds [2]. A study by Miller et al. at a tertiary medical center showed that 60% of golf cart injuries involve children [3]. Despite these data, the American National Standards Institute still does not require seatbelts for golf carts and consistent safety legislation is lacking [4].

A golf cart, as defined by the Georgia Department of Public Safety, is any motorized vehicle designed for the purpose of conveying one or more persons and equipment to play the game of golf in an area designated as a golf course. Its average speed must be less than 15 miles per hour (mph) [5]. The International Light Transportation Vehicle Association, Inc. (ILTVA), a leading manufacturer of golf cars, then created a personal transport vehicle (PTV) on a golf cart chassis and drive mechanism [6] to facilitate local personal transportation off the golf course. A PTV, identical in appearance to a golf cart, is a self-propelled vehicle with a minimum of 4 wheels, capable of a maximum level ground speed of less than 20 mph with a maximum gross vehicle weight of 1375 lb and capable of transporting not more than eight persons. Of note, these vehicles do not qualify as low speed vehicles, which operate between 20 and 25 mph and are regulated by the U.S. National Highway Traffic Safety Administration [7].

As expected, confusion has arisen as to what distinguishes a golf cart from a PTV and the two have become virtually interchangeable in much of Georgia's municipality legislation. To further complicate matters, in January of 2012 Georgia passed House Bill 384, amending OCGA § 40-6-331, which shifts the authority from the Department of

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Transportation to local governments in determining where these vehicles should be allowed to drive [8]. Prior to this date, golf carts and PTVs were largely confined to golf courses and golf communities. The new law allows local governing bodies to determine which public roads or paths are suitable for golf cart/PTV use, provided there is appropriate signage. This law was backed strongly by the golf car manufacturing industry to increase golf cart sales in Georgia as an alternative and affordable mode of transportation [9].

An increase in the number of unintentional pediatric golf cart injuries has been recognized at our rural, level-one trauma center in the past several years. Our study aims to investigate the injury patterns and associated burden of golf cart trauma in the pediatric population in southeast Georgia and determine if legislation has any impact on these traumas. We hypothesize that golf cart trauma represents a significant source of morbidity in the pediatric population, and that the severity and incidence of these disturbances have increased since the introduction of 2012 legislation.

1. Methods

We performed a 7-year retrospective chart review from 2010 to 2016 after obtaining approval from our institutional review board (# 2017.04.04). The trauma registry was queried for all accidents related to golf carts in children aged 18 and younger. Of note, our rural, level-one trauma center is positioned among approximately 130 golf courses in southeastern Georgia and serves as an exceptional facility to determine golf cart related trauma. From the registry, we extracted patient age, gender, injury severity score (ISS), Glasgow coma scale (GCS) score, and length of stay (LOS). We then reviewed individual charts for patient position relative to the cart during the event, location of the event by zip code region, and injuries sustained.

Patient position was classified as: (1) driver seat (2) passenger seat (3) ejected occupant (4) pedestrian struck by cart, and (5) unknown position but occupant in a golf cart. Location of incident was determined by the first three digits of the zip code in the retrieving emergency medical service documentation to determine if there were variations in trauma patterns based on geography. Injury patterns were divided into head, bony spine, thorax, abdomen, orthopedic, and skin. Head trauma was further stratified into skull fractures, facial fractures, and traumatic brain injuries (TBIs), which included any epidural hematoma, subdural hematoma, subarachnoid hematoma, intraventricular hemorrhage, diffuse axonal injury, or brain contusion.

Linear regression was used to determine LOS variability and the impact of continuous variables on LOS. Categorical predictors were evaluated with Mann–Whitney U-tests or Kruskal–Wallis H-tests. Logistic regression was used to predict injury pattern and ANOVA testing was used to determine injury variance among geographic regions. Results were deemed significant with a p-value set to 0.05 and data analyses were performed with the IBM Statistical Package for the Social Sciences software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.).

