Increased Testing and Health Care Costs for Pediatric Cannabis Exposures

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Objectives: This study aimed to evaluate the process of identifying marijuana exposure in a children's hospital emergency department and compare the cost of diagnostic testing and procedures.

Methods: A retrospective chart review was performed on patients 31 days to 20 years old with a positive marijuana toxicology screen result between November 2009 and December 2014. Primary outcomes included time to provider recognition of marijuana exposure, number of diagnostic tests and procedures performed, and length of hospital stay. Patients were analyzed based on time of exposure recognition (forthcoming compared with not forthcoming of marijuana exposure) and age (children <12 years compared with adolescents >12 years).

Results: There were 37 children and 38 adolescents included. Mean time to exposure recognition was 2.3 ± 4.3 hours in children compared with 0.4 ± 0.9 hours in adolescents ($P = 0.02$). Patients who were not forthcoming of marijuana exposure experienced more than twice as many diagnostic tests or procedures compared with children who were forthcoming of marijuana exposure (mean, 8.91 vs 4 tests, $P < 0.0001$) and more than a 4-fold higher cost of potentially avoidable diagnostic tests/procedures. Length of hospital stay was significantly longer in children (18.34 ± 2.39 hours) compared with adolescents (4.22 ± 0.52 hours; $P \leq 0.0001$). Few parents or guardians were able to disclose characteristics of the marijuana product.

Conclusion: Delay in recognition of marijuana exposure is associated with high resource utilization, unnecessary medical costs, and prolonged length of stay.

Key Words: cannabis, unintentional exposure, toxicity, costs and cost analysis, marijuana

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Marijuana has undergone a significant legal transformation within the United States. Despite federal regulation as a schedule I substance (a chemical without accepted medical use and with high potential for abuse), as of June 2018, marijuana is allowed in the District of Columbia and 29 states for its medicinal indications and has been decriminalized for recreational use in the District of Columbia and 9 states (including Colorado).[1] As one of the initial states to pass legislation regarding marijuana and the first state to open retail recreational marijuana dispensaries, Colorado leads the country in the changing landscape of marijuana use, abuse, and regulation.[2,3]

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As of June 4, 2018, Colorado had 498 medical marijuana centers and 533 recreational marijuana retail stores.[4] Although the marijuana industry in Colorado has exponentially increased, the state has experienced unintended consequences of increased accessibility. Since the legalization of marijuana and the ensuing widespread availability of marijuana-containing products, there has been an increase in unintentional exposures and accidental intoxication cases in Colorado.[5] In 2014, during the first year of retail marijuana sales, Colorado sold 148,000 lb of marijuana flower and 4.8 million units of edible products.[2] Marijuana products available for sale in Colorado take many shapes and forms including high-potency edibles (eg, baked goods, candies, lozenges, and soft drinks) and nonedibles (eg, lip balms, lotions, and transdermal patches). Because it is often difficult to distinguish a marijuana product from its drug-free counterpart, unintentional exposures can be expected.

Children's Hospital Colorado (CHCO) has reported an increase in the number of pediatric patients seeking treatment in the emergency department (ED) after unintentional marijuana exposure and toxicity.[6] Exposure to marijuana can cause significant clinical consequences such as euphoria, impaired motor skills, altered mental status, tachycardia, lethargy, somnolence, and in cases of acute toxicity, respiratory depression.[5–12] Newer articles describe younger pediatric patients who may present with encephalopathic signs and symptoms and some require intubation.[9,13,14] To the unsuspecting medical provider, clinical symptoms of marijuana intoxication can present like many other serious conditions. Without disclosure of marijuana exposure, the clinical constellation of marijuana toxicity may lead the treating medical provider to consider potentially avoidable diagnostic studies. The specific aims of this study are to (1) compare the cost of diagnostic testing and procedures based on whether patients disclose marijuana exposure and (2) evaluate the current process of identifying marijuana intoxication as the etiology of pediatric ED admissions.

METHODS

Study Design and Setting

This was a retrospective chart review of patients aged 31 days to 20 years admitted to Children's Hospital Colorado between November 1, 2009, and December 1, 2014, with a positive tetrahydrocannabinol (THC) urine test and an *International Classification of Diseases*–Revision code of 305.20 (cannabis abuse, unspecified use), 969.6 (poisoning by psychodysleptics [hallucinogens]), and E854.1 (accidental poisoning by psychodysleptics [hallucinogens]). Children's Hospital Colorado is a university-affiliated, freestanding, tertiary care children's hospital and level I trauma center with an annual ED census of more than 70,000 patients. Patients were excluded from the study if they had coexposure to other licit/illicit substances or if their positive THC urine test was incidental to their admission and not the primary reason for seeking care. Patients meeting inclusion criteria for a detailed review were then divided into groups

based on when marijuana exposure was identified. Children younger than 12 years and adolescents 12 years or older were analyzed separately to account for the influence of age on outcomes and diagnostic workup.

