

# Age as a predictor for hospital admission and length of stay in pediatric cannabis exposure

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## Abstract

Pediatric cannabis exposure is an increasing cause of Emergency Department (ED) visits and hospital admissions. Prior research has shown that younger children may experience more severe symptoms from unintentional ingestion, leading to higher admission rates but the association between age and likelihood of admission versus discharge from the ED among older children and adolescents remains underexplored. This study sought to evaluate whether age was a predictor of admission to a hospital following accidental cannabis ingestion in pediatric patients. The 2020 National Emergency Department Sample was used to identify patients with cannabis exposure (as defined by the ICD-10 codes). The primary outcome measure was admission to the hospital. Patients were grouped in the following age categories: 0-5 years, 6-11 years, 12-18 years, and 19-21 years. Pediatric patients aged 6 or older had lower odds of admission to a hospital following accidental cannabis exposure ( $p < 0.001$ ). However, for patients admitted to a hospital, older age was associated with longer length of stay ( $p < 0.001$ ). Although older pediatric age was associated with lower odds of hospital admission following accidental cannabis exposure compared to patients less than six years old, older age was associated with longer length of hospital stay.

**Key words:** Pediatric cannabis exposure, hospital admission, accidental ingestion, age, length of stay.

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## Introduction

Emergency Department (ED) visits and hospital admissions related to cannabis use have increased over the last decade, driven by increasing cannabis availability, rising delta-9-Tetrahydrocannabinol (THC) potency and broader modes of consumption, while perceived risk associated with cannabis use has decreased, especially among adolescents – the age group at highest risk for a cannabis-related ED visit.<sup>1,2</sup> Patient management for drug intoxication is often dose- or symptom-dependent.<sup>3</sup> However, in the setting of unintentional cannabis ingestion in pediatric patients, the amount ingested may be difficult to ascertain, and the degree of toxicity and symptom severity may vary widely among patients. Furthermore, guidelines for pediatric patient disposition are minimal, and the decision to admit children with this presentation is subject to significant variability across providers and facilities.<sup>4</sup>

In patients younger than six years old presenting to an emergency department with accidental cannabis exposure, younger age was associated with increased rates of admission and increased need for respiratory support.<sup>5</sup> However, the association between age and likelihood of admission versus discharge from the ED among older children and adolescents remains unclear. Therefore, we hypothesized that older pediatric age would be associated with lower odds of hospital admission and shorter length of hospital stay. The secondary aim was to identify associations between age and hospital Length Of Stay (LOS) in the setting of cannabis ingestion among pediatric patients presenting to EDs.

## Materials and Methods

Based on guidelines from the local Institutional Review Board, this study did not meet the criteria for human subjects' research. Using data from the 2020 National Emergency Department Sample (NEDS), a nationally representative sample of ED visits from nearly 1,000 hospital-owned EDs, we identified pediatric patients presenting to the ED for unintentional cannabis exposure from April 1, 2020, to December 31, 2020. Patients were identified using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) code T40.7X1A (cannabis poisoning, accidental, initial encounter). Patients up to 21 years old were included as this is the upper pediatric age limit utilized by the American Association of Pediatrics (AAP).<sup>6</sup> Patients with missing data associated with study variables were excluded from this study. Patients were excluded from the secondary analysis of in-hospital outcomes if they were not admitted to the same hospital as the index ED visit.

The primary outcome was admission to the hospital, including admission to the hospital of presentation or transfer to an outside hospital for admission, as compared to patients discharged or those who left Against Medical Advice (AMA). The secondary outcome among patients admitted to the hospital of presentation was hospital LOS. The primary exposure was age, classified based on prior literature as early childhood (0–5 years old), middle childhood (6–11 years old), early adolescence (12–18 years old), and late adolescence (19–21 years old).<sup>7</sup>

