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Kids gone wild – Alcohol use and patient characteristics in pediatric trauma during the coronavirus disease 2019 pandemic

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ABSTRACT

Importance: Reported coronavirus disease 2019 (COVID-19) pandemic effects on pediatric trauma have been variable.

Objective: We investigated the characteristics of pediatric trauma including alcohol use during the pandemic at our urban trauma center.

Methods: The trauma database of our adult level 1 trauma center was queried for all pediatric (age ≤ 18 years) patients presenting between March 1, 2020, and October 30, 2020. Data from 2017 to 2019 served as a control. Variables analyzed included demographics, mechanisms, injury severity, hospitalization characteristics, and positive blood alcohol.

Results: Pandemic pediatric trauma volumes increased by 67.5% (330/year *vs.* 197/year). Pandemic patients were younger (median age 13 *vs.* 14 years, $P = 0.011$), but similar in gender, ethnicity, severity, hospital length of stay, mortality, and rates of penetrating injury. Falls doubled (79/year *vs.* 34/year) and shifted away from high falls >6 meters (0% *vs.* 7.9%) to moderate falls 1–6 meters (58.2% *vs.* 51.5%) ($P = 0.028$). Transportation injury rates were similar however mechanisms shifted from motor vehicle crashes (−13.5%) towards recreational vehicles including motorcycles (+2.1%), all-terrain vehicles (+8.6%), and bicycles (+3.8%) ($P = 0.018$). Pediatric-positive blood alcohol was significantly higher (11.2% *vs.* 5.1%, $P < 0.001$), especially for ages 14–18 years (21.7% *vs.* 9.5%, $P < 0.001$).

Interpretation: Pediatric trauma volumes during the COVID-19 pandemic increased. Pandemic patients had more recreational vehicle injuries and higher rates of positive blood alcohol. This suggests an increased need for alcohol assessment and targeted interventions in the pediatric population during pandemics or periods of school closures.

KEYWORDS

Alcohol, COVID-19, Pediatric trauma, Pediatrics

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has had far-reaching effects on the provision of medical care worldwide. Notwithstanding the direct consequences of COVID-19, the infection control practices put in place including masking, social distancing, stay-at-home orders, school closings, quarantine mandates, and social isolation have potentially led to profound changes in normal childhood development and medical practice. Practices aimed at controlling the spread of COVID-19 have been demonstrated to have multiple effects on the pediatric population including decreased physical activity, changes in sleep patterns, increased mental health issues, decreased primary care visits, decreased dental care, decrease in routine vaccinations, and reductions in pediatric emergency room visits.[1–8] The reported effects of these restrictions on pediatric trauma during the COVID-19 pandemic have been more diverse and less understood. Recent studies report an increased incidence of injuries related to motor vehicle crashes, gunshot wounds, burns, and physical abuse.[9,10] Others contradict this notion, reporting decreased pediatric trauma volume, but increased injury severity after the start of the pandemic.[11] The goal of our study was to add to the growing body of literature describing the characteristics of pediatric trauma during the COVID-19 pandemic, with a focus on alcohol use during the pandemic at our mid-western urban trauma center.

METHODS

Ethical approval

This study was reviewed and approved by the Institutional Review Board of the University of Nebraska Medical Center under IRB#0674-21-EP.

Study participants

Using the institutional trauma database for our Adult Level 1 trauma center, a retrospective review of prospectively collected data was performed. All pediatric (age $\leq$ 18 years old) trauma cases from the onset of the COVID-19 pandemic (March 1, 2020, until October 30, 2020) admitted to the hospital were collected as the study group, along with cases from the same period of the three prior calendar years (2017–2019) to use as a control group. The four calendar months not collected in the study group were not collected in the control group to eliminate potential seasonal effects in the study.

Data collection

Abstracted from the database were demographics (age, gender, ethnicity, and mechanism of injury), admission blood pressure, injury severity scores (injury severity score, revised trauma score, and trauma injury severity score), and length of stay data (hospital, intensive care unit [ICU] and ventilator). Additionally, data on mortality outcome and the presence of positive blood alcohol at the time of the trauma evaluation were obtained.

Ethnicity was divided into Caucasian, African American, and Other. The Mechanism of Injury was divided into blunt, penetrating, and other. Falls were further categorized into heights <1, 1–6, and >6 meters. Transportation injuries were categorized into motor vehicles, motorcycles, all-terrain vehicles, and bicycles. Admission blood pressure was categorized at arrival as hypotensive or not, based upon an age-dependent systolic blood pressure definition (age $\times$ 2 + 70, maximum of 90 mm Hg).