2. Results

From 2010 to 2016, our trauma center treated 14,076 patients of which 8324 required activations. Of the total patients, there were 85 individuals involved in golf cart traumas. Forty- six patients were children less than 18 years of age and comprised our cohort. The peak years of golf cart trauma in our pediatric cohort occurred in 2014 (n = 10) and 2016 (n = 10). The incidence increased over time as well with 18 children presenting from 2010 through 2013 and 28 children presenting from 2014 through 2016. The average age was 8.6 years (± 4.54 SD) and males predominated at 67%. The average admission GCS for the study population was 14.6 (± 1.37 SD), ISS 9.9 (± 9.91 SD), and LOS 3 days (± 3.58 SD). The most common patient position was a passenger (n = 24, 52.2%) followed by an ejected occupant (n = 11, 24%), a driver (n = 6, 13%), a pedestrian struck (n = 3, 7%), and then unknown (n = 2, 4%). The events occurred with varying frequency as geographic distance from our hospital (region 314) increased. Specifically, region 299 had 15.2% (n = 7) of related events and region 304 had 21.7% (n = 10). Region 313 had 26.1% (n = 12), and region 315 had the greatest amount at 30.4% (n = 14) (Fig. 1).

2.1. Predicting length of stay

LOS ranged from 1 to 21 days and was impacted by several variables. Regarding continuous predictors, GCS accounted for 16.5% of variability in LOS and an increasing GCS correlated with a decreasing LOS (OR −0.634, p = 0.007). ISS accounted for 10% of the variability in LOS and increasing ISS was significantly associated with increasing LOS (OR 0.092, p = 0.042). Age was insignificant in predicting LOS (OR −0.015, p = 0.773). None of the categorical predictors evaluated with logistic regression were significantly associated with LOS, except for the presence of a TBI or an abdominal injury (Table 1). These variables significantly lengthened LOS when compared to their counterparts (i.e. non-TBI or nonabdomen injury).

2.2. Predicting injury type

Skull fractures were the most common injury in our study cohort afflicting 48% (n = 22) of children. Traumatic brain injuries were also highly prevalent, noted in 35% (n = 17) of patients. Orthopedic injuries (n = 8), soft tissue trauma (n = 6), bony spinal injuries (n = 3), thoracic trauma (n = 5), and abdominal injuries (n = 2) did occur but to a much lesser degree (Table 2). Increasing ISS was associated with an increased probability of sustaining a TBI (OR 1.295, p = 0.004). Decreasing ISS was associated with a 1.32 times increased likelihood of experiencing isolated skin trauma (p = 0.034) (Table 3).

Younger children were more likely to sustain a skull fracture (OR 1.170, p = 0.034) while older children were more likely to incur an orthopedic injury (OR 1.217, p = 0.045). Also, region 304 patients were 5.3 times more likely to experience an orthopedic injury than patients in all other zip codes combined (p = 0.045). Golf cart drivers were noted to experience bony spinous injuries 19.5-fold more as compared to nondrivers (p = 0.026). No other injuries were predicted by our variables to reach statistical significance (Table 3).

3. Discussion

Golf cart related traumas have increased in frequency at our institution. This trend is not surprising because per the Georgia-based ILTVA, 90% of the golf carts in the U.S. are made in Georgia [9]. Furthermore, the advent of 2012 legislation essentially legalizes and popularizes golf cart usage on public roads. Accordingly, the National Electronic Injury Surveillance System (NEISS) shows that golf cart trauma has increased 33% in children aged 0 to 19 from 2014 to 2017 [10]. Our research is in congruence with these data and recent national studies that demonstrate not only a rise in golf cart traumas, but that children are most affected [11,12].