Study covariates included patient sex (male, female), race and

ethnicity (White, Black, Hispanic, or none of the above), hospital region (Northeast, Midwest, South or West), and hospital location (metropolitan vs. non-metropolitan). Additionally, we controlled for presence of any comorbidities recorded in a secondary diagnosis field, including asthma (ICD-10-CM code J45), depression (F32-F34), anxiety (F40-F45, F58), attention deficit/hyperactivity disorder (ADHD, F90), and acute kidney failure (N17).<sup>8</sup> Acute kidney failure was re-termed Acute Kidney Injury (AKI), which is an equivalent and more widely used term, representing a broader spectrum of kidney dysfunction.<sup>9</sup> The NEDS database did not specify whether comorbidities present in the secondary diagnosis fields were newly diagnosed at the time of the ED visit or pre-existing. To produce national estimates, data were summarized using weighted means or proportions with 95% confidence intervals. Study variables were compared between pediatric patients of different age groups using Wald tests. Admission was analyzed using multivariable logistic regression, while LOS was analyzed using multivariable negative binomial regression, including all covariates. Data analysis was completed in Stata/SE 18.0 (College Station: TX; StataCorp, LP), and  $P < 0.05$  was considered statistically significant.

## Results

We identified 1,886 patients aged 0-21 years old presenting to the ED with a primary diagnosis of unintentional cannabis exposure and excluded 65 (3%) patients with missing data on study variables. Based on the remaining sample of 1,821 patients, we estimated 28% were aged <6 years, 9% were 6-11 years, 37% were

12-18 years, and 26% were 19-21 years old; overall, 22% required admission to the hospital.

Based on the subsample of patients admitted to the hospital of presentation (N=324), mean LOS was 2 days. Study outcomes and patient characteristics are compared by age category in Table 1. Overall, children (ages 0-11 years old) were the most likely to be admitted to the hospital, especially those of early childhood age (0-5 years old). However, adolescents (ages 12-21 years old) had longer LOS. Meanwhile, there were no significant differences in the distribution of sex, race and ethnicity, and hospital location categories between age groups. The prevalence of chronic conditions such as asthma, depression, anxiety, and ADHD increased with age, although not linearly.

The multivariable model of admission is shown in Table 2. Compared to the youngest age group, older ages were consistently associated with lower odds of admission (ages 6-11 years adjusted odds ratio [AOR]: 0.45; ages 12-18 years [AOR]: 0.18; ages 19-21 years [AOR]: 0.23; all  $p < 0.001$ ). Patient sex was not a predictor for hospital admission. Geographic region was found to influence hospital admission rates, with Northeastern hospitals admitting the greatest number of pediatric patients with unintentional cannabis exposure. Furthermore, patients from non-metropolitan areas were less likely to be admitted to the hospital compared to those from metropolitan areas. Among the comorbidities, depression, ADHD, and AKI were strong predictors of hospital admission, while anxiety was not.

Among patients admitted to the hospital of presentation, Table 3 shows the multivariable model for LOS. Outcomes were expressed as the Incidence Rate Ratio (IRR), which indicated the relative change in LOS for each variable compared to the chosen

**Table 1.** Weighted proportions or means with 95% confidence intervals of study outcomes and characteristics, stratified by age group (N=1,821).

