ABSTRACT. Objective. All-terrain vehicle (ATV) injuries among children represent a significant and growing problem. Although state-level analyses have characterized some aspects of pediatric ATV-related injuries, little information on the national impact on hospitalization is available. This study was designed to characterize more fully the patterns of injury, hospital length of stay, and hospital charges associated with ATV-related injuries, with a nationally representative sample.

Methods. Analyses were based on the 1997 and 2000 Healthcare Cost and Utilization Project Kids’ Inpatient Database (KID). The KID is the only national, all-payer database of hospital discharges for children. KID data were weighted to represent all discharges from general hospitals in the United States. Discharges with external cause-of-injury codes consistent with off-road ATV-related injuries were selected, and the affected population was described. Nationally representative rates of ATV-related injuries were calculated, and changes between 1997 and 2000 were documented.

Results. An estimated 5292 children were hospitalized because of ATV-related injuries during the 2-year period, and hospitalizations increased 79.1% between 1997 and 2000. Rates of ATV-related hospitalization were highest among adolescent white male subjects, consistent with previous studies. Most patients had hospital lengths of stay of <4 days (68%), but 10% had stays of ≥8 days. Injury severity varied considerably, with more than one third of patients sustaining moderate to severe injuries. Approximately 1% of hospitalizations resulted in in-hospital deaths. Total hospital charges for this injury mechanism were $74,367,677 for the 2-year study period. Most of these charges were paid by private insurers.


Pediatric all-terrain vehicle (ATV)-related injuries represent a significant and growing problem. ATVs have been sold in the United States since 1972 and have experienced a popularity surge in recent years.1 Accompanying this increase in popularity is concern regarding the associated risks for children who ride on or drive ATVs. Current discussions have centered on appropriate vehicle sizes for children and the potential for legislative and educational measures to decrease the ATV injury burden.

ATVs are 3- or 4-wheeled machines designed with motorcycle-style handlebars, a high center of gravity, and large, low-pressure tires intended for off-road use. ATVs typically range in engine size from 50 cm³ to >500 cm³ of displacement and can weigh as much as 600 pounds. Nearly all ATVs are designed for 1 rider, because precise, quickly executed, weight-distribution adjustments must be performed to maintain balance and control of the vehicle in turns or in rough-terrain situations.

ATVs have proved useful for a wide range of occupational and recreational purposes but are also associated with significant risks for fatalities and injuries. In 1986, emergency departments admitted an estimated 106,000 patients with ATV-related injuries, representing a 230% increase from 1983 estimates. In addition, there was an 18% increase in estimated ATV-related deaths from 1985 to 1986.2 Recognizing the growing problem of ATV-related injuries, public health organizations have attempted to prevent injuries through policy recommendations. The US Consumer Product Safety Commission (CPSC) developed a consent decree with ATV manufacturers and distributors, which began in 1988. The decree banned the sale of new 3-wheeled ATVs, established a nationwide ATV training program, improved warning materials such as labels to inform the public about the hazards associated with ATV use, and required age recommendations based on the size of the ATV. Specifically, ATVs with engines of >90 cm³ were not recommended for children <16 years of age.3 In addition, the American Academy of Pediatrics issued a policy statement discouraging ATV use for children <16 years of age4 and produced a model ATV safety bill that prohibits children <16 years of age from operating ATVs, mandates license, insurance, and registration requirements for all ATV operators, and bans operation of ATVs on
public roads or with passengers. The bill also endorses the use of motorcycle-style helmets, eye protection, and safety clothing, as well as vehicle modifications including seatbelts, roll bars, and automatic headlights.\(^4\)\(^5\)

Despite these efforts, the numbers of pediatric injuries continue to increase.\(^6\)\(^\text{-}^9\) The CPSC conducted ATV injury and exposure studies and reported that overall exposure to ATVs increased by 36% (number of drivers) to 50% (number of driving hours) from 1997 to 2001.\(^10\) The same report showed a disproportionate increase of 104% in ATV-related injuries. The risk of death for children in these studies was 4.5 to 12 times greater than that for adult comparison groups.\(^11\)\(^12\)

Because of this increasing problem, effective methods to prevent ATV-related injuries, particularly among children, are needed. Recent literature has described the benefits of helmet requirements and safety legislation.\(^1,4,6,12\)\(^\text{-}^15\) The CPSC has to have an active interest in this problem and held a public hearing in June 2003,\(^16\) during which ATV owners and dealers, state legislators, CPSC officials, doctors, researchers, and injury patients and their families discussed ATV injury prevention.