Our children's injury burden was also like that of the work of Miller et al. demonstrating a high incidence of skull, brain, and orthopedic injuries [3]. We saw that skull fractures occurred in nearly half the cohort of children involved in an accident, particularly younger children, with more than a third of patients sustaining a TBI. Also, research by Watson and colleagues showed that the most commonly injured body region in children was the head and neck at 32.1% [1] and Linnaus et al. found that almost one half of golf cart trauma resulted in a central neurologic injury [13]. Perhaps this finding is because younger patients are ejected more frequently and land on asphalt or concrete rather than grass [14]. Data show that even golf carts moving as slowly as 11 mph can eject an occupant going around a left turn [15]. Regardless of speed, young children do not have developed

Zip Code	N (%)
299	7 (15.2)
304	10 (21.7)
313	12 (26.1)
314	2 (4.3)
315	14 (30.4)

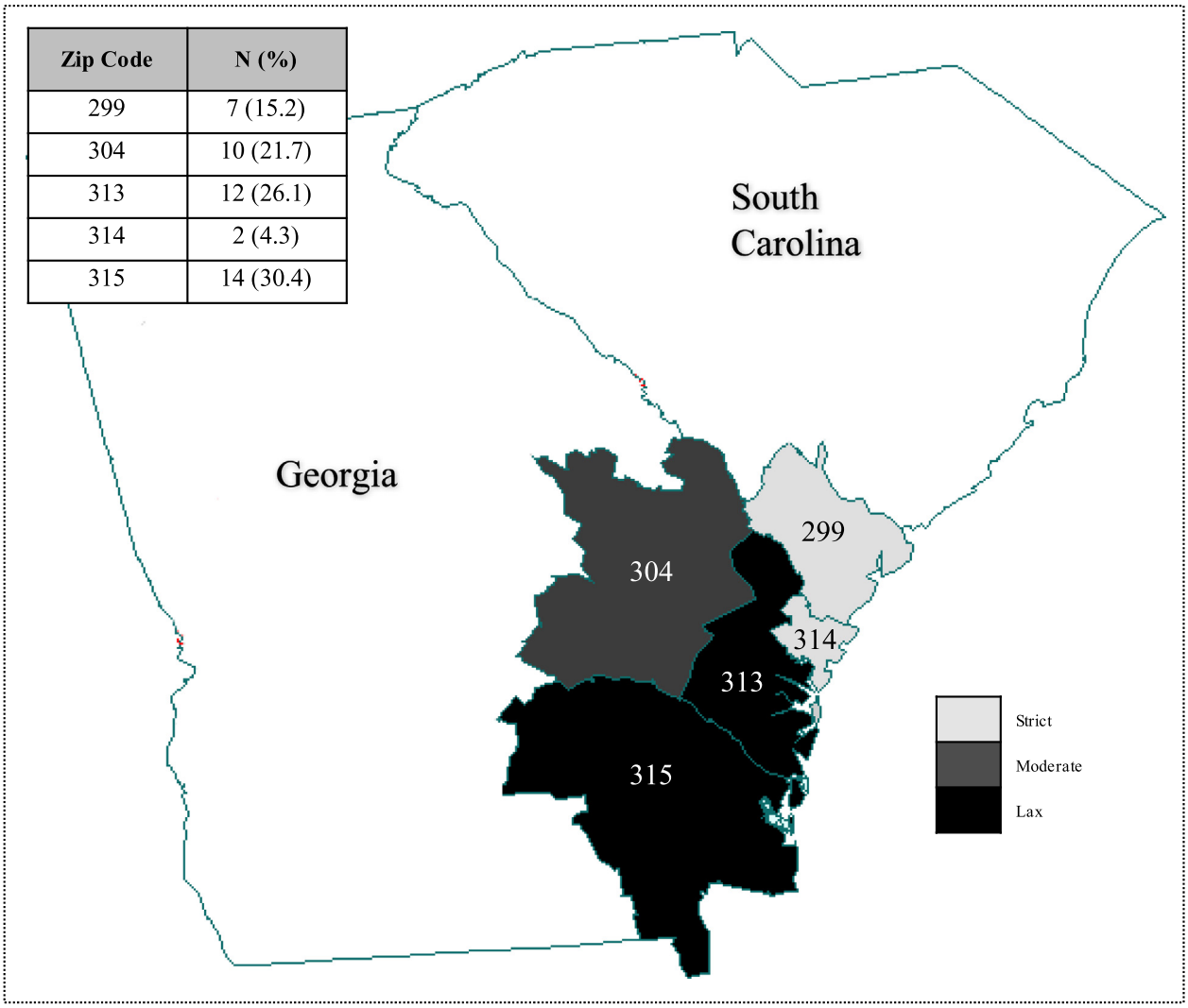

Fig. 1. Golf cart trauma by geographic region. Corresponding regional legislation severity denoted by scale.

motor skills like adults and experimental models demonstrate that an ejection from a turning cart occurs in less than 1.5 seconds. This brief duration is unlikely to provide sufficient time for developing children to react appropriately [16], and even if they do, most do not have the strength to hold onto the hand grips [1].

It might be assumed that older children are less at risk for injury than their younger counterparts because of their larger size, but golf cart safety features are designed for an anthropomorphic adult male [17]. Hip restraints affixed to a golf cart are often insufficiently high to prevent even an adult front seat passenger from falling out of a turning vehicle [14]. In fact, work by Seluga indicates that a restraint height of 12 inches is needed to prevent an ejection in a front seat passenger [18]. Unfortunately, children tend to lean forward, placing them in front of the standard hip restraints [1]. Furthermore, seat belts were historically not installed in golf carts because the use of seat belts without adequate overhead protection (i.e. canopy) could result in severe injury or death if the cart tipped [26].

Of note, the most commonly injured children in this study were passengers in collisions rather than ejected occupants. Many golf carts have brakes only on the rear wheels, leading to directional instability and rollover [3]. This mechanism can pin a child beneath the golf cart causing severe fracture patterns, as is seen with an all-terrain vehicle (ATV). Ranging between 37% and 63%, orthopedic trauma is the most common injury type following ATV accidents in the United States, particularly lower extremity fractures. Specifically, children aged 13 years and older tend to have multiple rather than isolated fractures and have a higher frequency of pelvic fractures [19]. These results are much like the orthopedic injuries seen in our golf cart series, which as we have shown, occur in older rather than younger children.

Orthopedic injuries were also noted to occur significantly more often in geographic region 304. This area carried a 5-fold increase in orthopedic trauma from golf carts and has a relatively lax ordinance for their use. One representative city in this region allows 12-year-old children to drive golf carts on public roads if they are accompanied by an individual 18 years or older who possesses a driver's license. This ordinance also allows 16-year-olds to drive golf carts on roads with maximum speed limits of 35 mph without holding a valid driver's license [20]. There is only a warning given for a first-time offender if a speed limit is broken and there is no specific mention of alcohol use in the ordinance. We suspect region 304's skewed orthopedic injury pattern is because of Georgia's 2012 legislation enabling such local municipalities to create their own golf cart laws—regardless of stringency.

Our trauma center resides in region 314 and its respective county carries much stricter golf cart legislation, which correlates with the lowest pediatric golf cart trauma in our study. The ordinance requires operators of golf carts to be both 16-years-old and have a driver's license. Operators can only drive on designated roads with speeds less than 25 mph. They must abide by established alcohol provisions and will receive a misdemeanor and fine for violation of any part of the ordinance [21]. Similarly, region 299 has stern legislation and despite having more

Table 1
Categorical predictors of length of stay.

Variable	Mean (days)	Statistic	p
Sex			
Male	3.16	$Z = -0.294$	0.768
Female	2.60		
Position			
Driver	2.33	$\chi^2 = 2.409$	0.661
Ejection	4.00		
Passenger	2.71		
Pedestrian	2.00		
Unknown	4.00		
Region			
299	3.71	$\chi^2 = 4.616$	0.329
304	1.90		
313	2.92		
314	1.00		
315	3.86		
Injury			
Skull Fracture	3.14	$Z = -0.046$	0.963
TBI	4.60	$Z = -2.748$	0.006
Facial Fracture	1.50	$Z = -0.677$	0.558
Bony Spine	2.33	$Z = -0.349$	0.769
Thoracic	2.33	$Z = -0.349$	0.769
Abdomen	8.50	$Z = -2.227$	0.017
Orthopedic	3.37	$Z = -0.592$	0.579
Skin	3.33	$Z = -0.256$	0.812