| Variable             | Age 0-5<br>(N=503) | Age 6-11<br>(N=164) | Age 12-18<br>(N=676) | Age 19-21<br>(N=478) | p      |
|----------------------|--------------------|---------------------|----------------------|----------------------|--------|
| Admitted to hospital | 0.35 (0.31, 0.40)  | 0.23 (0.17, 0.30)   | 0.15 (0.12, 0.18)    | 0.17 (0.14, 0.21)    | <0.001 |
| Hospital LOS (days)  | 1.2 (1.1, 1.3)     | 1.3 (1.0, 1.7)      | 2.9 (2.3, 3.4)       | 2.8 (2.2, 3.4)       | <0.001 |
| Sex                  |                    |                     |                      |                      |        |
| Male                 | 0.50 (0.46, 0.55)  | 0.55 (0.47, 0.63)   | 0.47 (0.43, 0.51)    | 0.52 (0.47, 0.57)    | 0.26   |
| Female               | 0.50 (0.45, 0.55)  | 0.45 (0.37, 0.53)   | 0.53 (0.49, 0.57)    | 0.48 (0.43, 0.53)    | 0.26   |
| Race and Ethnicity   |                    |                     |                      |                      |        |
| White                | 0.47 (0.43, 0.52)  | 0.44 (0.36, 0.52)   | 0.41 (0.37, 0.45)    | 0.43 (0.38, 0.47)    | 0.24   |
| Black                | 0.23 (0.19, 0.27)  | 0.24 (0.18, 0.31)   | 0.25 (0.21, 0.28)    | 0.26 (0.22, 0.30)    | 0.78   |
| Hispanic             | 0.21 (0.18, 0.25)  | 0.27 (0.21, 0.35)   | 0.27 (0.24, 0.30)    | 0.25 (0.21, 0.29)    | 0.16   |
| None of the above    | 0.09 (0.06, 0.12)  | NR <sup>b</sup>     | 0.07 (0.06, 0.10)    | 0.07 (0.05, 0.09)    | 0.38   |
| Region               |                    |                     |                      |                      |        |
| Northeast            | 0.19 (0.16, 0.22)  | 0.22 (0.16, 0.29)   | 0.16 (0.14, 0.19)    | 0.20 (0.17, 0.23)    | 0.23   |
| Midwest              | 0.22 (0.19, 0.25)  | 0.22 (0.17, 0.29)   | 0.22 (0.19, 0.24)    | 0.19 (0.16, 0.22)    | 0.61   |
| South                | 0.25 (0.22, 0.29)  | 0.28 (0.22, 0.35)   | 0.37 (0.35, 0.40)    | 0.32 (0.28, 0.36)    | <0.001 |
| West                 | 0.34 (0.30, 0.37)  | 0.28 (0.22, 0.35)   | 0.25 (0.23, 0.28)    | 0.29 (0.26, 0.33)    | 0.01   |
| Location             |                    |                     |                      |                      |        |
| Metropolitan         | 0.87 (0.84, 0.89)  | 0.90 (0.85, 0.94)   | 0.88 (0.86, 0.90)    | 0.86 (0.83, 0.89)    | 0.58   |
| Non-metropolitan     | 0.13 (0.11, 0.16)  | 0.10 (0.06, 0.15)   | 0.12 (0.10, 0.14)    | 0.14 (0.11, 0.17)    | 0.58   |
| Comorbidities        |                    |                     |                      |                      |        |
| Asthma               | 0.03 (0.02, 0.05)  | NR <sup>b</sup>     | 0.06 (0.05, 0.09)    | 0.06 (0.04, 0.09)    | 0.006  |
| Depression           | NR <sup>b</sup>    | NR <sup>b</sup>     | 0.06 (0.04, 0.08)    | 0.07 (0.05, 0.09)    | <0.001 |
| Anxiety              | NR <sup>b</sup>    | NR <sup>b</sup>     | 0.12 (0.09, 0.14)    | 0.17 (0.13, 0.20)    | <0.001 |
| ADHD                 | NR <sup>b</sup>    | NR <sup>b</sup>     | 0.05 (0.04, 0.07)    | NR <sup>b</sup>      | <0.001 |
| AKI                  | NR <sup>b</sup>    | NR <sup>b</sup>     | 0.02 (0.01, 0.04)    | 0.02 (0.01, 0.04)    | <0.001 |

<sup>a</sup>Limited to N=324 patients admitted to the hospital of presentation. <sup>b</sup>Estimates based on cell size <11 are not reported. ADHD, Attention Deficit/Hyperactivity Disorder; AKI, Acute Kidney Injury; LOS, Length Of Stay; NR, Not Reported.

reference group. Compared to the youngest age group (0-5 years old), ages 12-18 and 19-21 were associated with prolonged LOS (IRR: 2.1 and 2.2, respectively; both  $p < 0.001$ ), but there was no difference in LOS between 0-5 years old and 6-11 years old patients (IRR: 1.1;  $p = 0.450$ ). Sex, race and ethnicity, hospital location, and presence of select comorbidities did not predict LOS. The only variable other than age that had a statistically significant difference in LOS as the West hospital region relative to the Northeast.

## Discussion

This study examined the association between age and the likelihood of hospital admission following pediatric cannabis exposure, as well as the LOS for those admitted. Given the lack of clinical guidelines for pediatric patient disposition from the ED and the increasing prevalence of cannabis-related ED visits, our results hope to provide physicians insight on national trends regarding management of this population and may help guide medical decision-making. Also, as there may be multiple ED pathways according to different age groups, our data could guide the development of decision guidelines to reduce unnecessary admissions in the younger age group and have them go to a short-stay observation unit rather than being admitted for longer periods of time and could also provide additional guidelines for families.