The cost of diagnostic testing and procedures was obtained from the CHCO cost library in June 2015. The dollar value represents the hospital charge to the patient without insurance. This study protocol was reviewed and approved by the Colorado Multiple Institutional Review Board.

Outcome Measures

The following data were collected and reviewed: (i) patient information, such as year of admission, sex, age, ethnicity, primary insurance, and county of residence, and (ii) marijuana exposure information, such as time to exposure recognition, how exposure was identified, length of hospital stay, diagnostic tests and procedures performed, hospital disposition, type of marijuana product consumed (name, formulation, route of exposure, time of ingestion), source of marijuana product, site of exposure, and notification of Child Protective Services (CPS).

The primary outcomes measured in this study included the relationship between time elapsed before recognition by health care providers of marijuana exposure, number of diagnostic tests and procedures performed, and length of hospital stay. A potentially avoidable test was defined as a diagnostic or supportive measure that would not have been indicated had providers been aware of the marijuana ingestion upon ED admission (eg, electrocardiogram [ECG], computed tomographic scan, rapid strep test, respiratory viral panel, magnetic resonance imaging). A urine drug screen was considered to be a necessary test in the setting of marijuana exposure. To ascertain if marijuana acquisition or communication barriers may have influenced the timing of marijuana exposure disclosure, we evaluated self-reported information on marijuana supplier and site of exposure as well as patient/parent ethnicity and county of residence.

Primary Data Abstraction and Analysis

To improve accuracy and minimize inconsistencies, outcome measures and variables were collected from charts by 2 pharmacists and an intern pharmacist using a standardized form and then underwent a second data abstraction by a different pharmacist investigator. Findings were reviewed by a physician investigator. Periodic meetings were held to discuss any disputes in chart coding. A descriptive analysis was performed on each variable in the data set. Results are presented as mean ± SD and range, or percentage where appropriate. Medians are reported if significant skewing of the data was observed. A *t* test and 1-way analysis of variance were used to analyze time to exposure identification with length of stay and number of diagnostic and procedures required. A binary logistic regression model was constructed to test whether age, ethnicity, sex, weight, primary insurance, county of residence, number of dispensaries in county of residence, and previous experience with marijuana predicted time to marijuana exposure recognition. All analyses were performed with statistical analysis software JMP Pro version 13 and Prism version 7.

RESULTS

Baseline Characteristics

A total of 2287 patients with an *International Classification of Diseases*–Revision code consistent with cannabis abuse or poisoning were initially identified for review. After exclusion for coingestions or exposures, age limits, and admissions not related to a positive THC result, a total of 75 patients were eligible for analysis. Results are reported based on patient age group with 37 children (mean age, 2.9 ± 1.7 years; range, 0.7–7.8 years) and 38 adolescents (mean age, 15.9 ± 2.2 years; range, 12.6–19.9 years). More children were enrolled in Medicaid insurance compared with adolescents (n = 25 [66%] vs n = 16 [44%]; $P = 0.04$). Characteristics of these groups are described in Table 1.

Outcomes Observed in Children Younger Than 12 Years

Of the 37 children younger than 12 years, 15 were forthcoming of the marijuana exposure and 22 withheld information or were unaware of the exposure. Time to marijuana exposure recognition by medical team was on average 0.1 ± 0.4 hours in children who were forthcoming of marijuana exposure and 3.8 ± 5 hours on average in children who were not forthcoming of marijuana exposure ($P = 0.003$). A comparison of the number of diagnostic

TABLE 1. Baseline Characteristics and Outcomes of Children <12 Years Old and Adolescents ≥12 Years Old After Presenting to the ED for Management of Acute Marijuana Exposure