TBI traumatic brain injury.
Statistics: *Z* scores determined by Mann–Whitney U-test and χ^2 by Kruskal–Wallis H-test.

than 60 golf courses in its area, it remains the second lowest region for pediatric golf cart trauma. Drivers of golf carts in this area must be 16 years of age and carry a valid driver's license, and also have their carts registered and insured. Unique to 299 is that a permitted golf cart may only be operated within four miles of the address on the registration certificate and can only drive on a designated secondary highway or street for which the posted speed limit is 35 mph or less [22].

In contrast, regions 313 and 315 have vague legislation for golf carts and have the two highest incidences of pediatric golf cart trauma in southeastern Georgia. Although a driver's license is required and use on roads with speeds greater than 35 mph is forbidden [23], certain municipalities in these areas have provisions that essentially permit golf cart operators to not abide by any established laws if the cart is used at a golf course, private club, on private property, or in connection with a parade, festival, or 'special' event [24]. Another municipality in region 315 admits that these vehicles should be registered, but does not require it. Furthermore, a town in 313 allows children as young as 12 years to drive a golf cart on public streets if accompanied by any licensed individual, regardless of age, and makes no mention of a policy on alcohol use [25].

Table 2
Injuries sustained during golf cart accidents.

Injury	N	%
Head		
Skull fracture	22	47.8
TBI	17	36.9
Facial fracture	2	4.3
Bony Spine		
Cervical subluxation	1	2.1
Transverse process fracture	2	4.3
Thorax		
Lung pathology[a]	3	6.5
Rib fracture	1	2.1
Clavicle fracture	1	2.1
Abdomen		
Pancreatic transection	1	2.1
Gastric injury	1	2.1
Orthopedic		
Upper extremity fracture	2	4.3
Lower extremity fracture	5	10.9
Pelvic fracture	1	2.1
Skin		
Complex lacerations	5	10.9
Tissue defect	1	2.1

TBI traumatic brain injury.
[a] Denotes pulmonary laceration, contusion, or pneumothorax.

As of now, 23 Georgia cities have golf cart ordinances [8]. Offenders of these regulations receive citations; however, confusion exists owing to the regional variation in these laws leading to infrequent punishment. For example, public record shows that there was a low number of citations written for offending golf cart drivers in one 313 municipality in recent years— a total of 21 in 2015, 7 in 2016, and none in 2017. Unfortunately, we do not know which injury related incidents from our specific study were ticketed. However, from our study we do know that the incidence of events is not decreasing, so golf cart laws are likely not being enforced in southeastern Georgia.

The federal 2012 legislation does mandate that golf carts have braking systems, a reverse warning device, tail lamps, hip restraints, and a horn. The ILTVA makes recommendations too in their *Golf Course Safety Guidelines* [26]; however, they realize that they have no authority over governing bodies at the local or state level [27]. Unfortunately, despite these suggestions and recent evidence that golf carts can contribute to significant pediatric morbidity and mortality [28], the American Academy of Pediatrics (AAP) has yet to adopt a formal policy statement on the use of golf carts. In recent years, the AAP has revised and added policies for wheeled sports ranging from bicycles, two wheeled scooters, and skateboards to high velocity personal vehicles, including ATVs and dirt bikes. The AAP policy on ATVs states that no child younger than 16 years of age should drive such a vehicle; however, none of these policies pertain to golf cart use [29]. We believe, like Watson and colleagues, that because golf carts were not designed for the safe transportation of children, their use by children and/or for transporting children should be discouraged [1].