We found that older age was associated with a lower likelihood of hospital admission in pediatric patients presenting to the ED for cannabis exposure. Specifically, compared to children aged 0-5 years old, patients aged 6-11, 12-18, and 19-21 years old had significantly lower odds of admission. This aligns with existing literature that suggests that, while the full range of symptoms that occur in young children with cannabis intoxication has not been fully described,<sup>11</sup> younger children are at higher risk for severe out-

comes from cannabis exposure due to their smaller body mass and potential for higher relative dosing during ingestion.<sup>12</sup> The increased likelihood of admission among younger children may reflect concerns for respiratory or neurological complications, which are more prevalent in this age group.<sup>13</sup> Additionally, cases of cannabis intoxication in toddlers may also lead to involvement of social services to identify children at-risk for neglect in the home.<sup>14</sup> Even though cannabis intoxication among children younger than 6 years old may require intensive care or mechanical ventilation, their length of stay is no longer than a day.<sup>15,16</sup>

While older age reduced the likelihood of admission, it was associated with a longer LOS if the patient was admitted, with a significant difference between LOS between 0-5-year-olds and the 12-18 and 19-21 years old. This is unexpected as the literature suggests that adolescents generally have milder, more easily managed intoxication compared to younger children,<sup>17</sup> and that most pediatric patients with cannabis exposure recover within 8-12 hours.<sup>18</sup> In older age groups in this study, mean LOS was just under 3 days. This may be due to more complex medical or social situations in older children and adolescents, including comorbid mental health conditions such as depression and anxiety, which were more prevalent in the older age groups and are known to complicate hospital care.<sup>19</sup> Additionally, this trend could also be due to an increased risk of overdosing with age as adolescents intentionally use cannabis products. This population also increasingly views edibles as safe to ingest.<sup>20</sup> The delayed onset of effects and variable amount of cannabis across products may lead to unintentional overdose.<sup>21</sup> While there was no effect of sex, race or ethnicity or area of residence (metropolitan compared with nonmetropolitan) on admission rates, patients treated in hospitals in the West were less likely to be admitted than those in the Northeast. Similarly, while sex, race, or ethnicity had no impact on LOS of admitted patients, the regional influence persisted, with patients in the West having a significantly shorter stay compared to those in the Northeast. Studies have suggested that these differences are not

**Table 2.** Multivariable logistic regression model of hospital admission (N=1,948).

| Variable                        | Odds ratio | 95% CI        | p      |
|---------------------------------|------------|---------------|--------|
| Age Category (Ref: 0-5 years)   | Ref.       |               |        |
| 6-11 years                      | 0.45       | 0.29, 0.70    | <0.001 |
| 12-18 years                     | 0.18       | 0.13, 0.25    | <0.001 |
| 19-21 years                     | 0.23       | 0.17, 0.33    | <0.001 |
| Sex (Ref: Male)                 |            |               |        |
| Female                          | 1.00       | 0.77, 1.29    | 0.987  |
| Race and Ethnicity (Ref: White) |            |               |        |
| Black                           | 1.20       | 0.86, 1.66    | 0.286  |
| Hispanic                        | 1.41       | 1.00, 1.98    | 0.048  |
| None of the above               | 0.64       | 0.37, 1.10    | 0.107  |
| Region (Ref: Northeast)         |            |               |        |
| Midwest                         | 0.58       | 0.39, 0.86    | 0.007  |
| South                           | 0.81       | 0.56, 1.15    | 0.233  |
| West                            | 0.51       | 0.35, 0.74    | <0.001 |
| Location (Ref: Metropolitan)    |            |               |        |
| Non-metropolitan                | 0.70       | 0.47, 1.02    | 0.062  |
| Comorbidities                   |            |               |        |
| Asthma                          | 1.81       | 1.05, 3.10    | 0.032  |
| Depression                      | 4.88       | 2.76, 8.62    | <0.001 |
| Anxiety                         | 1.52       | 0.95, 2.46    | 0.084  |
| ADHD                            | 2.66       | 1.33, 5.33    | 0.006  |
| AKI                             | 78.81      | 18.32, 339.00 | <0.001 |

ADHD, Attention Deficit/Hyperactivity Disorder; CI, Confidence Interval; LOS, Length Of Stay; OR, