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Golf cart injuries have similar severity to all-terrain vehicle injuries in children: a multicenter comparison over a 5-year period

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ABSTRACT

Background Golf carts (GCs) and all-terrain vehicles (ATVs) are popular forms of personal transport. Although ATVs are considered adventurous and dangerous, GCs are perceived to be safer. Anecdotal experience suggests increasing numbers of both GC and ATV injuries, as well as high severity of GC injuries in children. This multicenter study examined GC and ATV injuries and compared their injury patterns, resource utilization, and outcomes.

Methods Pediatric trauma centers in Florida submitted trauma registry patients age <16 years from January 2016 to June 2021. Patients with GC or ATV mechanisms were identified. Temporal trends were evaluated. Injury patterns, resource utilization, and outcomes for GCs and ATVs were compared. Intensive care unit admission and immediate surgery needs were compared using multivariable logistic regression.

Results We identified 179 GC and 496 ATV injuries from 10 trauma centers. GC and ATV injuries both increased during the study period (R^2 0.4286, 0.5946, respectively). GC patients were younger (median 11 vs 12 years, p=0.003) and had more intracranial injuries (34% vs 19%, p<0.0001). Overall Injury Severity Score (5 vs 5, p=0.27), intensive care unit (ICU) admission (20% vs 16%, p=0.24), immediate surgery (11% vs 11%, p=0.96), and mortality (1.7% vs 1.4%, p=0.72) were similar for GCs and ATVs, respectively. The risk of ICU admission (OR 1.19, 95% CI 0.74 to 1.93, p=0.47) and immediate surgery (OR 1.04, 95% CI 0.58 to 1.84, p=0.90) remained similar on multivariable logistic regression.

Conclusions During the study period, GC and ATV injuries increased. Despite their innocuous perception, GCs had a similar injury burden to ATVs. Heightened safety measures for GCs should be considered.

Level of evidence III, prognostic/epidemiological.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Golf carts are perceived as a safe form of transport, whereas all-terrain vehicles (ATVs) are perceived as adventurous and dangerous.
⇒ Golf carts may contribute to severe injuries in the pediatric population, but temporal trends, injury patterns, and outcomes compared with ATVs are not well-defined.

WHAT THIS STUDY ADDS

⇒ Golf cart and ATV injuries are both increasing in the state of Florida.
⇒ Golf cart injuries were more likely to result in ejection and intracranial injury compared with ATV injuries.
⇒ Golf cart injuries were similar to ATV injuries with respect to resource utilization and clinical outcomes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ More effective safety measures are needed for children using golf carts.

BACKGROUND

All-terrain vehicles (ATVs) have long been recognized as a more dangerous mode of transport unsuitable for personal use on paved public roads. Most municipalities and states restrict their use on public roads with few specific exceptions. Golf carts (GCs) are increasingly popular modes of personal transport due to their convenience, environmental profile, and perceived safety. Another perceived advantage is the lack of licensing required for their operation. The increased prevalence of GCs on public roads has largely outpaced safety measures, with states only more recently passing legislation explicitly addressing their use as personal transport outside of golf courses. Responsibility has largely fallen on individual municipalities to regulate their use on designated city roads. There is mounting data to suggest that the severity of GC injuries in the pediatric population is underappreciated.[1–4]

To clarify the frequency and severity of injury in pediatric patients from GC incidents and compare them with those of ATVs, a review of trauma databases from multiple trauma centers in a single state was performed. Our hypothesis was that both GC and ATV injuries would show an increase over time and that the severity of GC injuries is on par with those injuries sustained in ATV traumas.

METHODS

As part of a larger study evaluating the effects of the SARS-Cov2 (COVID-19) pandemic on pediatric trauma, all pediatric trauma centers within the state of Florida were invited to submit de-identified patient data from their trauma registries. The study period covered January 2016 through June 2021. Informed consent was waived. All patients 15 years old or younger were included, in accordance with the Florida Department of Health's age-based definition of pediatric trauma patients. Each patient record was reviewed to identify patients with GCs or ATVs as the mechanism of injury. All patients with GC or ATV mechanisms were included. To evaluate temporal trends, the study period was divided into 3-month intervals and the total numbers of GC and ATV injuries calculated for each interval. The relationship of time to the number of GC and ATV injuries was evaluated with a univariate linear regression model. For the purposes of this study, only simple linear temporal trends were evaluated, since the authors recently published a separate analysis focusing on pediatric injury temporal trends in the context of social determinants of health and the COVID-19 pandemic.[5] Free-text descriptions of injury circumstances were reviewed to extract specific details regarding patient's position in the vehicle (driver vs passenger), whether a collision occurred, and whether the patient was ejected. Patient demographics, injury details including overall injury patterns and anatomic regions injured, resource utilization, and outcomes were compared between GC and ATV groups. χ^2 tests were used for categorical variables and Kruskal-Wallis tests for continuous variables. The following two resource utilization outcomes of interest were evaluated further with multivariable logistic regression modeling: (1) intensive care unit (ICU) admission and (2) urgent surgery (defined as going directly to the operating room from the emergency department). The primary independent variable was vehicle type: GC versus ATV. Covariates were included in the model if they were significantly different ($p<0.05$) between the GC and the ATV groups at baseline. Given the GC and ATV group sizes, the study had 94% and 76% power to detect absolute ICU admission risk differences of 10% and 8%, respectively. Power was 93% and 60% to detect absolute differences in urgent surgery risk of 7% and 5%, respectively. Statistical analysis was performed with SAS V.9.4 (SAS Corporation).

RESULTS

Between January 2016 and June 2021, 23 539 patients from 10 trauma centers were identified, of which 179 and 496 were associated with GCs and ATVs, respectively. During the study period, there was an increase in the number of both GC and ATV injuries seen at the participating trauma centers (figure 1). This increase was statistically significant on regression modeling, with an exponential curve producing the best fit (R^2 0.4286 and 0.5946 for GC and ATV, respectively). Visually, there appeared to be a notable spike in ATV injuries during the COVID-19 period (marked by a blue arrow) and an accelerated increase in GC injuries afterward. The general demographics of the cohorts are shown in table 1. Overall, patients were mostly non-Hispanic white males. Patients involved in GC injuries were younger than those injured in ATV incidents with a notably higher percentage of the youngest age group (0–5 years). Injury details and patterns by vehicle type are described in table 2. Patients involved in GC incidents were more likely ejected and, despite similar Glasgow Coma Scale (GCS) at presentation, were found to have a higher rate of intracranial injuries than ATV riders (34% vs 19%, $p<0.0001$). Among GC patients for whom ejection status was

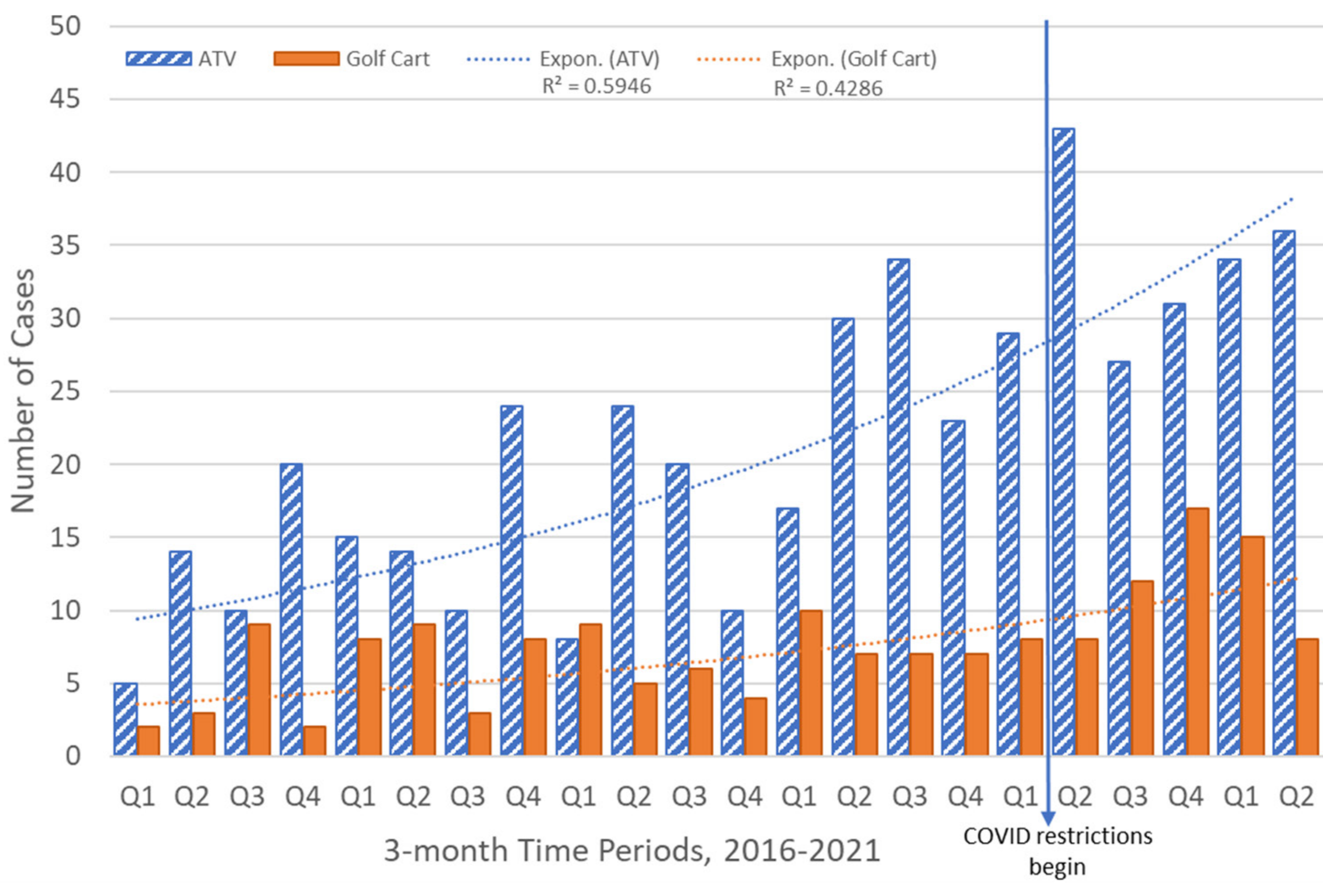

Figure 1 Number of golf cart and ATV injury patients treated at Florida Pediatric Trauma Centers, January 2016 to June 2021. ATV, all-terrain vehicles.

Table 1 Description of study population, by vehicle type

	GC (n=179)	ATV (n=496)	P value*
Age, years, median (IQR)	11 (6–14)	12 (9–14)	0.003
Age group, n (%)			0.001
0–5	38 (21)	56 (11)	
6–9	37 (21)	85 (17)	
10–15	104 (58)	355 (72)	
Sex, n (%)			0.23
Male	101 (56)	297 (60)	
Female	76 (42)	198 (40)	
Unknown	2 (1)	1 (<1)	
Race, n (%)			0.05
Black or African American	16 (9)	63 (13)	
White	149 (83)	368 (74)	
Other/unknown	14 (8)	65 (13)	
Ethnicity, n (%)			0.04
Hispanic	19 (11)	52 (10)	
Non-Hispanic	121 (68)	288 (58)	
Unknown	39 (22)	156 (31)	
Transfer status, n (%)			0.001
Arrived directly from scene	63 (35)	252 (50)	
Transferred in from another facility	74 (54)	143 (36)	
Unknown	42 (23)	101 (20)	

*χ^2 or Fisher's exact tests for categorical variables; Wilcoxon rank-sum tests for continuous variables.
ATV, all-terrain vehicle; GC, golf cart.

reported (n=74), the rate of ejection was high at 65/74=88%. GC patients were less likely to suffer extremity injuries compared with ATV riders (39% vs 56%, p<0.0001). Overall injury patterns showed a lower rate of multisystem injury, but higher rates of isolated head injury, among GC patients versus ATV patients. The incidence of moderate–severe traumatic brain injury (TBI) was similar in the GC and ATV groups (6% in both), whereas mild TBI was more frequent in the GC group (55% vs 44%). The treatment and outcomes of the groups are compared in table 3. Hospital admission rates, ICU admission rates, need for ventilator support, need for urgent operative intervention, and mortality did not differ between children injured by GC or ATV. There was a statistically significant longer ICU length of stay for ATV injuries. On multivariable logistic regression modeling to adjust for baseline differences in age, race/ethnicity, and transfer status, ICU admission and urgent surgery utilization remained similar between GC and ATV patients. For ICU admission, GC versus ATV, the adjusted OR was 1.19, with 95% CI 0.74 to 1.93 (p=0.47). For urgent surgery, the adjusted OR was 1.04, 95% CI 0.58 to 1.84 (p=0.90).

DISCUSSION

This study evaluates injury patterns and characteristics of GC and ATV in pediatric patients. Using institution-level data across multiple trauma centers within the state gives a granular view of a state-level cohort. Every entry into the institutional trauma database that was potentially a GC or ATV injury was evaluated to ensure accurate documentation. Narrative data was available for review in addition to the injury E-code used in trauma databases. This is crucial as the ICD-9 and 10 codes are nonspecific for GC injuries. Additionally, institutional trauma databases are not samples but rather encompass every admission. As a result, this study was able to potentially evaluate and include every injury during the study period. Our study is the largest pediatric-specific evaluation of GC injuries confirmed by evaluation of specific trauma database entries.

Initial national studies using national sampling databases examining GC injuries were not designed to look at the

Table 2 Injury details by vehicle type

	GC (n=179)	ATV (n=496)	P value*
Patient position in vehicle, n (%)			<0.0001
Driver	24 (13)	232 (47)	
Passenger	77 (43)	135 (27)	
Unknown	78 (44)	129 (26)	
Ejection from vehicle, n (%)			<0.0001
Yes	65 (36)	84 (17)	
No	9 (5)	34 (7)	
Unknown	105 (59)	378 (76)	
Injury severity score, median (IQR)	5 (4–10)	5 (4–10)	0.40
GCS category at presentation, n (%)			0.24
Normal (GCS=15)	140 (78)	356 (72)	
Abnormal (GCS≤14)	16 (9)	54 (11)	
Unknown	23 (13)	86 (17)	
Anatomic region injured, n (%)			
Head, any	109 (61)	249 (50)	0.01
Head, with intracranial injury	60 (34)	95 (19)	<0.0001
Neck	3 (2)	18 (4)	0.20
Chest	15 (8)	59 (12)	0.20
Abdomen/pelvis/perineum/lower back	16 (22)	57 (11)	0.35
Extremities	69 (39)	278 (56)	<0.0001
Burn	2 (1)	7 (1)	1.0
Overall injury pattern, n (%)			<0.0001
Multisystem	35 (20)	162 (33)	
Isolated head, without intracranial injury	28 (16)	55 (11)	
Isolated head, with intracranial injury	50 (28)	57 (11)	
Isolated extremity	45 (25)	141 (28)	
Other single system	2 (1)	13 (3)	
Superficial/unknown	15 (8)	54 (11)	
Traumatic brain injury severity			0.04
None	70 (39)	247 (50)	
Mild or unspecified (GCS 14–15)	99 (55)	220 (44)	
Moderate or severe (GCS<13)	10 (6)	29 (6)	

*χ^2 or Fisher's exact tests for categorical variables; Wilcoxon rank-sum tests for continuous variables.
ATV, all-terrain vehicle; GC, golf cart; GCS, Glasgow Coma Scale.

Table 3 Treatment and outcomes by vehicle type

	GC (n=179)	ATV (n=496)	P value
Admitted to hospital, n (%)	154 (86)	436 (88)	0.52
Length of hospital stay, days, median (IQR)	2 (1–3)	2 (1–3)	0.62
Admitted to ICU, n (%)	35 (20)	82 (17)	0.36
Length of ICU stay, days, median (IQR)	2 (1–3)	2 (2–4)	0.04
Required ventilator support, n (%)	6 (3)	21 (4)	0.61
To OR from emergency department, n (%)	19 (11)	53 (11)	0.98
Discharge to facility other than home, n (%)	3 (2)	13 (3)	0.58
Death, n (%)	3 (2)	6 (1)	0.70

*χ^2 or Fisher's exact tests for categorical variables; Wilcoxon rank-sum tests for continuous variables.
ATV, all-terrain vehicle; GC, golf cart; ICU, intensive care unit; OR, operating room.

pediatric population though they did identify pediatric patients as a significant proportion of injuries.[6 7] Their findings that most injuries occurred at a recreational field and involved soft tissue/extremity injuries differ from the findings presented in this article and are likely the result of differing study populations and evolving GC usage patterns since their publication.[6 7] Indeed, studies comparing the difference in pediatric and adult GC injury patterns noted children to more likely be ejected and suffer head and neck injuries in incidents at home or on the road.[8 9] Looking specifically at pediatric patients, our findings confirm this pattern of injury.

Prior studies comparing ATV and GC trauma in pediatric patients have been single-institution reviews. One study comparing ATV and GC injuries identified a similar incidence of head injuries, Injury Severity Score, GCS, ICU utilization, hospital days, and death between with two groups with only a difference in ventilator days with GC injuries having less days.[10] Another study compared all recreational vehicles, not just GCs and ATVs.[1] Specific comparison between these two groups within the study identified a higher rate of neurologic injury and ICU utilization at a younger age distribution in the GC cohort compared with the ATV cohort.[1] The present study adds to this data with larger numbers of both GC and ATV patients from across multiple institutions within a state. Our findings at a larger level are consistent with previous findings of at least equal severity of injury and resource utilization between the two mechanisms of injury at a younger age. The lack of licensing requirements for operation in addition to perceptions of safety may be responsible for the younger age associated with GC incidents.

During the last several years, there has been increasing recognition of the dangers of GC use and their potential as a cause of significant trauma among pediatric providers.[2–4] Our data adds to the current discourse surrounding GC, their increasing use as personal transport, and the increasing number of GC injuries as a result. The potential for injury with ATV use has long been recognized. The American Academy of Pediatrics issued its first policy statement regarding the matter in 1987 with multiple subsequent reaffirmations.[11] Regulations and policies surrounding GCs, however, lag behind their off-road cousins. Although most states have restrictions on the use of both ATVs and GCs on state paved roads, many states leave open the use of GCs as personal transport within municipalities to be regulated at the local level. This is a pattern of regulation for the study state of Florida.[12]

Safety equipment above what is commonly available on GCs used on the golf course is often required in municipalities that allow street use of GCs.[13 14] The two studies that attempted to specifically examine safety equipment use in GCs found very low utilization of restraining belts.[1 2] Overall, specific data regarding utilization of safety equipment was lacking but assumptions could potentially be made about the frequency of their use given the high rate of ejections in GC injuries. Although safety gear, including helmets, is uniformly recommended for safe ATV use,[11] analogous recommendations for GC use are non-existent. Municipalities have attempted to enhance the safety of GC operations by requiring a multitude of measures, including appropriate brakes, tires, lights, street signage, and minimum ages of operation,[13] but these measures are additions to a vehicle that is defined in Florida statute as 'a motor vehicle that is designed and manufactured for operation on a golf course for sporting or recreational purposes'.[12] Perhaps the core of the issue is that GCs are simply not designed for paved road use, and transitioning to low-speed vehicles that are specifically designed for personal transport on public roads with appropriate safety measures already included is a potential remedy for the situation.[14]

There are limitations to our study tied to the multi-institutional nature of data sources. Variability in the format and completeness of information recorded between institutions led to a significant percentage of missing information, especially in the categories of patient position, ejection, and transfer status. Some institutions recorded these details more consistently than others. The data analysis of ejection and passenger position was mostly within institutions that recorded these details more consistently. As a result, they are likely accurate representations of the injury pattern, just gleaned from fewer involved institutions. Although the possibility of institutional variability limits the generalizability of position and ejection comparisons, the high rate of documented ejection from GCs (at least 36%) provides valuable insight irrespective of any comparison to ATVs. Finally, although individual record review of narrative data was used to increase accuracy, there exists the possibility of inaccuracies due to human recording error.

Common perceptions of GCs being safe modes of personal transport have led to their steadily increasing use on paved roads within municipalities. While offering many advantages to cars, our study adds to the growing evidence that GC use as it currently stands is a source of significant trauma and morbidity in the pediatric population. With equivalent overall injury severity in a younger population, GCs are not a safer mode of transport than ATVs. Highlighting the injury pattern consistent with existing studies (ejection and head trauma among younger patients) for GC trauma, our study should help shape injury prevention efforts. We applaud the recent passage of an amendment to Florida Statute 316.212, requiring people under 18 years to possess a valid learner's or driver's license to operate GC on public roads.[12] We think public officials should be made aware of these findings, and legislation regulating GC as personal transportation use on public paved roads should be introduced. Statewide licensing requirements, registration, and standardized safety equipment should be the minimum required for GC operation as is the case with any vehicle utilizing public paved roads.

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