Statistical analysis

Categorical data were analyzed using Fisher's Exact Test, and scale/ordinal variables were analyzed using Student's *t*-test or the Wilcoxon-Mann-Whitney test, where appropriate. Statistical analysis was completed using R (version 4.1.1, Vienna, Austria). A P-value of < 0.05 was chosen a-priori to denote statistical significance.

The alcohol use graph was created using the Loess package weighting each time period on its population density with a span of 0.75.

RESULTS

The characteristics of pediatric trauma patients over the study period are detailed in Table 1. Overall pediatric trauma volumes increased by 67.5% (330/year *vs.* 197/year) during the pandemic. Pandemic patients were younger (median age 13 [5–16] *vs.* 14 [8–17] years, $P = 0.011$) with similar gender distribution. Ethnicity showed a trend during the pandemic towards more Caucasian patients (69.4% *vs.* 61.9%) with fewer African American patients (16.8% *vs.* 20.4%) and other ethnicities (13.8% *vs.* 17.7%) but this did not reach statistical significance ($P = 0.075$). Injury severity measures by injury severity score, revised trauma score and trauma injury severity score were not statistically different. Age-dependent hypotension was less frequent in the pandemic period (0.9% *vs.* 3.1%, $P = 0.039$).

Overall hospital length of stay and percentages of patients requiring ICU admission were also similar. Examining patients who were admitted to the ICU, pandemic patients had a similar ICU length of stay (2 [2–3] *vs.* 2 [2–3] days, $P = 0.662$). Looking at patients who required ICU admission, similar numbers of patients required mechanical ventilation; while the median ventilation days during the pandemic were longer, this difference did not reach statistical significance (3 [2–11] *vs.* 2 [2–4], $P = 0.065$). In-hospital mortality was lower during the pandemic, but also this

TABLE 1 Pediatric trauma patient characteristics gathered pre-pandemic and during the pandemic

Variables	Pre-pandemic ($n = 592$)	Pandemic ($n = 330$)	*P*
Age (year)	14 (8–17)	13 (5–16)	0.011
Gender (male)	361 (61.0)	206 (62.4)	0.673
Ethnicity[†]			0.075
Caucasian	364 (61.9)	227 (69.4)	
African American	120 (20.4)	55 (16.8)	
Other	104 (17.7)	45 (13.8)	
Mechanism of injury			0.642
Blunt	497 (84.0)	285 (86.4)	
Penetrating	69 (11.7)	33 (10.0)	
Other	26 (4.4)	12 (3.6)	
Hypotension on arrival	18 (3.0)	3 (0.9)	0.039
Injury severity score	5 (4–12)	9 (4–16)	0.078
Revised trauma score	7.84 (7.84–7.84)	7.84 (7.84–7.84)	0.635
Trauma injury severity score	0.995 (0.993–0.996)	0.994 (0.991–0.996)	0.124
Hospital length of stay (day)	1 (1–3)	1 (1–3)	0.529
ICU admission	187 (31.6)	110 (33.3)	0.607
ICU length of stay (day)	2 (2–3)	2 (2–3)	0.662
Ventilated	68 (11.5)	37 (11.2)	1.000
Ventilation days	2 (2–4)	3 (2–11)	0.065
Mortality	24 (4.1)	6 (1.8)	0.081
Firearm injury	34 (5.7)	18 (5.5)	1.000
Transportation injury	263 (44.4)	136 (41.2)	0.368

Data are shown as *n* (%) or median (interquartile range). ICU, intensive care unit.
[†]Ethnicity data were missing for 4 patients in the pre-pandemic period and 3 patients during the pandemic period.

TABLE 2 Characteristics of pediatric falls during the study periods

Fall height (meter)	Pre-pandemic ($n = 101$), *n* (%)	Pandemic ($n = 79$), *n* (%)
<1	41 (40.6)	33 (41.8)
1–6	52 (51.5)	46 (58.2)
> 6	8 (7.9)	0 (0.0)

Fisher's Exact test: *P*-value = 0.028.

did not reach statistical significance (1.8% *vs.* 4.1%, $P = 0.081$).