Additional information about the extent and character of ATV-related injuries could inform the debate about these vehicles and might strengthen the efforts of those working to prevent injuries through education or other activities. This study was designed to determine the impact of ATV-related injuries on the hospital care of children and adolescents. National data were used to assess the numbers of children and adolescents admitted to US hospitals for treatment of ATV-related injuries in 1997 and 2000. Additional analyses determined the distributions of hospitalizations across gender, ethnicity, income, and age categories and the severity of the injuries sustained.

**METHODS**

**Study Design and Data**

This study was a retrospective analysis of 1997 and 2000 hospitalizations based on the Kids’ Inpatient Database (KID).\(^17\)\(^18\) The KID is a pediatric hospital discharge database developed by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. Data from 22 states in 1997 and 27 states in 2000 are included in the database. A 10% sample of normal newborn discharges and an 80% sample of all other pediatric conditions, such as hospitalizations for treatment of specific injury mechanisms. Information on patient demographic factors, hospital characteristics, including hospital region, hospital type, and hospital bed size, were also considered in our analysis. KID variables used to examine the severity of injury included length of stay, patient disposition at discharge, and total hospital charges. In addition, ICDMAP-90 software was used to calculate injury severity scores (ISSs).\(^22\)\(^23\)

National estimates were calculated with a stratified sampling design and were generated with Stata statistical analysis software.\(^1,12\) Because a sample size of 70 is required for national estimates, small categories were combined to produce cells large enough for inclusion in weighted analyses.

**RESULTS**

The unweighted datasets contained a combined total of 2373 ATV-related hospitalizations for children ≤18 years of age across both study years, 1997 and 2000. After weighting, this yielded a national estimate of 5292 cases, with 1896 (SE: 136) hospitalizations in 1997 and 3396 (SE: 147) hospitalizations in 2000, representing a 79.1% increase from 1997 to 2000.

We calculated the percentages of ATV-related hospitalizations that resulted in an in-hospital death for both years. The numbers of deaths for 1997 and 2000 were too small to be used in national estimates of in-hospital mortality rates; therefore, the percent died category is based on unweighted data. The percent died results were equal for the 2 years, representing 0.9% of hospitalizations.

Table 1 provides patient demographic characteristics. The proportion of hospitalizations experienced by the youngest age category (0–9 years) decreased from 23.6% to 17.5% between 1997 and 2000, with a corresponding increase in the oldest age category (15–18 years) from 31.6% to 37.7%. Children 10 to 14 years of age experienced ~45% of hospitalizations for both years. The proportions of hospitalizations experienced by male and female subjects remained stable over time, at 78% and 22%, respectively. Whites experienced >60% of hospitalizations; however, additional analyses of race were not performed, because race data were missing in ~25% of cases.

Hospitalization rates (per 100 000 population) were calculated for age and gender variables based on 1997 and 2000 US census data.\(^26\) Rates increased strikingly with time, most notably among older children and male subjects. Hospitalization rates for children 0 to 9 years of age increased 30%, to 1.49 cases per 100 000 population. Rates for children 10 to 14 years of age increased 67%, from 4.45 cases per 100 000 population to 7.51 cases per 100 000 population.
100 000 population in 1997 to 7.41 cases per 100 000 population in 2000. A 103% increase was observed among children 15 to 18 years of age (from 3.91 cases per 100 000 population to 7.95 cases per 100 000 population). Male hospitalization rates increased 74%, from 3.91 cases per 100 000 population to 6.81 cases per 100 000 population; female rates increased 63%, from 1.20 cases per 100 000 population to 1.95 cases per 100 000 population.

The distribution of patient income categories changed considerably from 1997 to 2000. The low-income category ($0–35 000) represented 73.0% of ATV hospitalizations in 1997 but only 46.2% of hospitalizations in 2000. A corresponding increase was observed for the high-income category (> $35 000), which represented 19.1% of hospitalizations in 1997 and 52.8% in 2000.

The proportions of hospitalizations covered by public insurance, including Medicaid and Medicare, remained relatively equivalent during the study period, ie, ~16% in both 1997 and 2000. The private insurance category, including health maintenance organizations, represented a large majority of hospitalizations for both years, increasing from 70.1% in 1997 to 73.5% in 2000. The third insurance category contains all other KID expected-payer designations, including self-pay, no charge, and other. This category decreased from 12.8% of hospitalizations in 1997 to 10.0% in 2000.

Table 2 provides characteristics of the hospitalizations of children with ATV-related injuries. The length of stay remained relatively stable from 1997 to 2000. Approximately 70% of hospitalizations for both years resulted in a length of stay of 0 to 3 days.
Approximately 20% of hospitalizations involved a length of stay of 4 to 7 days, and the remaining 10% had a length of stay of >7 days. Most hospitalizations (4918 patients; 93.5%) resulted in routine discharge to home. The remaining 6.3% of patients died in the hospital, were discharged against medical advice, or were transferred to a skilled-nursing facility, intermediate-care facility, or home health care.

The proportion of mild injuries (ISS values of 0–8) decreased slightly from 1997 to 2000, ie, from 62.7% to 58.9% of ATV-related hospitalizations. The proportions of moderate injuries (ISS values of 9–16) remained approximately equal, at 28% of ATV-related hospitalizations, for the 2 years. The most severe injury category (ISS values of >16) increased from 9.1% of ATV-related hospitalizations in 1997 to 12.0% of hospitalizations in 2000. In addition to examination of ISS values according to category, KID weight variables were used to create a national estimate of the mean ISS values for the 2 years. The estimated ISS mean increased slightly, from 7.50 (SE: 0.42) in 1997 to 8.29 (SE: 0.20) in 2000.

Hospital charges were calculated from a dataset that included transfers to a short-term hospital. KID weight variables were used to create a national estimate of charges for the 2 years. The mean charge per hospitalization remained stable across the years, with charges of $13 336 (SE: $654) in 1997 and $13 823 (SE: $430) in 2000. Estimated total charges associated with charges according to insurance type were largely unchanged from 1997 to 2000, with 70% and 20% of hospitalizations having charges being paid by private insurance and public insurance, respectively.

Table 3 provides hospital characteristics for ATV-related hospitalizations. The Northeast and West regions showed small decreases in hospitalizations from 1997 to 2000, and the South and Midwest regions showed corresponding increases. Overall, the South had the highest percentage of hospitalizations (39%) in 2000, followed by the Midwest (27.4%). ATV-related hospitalizations are much less frequent in the West and Northeast (<20%).

Hospital location (urban versus rural) and teaching status are recorded in the KID. Rural hospitals received relatively equal percentages of hospitalizations (~21%) in 1997 and 2000. The representation of urban nonteaching hospitals decreased considerably, from 42.1% of hospitalizations in 1997 to 28.1% in hospitalizations in 2000. A corresponding increase was seen in the representation of urban teaching hospitals, from 36.1% in 1997 to 49.8% in 2000.

Hospital size (measured as the number of available beds) is described in the KID as small, medium, or large. Small and medium-sized hospitals had decreased representation of ATV-related hospitalizations from 1997 to 2000, whereas that of larger hospitals increased from 51.3% to 59.4%.

### DISCUSSION

The CPSC 1997 and 2001 ATV injury studies, with a random-digit-dialing survey design, have provided the most comprehensive, nationally representative data demonstrating the recent increase in ATV-related injuries among children. Those studies were limited to the reports of survey respondents and lacked clinically important information about the nature of the injuries sustained. Our study extends those findings by using a large, nationally representative, pediatric discharge database. Results provide evidence supporting the increasing number of ATV-related injuries experienced by children. The study period is significant; the study used KID data collected in the years surrounding the end of the initial CPSC 10-year consent decree in 1998, which allows us to substantiate the subsequent increase in ATV-related injuries suggested in the CPSC injury reports.

Use of the KID data enabled a more detailed look at the hospital impact of ATV-related injuries at a national level than had been possible previously. The estimated number of ATV-related hospitalizations in our sample increased nearly 80%, to >3300 hospitalizations in 2000, which was even more dramatic than the CPSC report of a 56.5% increase in emergency department-treated injuries during the same time period. This larger change in admissions may reflect increasing severity of injuries, necessitating hospital-