Baseline Characteristics	Children <12 y (n = 37)	Adolescents ≥12 y (n = 38)	*P*
Age, mean ± SD (range), y	2.9 ± 1.7 (0.7–7.8)	15.9 ± 2.2 (12.6–19.9)	<0.0001
Male, n (%)	20 (54)	25 (66)	0.35
Experience with marijuana, n (%)			
Naïve	36 (97)	2 (5)	<0.0001
Previous experience	1 (3)	36 (95)	<0.0001
Year of admission, n (%)			
Before recreational marijuana regulation	20 (54)	25 (66)	0.35
After recreational marijuana regulation	17 (46)	13 (34)	0.35
Medicaid insurance, n (%)	25 (66)	16 (44)	0.04
Primary outcomes			
Time to marijuana exposure recognition by medical team, mean ± SD, h	2.3 ± 4.3	0.4 ± 0.9	0.02
No. all diagnostic tests, n ± SD	6.9 ± 0.6	3.6 ± 0.3	<0.0001
Length of hospital stay, mean ± SD, h	18.3 ± 2.4	4.2 ± 0.5	<0.0001

Data are presented as mean ± SD (range) or percentage, as appropriate.

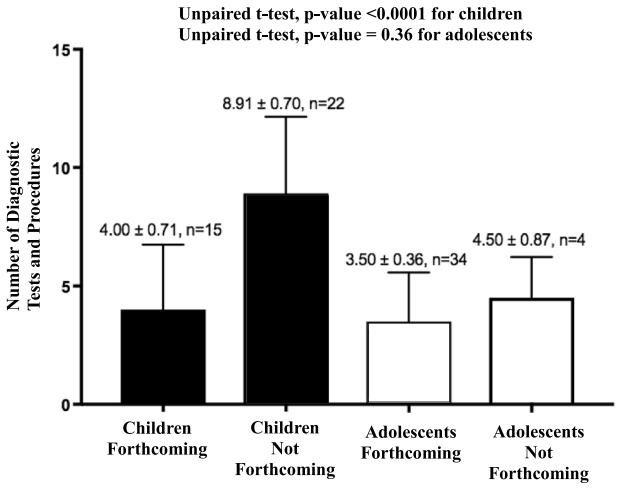

FIGURE 1. Comparison of the number of all diagnostic tests and procedures per patient who were forthcoming of marijuana exposure or who were unaware or not forthcoming of marijuana exposure.

tests and procedures is illustrated in Figure 1. Children that were forthcoming about marijuana exposure had 26 potentially avoidable diagnostic tests ordered for an estimated average cost of $1187 per patient (total estimated cost $17,802 for n = 15), whereas children that had delayed or unknown marijuana exposure had 121 potentially avoidable diagnostic tests ordered for an estimated average cost of $3709 per patient (total estimated cost $81,606 for n = 22). Differences between number of tests and cost were significant between forthcoming and delayed or unknown exposure (P = 0.02). Minor clinical effects were more common in children who were forthcoming of marijuana exposure (n = 6 [40%] vs n = 2 [9%]; P = 0.04). Major clinical effects requiring intubation or admission to the intensive care unit were more common in children with delayed recognition of marijuana exposure, but this finding was not statistically significant (n = 6 [27%] vs n = 0 [0%]; P = 0.06). The oral route of exposure was the most common method of marijuana exposure in children with prompt disclosure of intoxication, whereas an unknown route was more common in children with delayed disclosure. The most common source of marijuana product was the child's parent or guardian (n = 19 [51%]). There was no statistically significant difference with respect to source of marijuana product or site of exposure. Child Protective Services was notified more often when children or parents were not forthcoming of marijuana exposure (n = 10 [67%] vs n = 21 [95%]; P = 0.03).

Outcomes Observed in Adolescents at Least 12 Years Old

Of 38 adolescents, 34 were forthcoming of the marijuana exposure and 4 patients withheld information or were unaware of the exposure. Time to marijuana exposure recognition by the medical team was not statistically significant between those that were forthcoming compared with those that were not (0.4 ± 1.0 hours vs 0.9 ± 0.8 hours, P = 0.25). Number of diagnostic tests and procedures as well as cost of potentially avoidable diagnostic tests or procedures was not statistically significant in adolescents. Adolescents that were forthcoming about marijuana exposure had 43 potentially avoidable diagnostic tests ordered for an estimated average cost of $233 per patient (total estimated cost $7930 for n = 34), whereas adolescents that had delayed or unknown marijuana exposure had 6 potentially avoidable diagnostic tests ordered for an estimated average cost of $226 per patient (total estimated cost $905 for n = 4; ($P$ = 1.0 for both number of tests and cost). There was no statistically significant difference between adolescent groups with respect to marijuana experience, year of admission, clinical effects, route of marijuana exposure, type of marijuana product, source of marijuana product, or site of exposure. Child Protective Services was notified for 3 patients in adolescents who were forthcoming of marijuana exposure and for zero patients in adolescents who were not forthcoming of marijuana exposure.