Mechanism of injury analysis demonstrated similar percentages of blunt (86.4% pandemic vs. 84.0% pre-pandemic) and penetrating trauma (10.0% pandemic *vs.* 11.7% pre-pandemic) between the study periods ($P = 0.642$). No differences in the percentage of firearm injuries were noted. An increased number of pandemic patients presented with falls (24.0% *vs.* 17.1%, $P = 0.012$) with fall patterns shifting away from falls > 6 meters (0% *vs.* 7.9%) and towards 1–6 meters (58.2% *vs.* 51.5%) ($P = 0.028$, Table 2). Reported numbers of transportation-related injuries (41.3% *vs.* 44.4%, $P = 0.368$) were similar. However, as detailed in Table 3, transportation mechanisms shifted away from motor vehicle crashes, towards recreational vehicles, such as motorcycles, all-terrain vehicles, and bicycles.

Finally, an analysis of blood alcohol specimens obtained at the time of trauma evaluation revealed a significant increase in the number of patients with alcohol present

TABLE 3 Reported numbers of transportation-related injuries by vehicle

Transport injuries	Pre-pandemic ($n = 263$), n (%)	Pandemic ($n = 136$), n (%)
Motor vehicle crash	200 (76.0)	85 (62.5)
Motorcycle	8 (3.0)	7 (5.1)
All-terrain vehicle	20 (7.6)	22 (16.2)
Bicycle	35 (13.3)	22 (16.2)

Fisher's Exact test: P-value = 0.018.

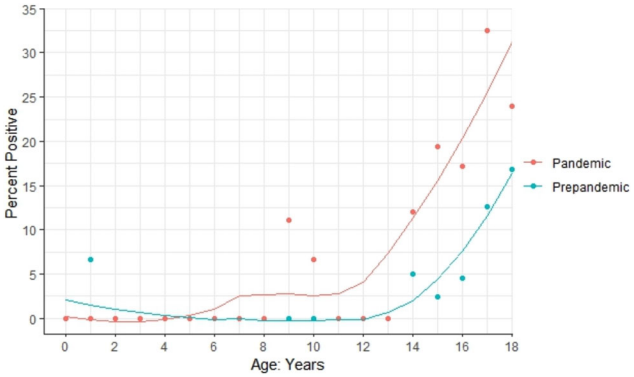

FIGURE 1 The results of alcohol-positive tests compared between the coronavirus disease 2019 pandemic and pre-pandemic periods. The rates of positive alcohol tests increased during the pandemic period, especially in the 14–18 years old population.

on arrival (11.2% positive during the pandemic *vs.* 5.1% pre-pandemic, $P < 0.001$). As detailed in Figure 1, this trend was especially predominant in the 14–18-year-old age group (21.7% *vs.* 9.5%, $P < 0.001$).

DISCUSSION

Our study identified changes in pediatric trauma patient demographics, hospitalization characteristics, injury mechanisms, and alcohol use during the heart of the COVID-19 pandemic in Nebraska. During the pandemic, pediatric trauma volumes at our center increased considerably. The pediatric trauma patients presenting during the pandemic were slightly younger, less likely to be hypotensive on presentation, and more likely to be injured in low-level falls and recreational vehicle crashes. In addition, pandemic patients were more likely to have used alcohol prior to their trauma. During the pandemic, patient gender, injury severity, inpatient mortality, ICU utilization and ICU length of stay, ventilator utilization, and length of ventilation were similar to the pre-pandemic period. When looking at the underlying differences between these groups, it is vitally important to consider the potential effects of infection prevention measures rapidly adopted in an effort to contain the spread of the COVID-19 pandemic.

After the initial identification of COVID-19 in December 2019, the infection rapidly spread across the world, with the formal recognition of a pandemic in early 2020. It was rapidly identified that infection with COVID-19 could be associated with multiple effects including severe pneumonia, respiratory failure, and death. This led to the rapid initiation of public health measures in an effort to control the spread of the pandemic, both in the United States and internationally.[12] In general, children who develop COVID-19 have a milder course, though it is well recognized that patients with significant risk factors can develop severe disease.[12,13] Significant concern was also raised for infected children potentially acting as a vector for infection of other children and at-risk adults.[14]

While infection control measures were rapidly instituted in many, if not most, parts of the world, the restrictiveness, and severity of these measures varied widely. Some areas instituted strict restrictive policies with mandatory lockdowns, forced quarantine, and closure of all "non-essential" businesses and services including schools and outdoor areas such as public parks and recreation areas. Other areas took a less restrictive approach. In April 2020, Nebraska directed health measures, closed schools to in-person learning, limited the size of public gatherings, required restaurants and bars to close in-person dining areas, canceled elective medical and surgical procedures, and instituted mandatory in-home quarantine for those patients contracting COVID-19 who did not require hospitalization. Masking and social distancing were encouraged but not mandated. These measures were gradually de-escalated and lifted in the subsequent months.

It is important to examine the potential unintended effects caused by infection control procedures and policies on pediatric patient outcomes. Prior studies have shown significant negative effects for individual patients with hospital-based infection prevention strategies such as contact precautions, including increased patient anxiety and depression, higher risk of adverse events, and, specifically in trauma, increased risk of venous thromboembolism, pneumonia, and urinary tract infection.[15–19] Extrapolating this to the more broad-based community and societal infection control practices instituted at the onset of the

COVID-19 pandemic, including social distancing, stay-at-home orders, school closings, quarantines, lock-downs, and social isolation, it is not unexpected that there could be profound deleterious effects from these measures.

In the pediatric population, the effects of isolation for COVID-19 prevention are wide-ranging. Decreased physical activity, sleep dysregulation, and increased risk of obesity are well reported.[1,2,20–22] School closures have led to documented decreases in learning, decreased availability of mental health services, and increases in emotional and behavioral problems including hyperactivity, anxiety, and depression.[23–25] These effects are further amplified in those with special educational needs, children with acute or chronic disease, single-parent households, and families with lower socioeconomic status.[26] Remote learning with either totally virtual or combined in-person/virtual learning has been reported to increase stress on both children and parents with reported concerns about job security, childcare challenges, and parental emotional distress.[27] In Nebraska, all schools were closed by directed health measures during the initial period of the pandemic from April 1, 2020, through the end of the 2020 school year. Starting in August of 2020 person learning was permitted and encouraged statewide and the majority of schools had returned to in-person learning by January 2021.

COVID-19 isolation has also had profound effects on pediatric medical care. Studies have reported decreased pediatric primary care visits and decreases in routine immunization rates.[4,6,7,28] Multiple studies reported decreased pediatric emergency department visits.[8,29–32] However, it is troubling that some centers noted concerning findings such as higher acuity, increased hospital and intensive care admission rates, and potentially delayed presentations for common serious illnesses such as appendicitis and fractures.[8,32,33] The effect of COVID-19 on the field of pediatric surgery has been profound – requiring many changes to maximize safety while maintaining the ability to do high-acuity procedures.[34]

The reported effects of the pandemic on pediatric trauma have been variable. Haddadin et al.[31] in Tennessee reported an increase in the proportion of trauma cases compared to overall emergency department visits, with an increase in injuries due to recreational vehicle use. Sethuraman et al.[10] in Michigan reported overall decreased emergency department visits for trauma but increases in trauma activations, injury severity, intensive care unit admissions, child abuse, firearm injuries, dog bites, and deaths. In New York, Shi et al.[35] reported decreases in pediatric trauma activations but with increased injury severity, more operative cases, and increased falls. In Texas, Sanford et al.[36] found overall decreased pediatric trauma, but with increased burns and penetrating injuries. A study by Shaw et al.[33] from Colorado, describes an overall decrease in pediatric fractures but with increased fractures in younger children, more severe fractures in older children, and a significant increase in delayed presentation for treatment.

Diverse effects of COVID-19 precautions on pediatric trauma are also seen internationally. In Ireland, Sheridan et al.[37] concluded that pediatric trauma volumes significantly decreased, with an association with the reduction in school days and presumably outdoor activity. In Italy, a study by Verdoni et al.[38] demonstrated significant decreases in pediatric trauma volumes but with increased severity and the likelihood of in-home injuries, while another by Ruzzini et al.[39] demonstrated an 81% reduction in admissions for fractures, trauma, sprains, and dislocations. In China, Li et al.[40] reported an overall decrease in pediatric fractures but with an overall increase in young male patients. Raitio et al.[41] reported a 31% decrease in the need for operative intervention for pediatric orthopedic trauma in Finland. In France, Bolzinger et al.[42] reported a 50% decrease in pediatric traumatology activity but with only a 14% decrease in operative interventions with overall younger patients who were more likely injured in 'domestic' or trampoline-related incidents.

Another interesting trauma-related finding is the heterogenicity of pandemic effects within one state. Two studies analyzed pediatric trauma in California during the pandemic. In Southern California, Yeates et al.[43] demonstrated no differences in pediatric trauma volumes with similar rates of penetrating injuries, alcohol, and drug positivity, and admission vital signs, but an overall decreased length of hospitalization. Slightly north in Los Angeles, Chaudhari et al.[9] reported no significant changes in pediatric activation volume but with increased gunshot wounds, burns, and motor vehicle crashes but an overall decrease in pediatric trauma mortality.

Several multicenter and multistate groups have also reported pandemic effects on trauma. Bessoff et al.[11] report an overall decrease in pediatric trauma during the pandemic but with increased severity and an increase in gunshot wounds. Collings et al.[44] performed a more detailed analysis of pediatric gunshot wounds demonstrating an odds ratio of 1.78 [1.45–2.12] of firearm injury during the pandemic with African Americans, other minorities, and the most socially vulnerable being at the highest risk.

Regarding non-accidental trauma and child abuse, reported findings are also variable. Studies from Colorado and Michigan demonstrated increases in the incidence of non-accidental trauma and abuse, while a similar study from a pediatric trauma center in New York demonstrated rates to be unchanged.[10,33,35] Multicenter and multistate studies have not demonstrated an overall increase in rates of

non-accidental trauma in children.[11] However, Lewit et al.[45] did demonstrate that African American children experienced an increased rate of non-accidental trauma, although the overall for all children rate remained the same.

When interpreted in the context of other studies, our data is interesting in several ways. First, our pediatric trauma volumes increased, with a significant increase in 'recreational' transportation injuries. This suggests that children did not "stay at home" during the pandemic, but in fact, may have had more outdoor recreational activities. These findings are possibly related to the 'stringency' of the Nebraska COVID-19 mitigation strategies which did not include a 'stay-at-home' mandate. Overall, this may have led to less direct supervision of children when schools closed. The increase demonstrated in moderate-level falls may be the effect of children assisting at home with projects requiring climbing or increased outdoor recreational activity.

How do we account for the increase in alcohol use in the older pediatric population? A recent study looking at pandemic substance use levels by Pocuca et al.[46] sheds some light on the topic. Emerging adults who reported only monthly alcohol use prior to the pandemic increased both their alcohol use and binge drinking during the pandemic. Interestingly, those who reported greater than monthly pre-pandemic alcohol reported decreased binge drinking during the COVID-19 pandemic, however, they did not change their frequency of alcohol use. Risk factors for increased substance use included employment loss, financial worries, and reported loneliness. These findings underscore the need for targeted support for vulnerable populations during periods of pandemics or forced social isolation.

Finally, when investigating the effects of COVID-19 isolation on the pediatric population, potentially long-lasting effects on children's psychosocial development must be considered. In a recent review, Lehmann et al.[25] detailed the significant effects of pandemic isolation, with the resulting school closures, on psychosocial outcomes. Their review describes in depth the potential negative consequences of school closures including 'failures in developmental competencies' which can contribute to negative psychosocial and emotional outcomes and psychopathology. In another detailed review, Merrill et al.[47] point out the significant and diverse negative effects of epidemics and pandemics on children, with consequences including depression, anxiety, child abuse, improper nutrition, decreased play, increased screen time, and negative academic impacts. In the end, society might not truly know the full effects of pandemic isolation for years to come.

As with any retrospective review, our study has several important limitations. First and foremost, as a retrospective review, our study can only establish an association, not causation. This is important when interpreting our results. Second, it is possible that factors outside of our institution may have contributed to some of the effects noted. Of note, we especially cannot account for any potential changes in pediatric trauma referral and admission patterns of other institutions in our community. We did note an increase in patients transferred in from other facilities during the pandemic, however, this requires further investigation to establish any significance. Furthermore, our study specifically investigated children presenting after traumatic injury. We therefore cannot estimate the effects of COVID-19 isolation on those who were not injured. Regarding alcohol use, our center routinely tests all trauma activations for alcohol at the time of their evaluation and admission. No major changes in trauma laboratory analysis protocols were made during the study period and internal data suggests that no major changes occurred in alcohol testing rates. Finally, we must point out that our dataset did not contain information on concurrent drug use, which also may have increased during this time period. However, given our findings, especially those regarding alcohol consumption, our results do raise several areas of concern.

Overall, our study demonstrated that pediatric trauma volumes during the COVID-19 pandemic increased. Pediatric trauma patients presenting during the pandemic were younger, have a higher incidence of recreational injuries, and had higher rates of positive blood alcohol – especially in patients ages 14–18. This suggests an increased need for alcohol assessment and targeted interventions in the pediatric population during the pandemic. Additional preventative measures during pandemics or school closures, for both parents/caregivers and youth, are also likely warranted.

Given the potential for future pandemics and the potential reinstatement of societal infection control practices, it is important to consider the reasons for the wide variety of reported effects on pediatric trauma. One important potential consideration is the wide range of stringency or "virulence" of COVID-19 prevention measures enacted by different countries, states, and localities. Is it possible that changes in the restrictiveness of enacted measures might lead to differing or less profound effects? More research is clearly needed.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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