### Table 3. Characteristics of Hospitals Treating Children and Adolescents for ATV-Related Injuries

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1997</th>
<th></th>
<th>2000</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>SE</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Total hospitalizations</td>
<td>1896</td>
<td>136</td>
<td>100</td>
<td>3396</td>
</tr>
<tr>
<td>Hospital region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>391</td>
<td>56</td>
<td>20.6</td>
<td>542</td>
</tr>
<tr>
<td>South</td>
<td>658</td>
<td>108</td>
<td>34.7</td>
<td>1326</td>
</tr>
<tr>
<td>Midwest</td>
<td>450</td>
<td>51</td>
<td>23.7</td>
<td>931</td>
</tr>
<tr>
<td>West</td>
<td>397</td>
<td>32</td>
<td>20.9</td>
<td>597</td>
</tr>
<tr>
<td>Location/teaching status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban teaching</td>
<td>684</td>
<td>72</td>
<td>36.1</td>
<td>1692</td>
</tr>
<tr>
<td>Urban nonteaching</td>
<td>798</td>
<td>106</td>
<td>42.1</td>
<td>954</td>
</tr>
<tr>
<td>Rural</td>
<td>415</td>
<td>40</td>
<td>21.9</td>
<td>733</td>
</tr>
<tr>
<td>Hospital bed size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>363</td>
<td>55</td>
<td>19.1</td>
<td>471</td>
</tr>
<tr>
<td>Medium</td>
<td>561</td>
<td>56</td>
<td>29.6</td>
<td>891</td>
</tr>
<tr>
<td>Large</td>
<td>972</td>
<td>112</td>
<td>51.3</td>
<td>2016</td>
</tr>
</tbody>
</table>

* May not equal 100% because of missing data.
hospitalization) in the early 1990s.6 The total charges higher than those noted in a Utah study ($4240 per $13 000 per hospitalization) were substantially associated with these injuries using data available in the KID. More than one half of ATV-related injuries in our study were associated with ISS values of ≥16 years of age.7,8 Our national data, by comparison, demonstrated mean scores of 7.50 in 1997 and 8.29 in 2000, representing injuries treated in general as well as in trauma referral centers. Although more than one half of ATV-related injuries in our study were associated with ISS values of <9, it is notable that many of the patients (>10%) sustained very severe injuries, with scores of >16 and correspondingly prolonged hospital stays of >1 week in many cases. Although very few deaths were reported in our study, these hospitalizations represent substantial injuries. We were unable to characterize the long-term morbidity associated with these injuries using data available in the KID.

The mean charges reported here (more than $13 000 per hospitalization) were substantially higher than those noted in a Utah study ($4240 per hospitalization) in the early 1990s.6 The total charges associated with the hospitalizations over 2 years exceeded $70 million, demonstrating an expensive, avoidable, public health problem. The bulk of these hospital expenses were borne by private insurers.

For several reasons, we think that the total cost of ATV-related injuries is underestimated in this study. Physician charges are not included in the KID; therefore, charge estimates described in this study underestimate the cost of ATV-related hospitalizations. In addition, we have no follow-up data to characterize the long-term health care needs of the affected patients. Finally, the KID does not include ATV-related injuries treated in outpatient or emergency department settings.

The burden of ATV-related injuries is unevenly distributed throughout the country, with injuries being most common in the South and Midwest regions of the country, consistent with previous usage reports.27,31 Our results also indicate a shift to hospitalization in larger, urban, teaching hospitals from 1997 to 2000. Rural hospitals maintained ~21% of ATV-related hospitalizations for the 2 years. The notable change in location/teaching status from 1997 to 2000 was the shift from urban nonteaching hospitals to urban teaching hospitals.

Several limitations should be acknowledged. The use of ICD-9-CM E-codes as selection criteria excluded injuries that occurred on paved roads. ATV crashes occurring on paved roads have been associated with more severe injuries.9,11,31,32 Therefore, we think that our findings underestimate both the number and the severity of ATV-related injuries. However, because ATVs are not designed for use on paved roads, this analysis provides an opportunity to describe a population using ATVs in the setting for which they were designed. We attempted, through careful selection of the E-codes, to include only ATV-related hospitalizations in our data. It is possible that some cases of other off-road vehicles might have been included in our results, although the consistency of our data with previously published ATV injury studies suggests that the degree of misclassification was small.

Data from the KID are currently available only for the years 1997 and 2000, preventing a more detailed analysis of ATV-related hospitalizations over time. The anticipated release of KID data for 2003 will enhance our ability to describe hospitalization trends.

Some concerns might be raised that the increase in ATV-related hospitalizations found in the KID might be an artifact of its design. However, previous studies demonstrated stable KID hospitalization estimates for conditions for which no increase should be expected.33,34

CONCLUSIONS

This study provides additional evidence supporting recent substantial increases in the number of ATV-related injuries among children. The hospitalization impact of ATV-related injuries among children is considerable. Our data support the need for ongoing creative attempts to identify effective strategies to decrease ATV injuries among children.

ACKNOWLEDGMENTS

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