Outcomes Observed in Children Compared With Adolescents

In all groups, regardless of when marijuana exposure was disclosed, the time to marijuana exposure recognition by the medical team was 2.3 ± 4.3 hours in children compared with 0.4 ± 0.9 hours in adolescents (P = 0.02). Children underwent about twice as many diagnostic tests and procedures compared with adolescents (6.92 ± 0.64 vs 3.61 ± 0.33, P < 0.0001). A delay in marijuana disclosure and recognition in children was associated with more than twice as many diagnostic tests or procedures compared with adolescents (8.91 ± 0.70 tests vs 4 ± 0.71 tests, P < 0.0001) and more than a 4-fold higher cost of potentially avoidable diagnostic tests/procedures. Table 1 depicts a comparison of the number of diagnostic tests and procedures per patient by age group and based on those forthcoming of marijuana exposure or those unaware or not forthcoming of marijuana exposure. The most common potentially avoidable tests and procedures performed included the following: basic metabolic panel, complete blood count, ECG, noncontrast head computed tomography, glucose test, complete metabolic panel, and x-rays. Length of hospital stay was significantly longer in children (18.34 ± 2.39 hours) compared with adolescents (4.22 ± 0.52 hours; P < 0.0001). Figure 2 depicts a comparison of hospital length of stay by age group and based on those forthcoming of marijuana exposure or those unaware or not forthcoming of marijuana exposure. There was no statistically significant difference in length of stay between groups. Patients/parents who were forthcoming about marijuana ingestion provided more information on marijuana product and time of ingestion and were more likely to experience intoxication with their own marijuana supply. However, few patients/caregivers were able to disclose characteristics of marijuana product such

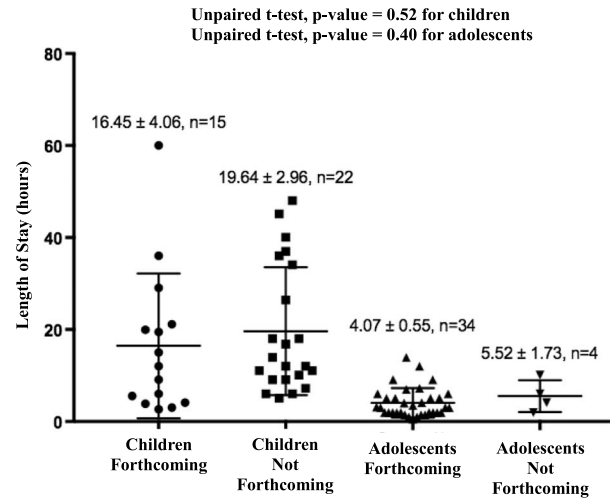

FIGURE 2. Length of hospital stay in patients who were forthcoming of marijuana exposure or who were unaware or not forthcoming of the marijuana exposure.

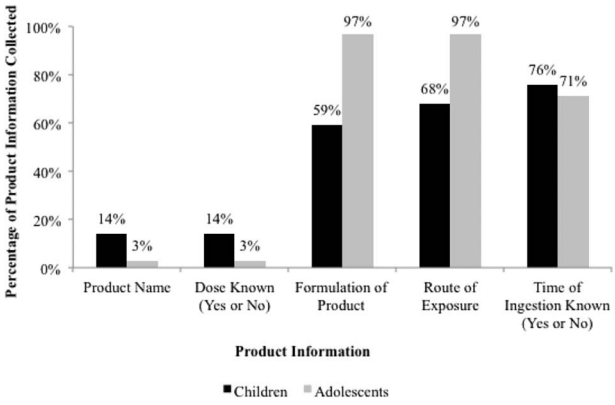

FIGURE 3. Information collected by medical staff during admission related to marijuana product and marijuana ingestion in children younger than 12 years (n = 37) and adolescents at least 12 years old (n = 38).

as product name, dose, route of exposure, or time of ingestion (Fig. 3). The average percentage of product information collected was 46% for children and 54% for adolescents. Adolescents were more likely to have previous marijuana experience compared with children (n = 36 [95%] vs n = 1 [3%]; $P < 0.0001$). There was no statistically significant difference in the number of admissions before or after the introduction of recreational marijuana regulation. There was also no statistical significance between marijuana exposure and the number of marijuana dispensaries per county of residence.