While the incidence of pediatric golf cart trauma is becoming more commonplace in southeastern Georgia, so is the permissibility of golf cart use on public roads nationwide. More than 350 cities and counties across the U.S. allow carts on public roads according to the ILTVA, [30] and proponents have valid arguments. Carts are easy to use and maintain, they are relatively cheap, and they are environmentally friendly. However, the National Highway Traffic Safety Administration recognizes how fragile and uncrashworthy a golf cart is, particularly for a child on a fast-moving road. In 2015, there were 32 reported occupants involved in fatal crashes and 19 occupant fatalities owing to golf carts in the United States, outranking occupant deaths from limousines, snowmobiles, and construction equipment [31]. Although the ages of these fatalities are not disclosed, many of these golf cart fatalities involved driver negligence, distraction, or substance abuse [30].

Thus, in order to prevent further damage, we should urge our policy makers to be more cognizant of the vulnerability of golf carts compared to other passenger cars on the road. Golf carts should be registered, insured, and only operated by adult persons with valid driver's licenses on roads with designated travel lanes [32]. Cart speeds should remain capped at 20 mph and the vehicles should not be permitted on roads with speed limits surpassing 25 mph. Most importantly, clarification and enforcement of existing laws must occur as well as research into golf cart injury patterns to determine how these vehicles can be used appropriately and safely by our community.

3.1. Limitations

This study has several limitations. Not only is it retrospective, but our power may have been too low to draw significant conclusions regarding factors predictive of certain injury patterns or long-term outcomes. However, the total volume of golf cart injuries is likely underrepresented because our study only accounts for children who came to our trauma center. Also, we did not evaluate any adult related golf cart events or the impact of adult presence on pediatric golf cart trauma. Anecdotally, adults driving golf carts for leisure are often intoxicated,

Table 3
Logistic regression predicting selected injuries.

Variable	Skull Fracture		TBI		Bony Spine		Orthopedic		Skin	
	OR	p	OR	p	OR	p	OR	p	OR	p
Age	0.855	0.034	1.022	0.751	0.988	0.926	1.217	0.045	0.958	0.669
GCS	0.528	0.271	0.774	0.278	-	-	0.000	0.998	-	-
ISS	1.031	0.535	1.295	0.004	1.021	0.825	0.960	0.556	0.757	0.034
Sex (male)	0.721	0.604	0.661	0.551	1.035	0.978	0.407	0.257	0.963	0.968
Position										
Driver	-	-	-	-	0.051	0.026	2.833	0.284	4.500	0.138
Passenger	1.200	0.758	0.625	0.461	-	-	0.486	0.367	0.905	0.909
Ejected	4.000	0.068	0.288	0.084	-	-	0.400	0.418	-	-
Pedestrian	2.300	0.509	-	-	0.098	0.102	-	-	3.800	0.310
Region										
299	3.235	0.190	0.295	0.147	-	-	-	-	-	-
304	0.200	0.061	5.727	0.115	1.889	0.620	5.333	0.045	2.000	0.467
313	0.714	0.620	1.636	0.515	1.455	0.769	1.933	0.424	1.500	0.666
314	1.095	0.950	-	-	-	-	5.286	0.258	-	-
315	2.631	0.145	0.333	0.102	0.867	0.910	-	-	1.167	0.869

GCS Glasgow coma scale; *ISS* injury severity score; *OR* odds ratio; *TBI* traumatic brain injury.
The categorical variables not depicted (ie unknown mechanism), blank cells, and unlisted injury pattern outcomes (ie facial fractures, thorax, abdomen) are not shown because they lacked sufficient power to perform regression.

which is supported by previous literature and known to be a risk factor for severe golf cart trauma [13]. Lastly, these data came from our trauma registry, which did not track golf cart speed, possible driver intoxication, driver age, or modifications to the involved golf cart that may have made it safer or more dangerous. Nevertheless, we did manually review each chart and any corresponding police documentation or emergency medical service reports to maximize the accuracy and completeness of each child's profile.

3.2. Conclusion

Children are at high risk for skull fractures, TBIs, and orthopedic injuries following golf cart trauma in our community. Georgia's municipality based golf cart laws, which vary geographically, may contribute to the growing frequency and distribution of this phenomenon. Child safety is a priority and investing in unified legislation and research regarding this unique issue is paramount for prevention of further injury.

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