DISCUSSION

Time to recognize marijuana exposure in the ED was more than 5 times longer in children than adolescents. Among children, delay in diagnosis or lack of knowledge of marijuana exposure upon presentation led to 2- to 3-fold more diagnostic tests and higher medical costs. Our findings indicate that there is a higher pretest probability for children than for adolescents. This may be due to nonspecific signs and symptoms upon presentation and concern for more severe complications with younger patients. Excessive utilization of diagnostic tests, procedures and resources, and major clinical effects may have significant economic and psychological burden on patients.[15,16]

Although not statistically significant, patients without known marijuana exposures were more likely to experience major (rather than minor or moderate) clinical effects and stayed in the hospital significantly longer compared with patients (or family members) with a known exposure. The number of diagnostic tests and procedures, cost of potentially avoidable diagnostic tests or procedures, and length of hospital stay were not statistically significant in adolescents.

Parents or guardians of young children may have withheld information on the marijuana exposure because they feared involvement from CPS. This was evidenced in our findings as CPS was more likely notified when information was withheld from the health care team. Recent literature suggests that although marijuana legislation may have an impact on the incidence of marijuana exposures, providers contacted social workers and CPS less often in recent years.[5] Marijuana remains a schedule 1 drug federally, and many argue that this federal status should mandate reporting childhood exposure. On the contrary, if the state has legalized its use, perhaps it should be treated similar to other legal household products, pharmaceuticals, and recreational drugs.

Considering that the most common source of marijuana product was the child's parent or guardian, health care providers should provide education to parents or caregivers about the importance of proper medical or recreational marijuana storage to ensure that pediatric patients are not able to easily access these products. Parents or guardians should also be instructed not to inhale or ingest marijuana products in the same area as pediatric patients to reduce the risk of passive inhalation or unintentional exposure.

Currently, if a patient presents to the ED with signs or symptoms of marijuana exposure, a urine sample is obtained and a urine drug screen is performed with results obtained within the hour. Providers in the ED initially screen for hallmark symptoms of marijuana ingestion such as lethargy or somnolence, altered mental status, ataxia, and tachycardia. Health care providers, especially in states that have legalized marijuana, should be educated to recognize symptoms and made aware of the potential severity of symptoms that may develop. Recognition of marijuana exposure can lead to improved patient outcomes while avoiding unnecessary tests, monitoring, and costs. Improved surveillance methods to follow marijuana product name, dose, formulation, route of administration, time of ingestion, and history of previous marijuana use is needed to properly follow the public health impact of marijuana legalization. This part of the process is critical because our study demonstrated a lack of information on marijuana product ingestion with only 46% to 54% of desired product information available. It is possible that health care providers have not received standardized training, or any previous training, related to unintentional marijuana exposure or overdose and is an area of education that should be provided. Earlier identification of marijuana exposure will result in a decreased number of diagnostic tests and procedures performed and ultimately decrease time and financial burdens for patients and the hospital.

This study evaluated unintentional marijuana exposure before and after decriminalization of recreational marijuana to assess the impact of marijuana legislation on pediatric patients. Although our study shows that early recognition and disclosure of marijuana exposure may help decrease hospital costs and unnecessary tests, there are some limitations. These limitations include the small patient population observed, varying disposition upon presentation, varying patient experience with marijuana, and lack of marijuana product information collected. Another limitation is that only a urine drug screen was considered to be a necessary test. We recognize that tests such as complete metabolic panel, complete blood count, and ECG are often part of routine care in the ED. Therefore, we may have overestimated the number and cost of truly unnecessary tests. This was a retrospective chart review, and the determination of time to diagnosis was based on medical charts. Thus, the timeline of diagnosis may be inaccurate for some patients. Furthermore, it is important to note that urine drug screens can be misleading if interpreted out of clinical context because they do not reflect real-time exposure.[17] Urine toxicology screening can be positive for up to 7 days with acute ingestion and up to 30 days with chronic (daily) use. A positive result indicates a recent exposure rather than a definitive diagnosis. Study investigators controlled for this by including patients with cannabis exposure as the primary etiology for the admission. Future directions include providing improved education to health care workers to identify potential exposures and drug-drug interactions relating to marijuana upon admission.

Patients and/or caregivers who withhold marijuana exposure information or are unaware of marijuana exposure are more likely to have a delay in diagnosis, more diagnostic testing, and higher medical costs. These patients also experience a longer hospital stay than do patients who were forthcoming about the exposure.

As marijuana accessibility increases, so does the potential for unintentional exposures. Improved education and surveillance methods are needed to better identify and cost-effectively treat marijuana exposures and follow the public health impact. Additional studies are needed to evaluate the short- and long-term effects of cannabis exposure in pediatric patients.

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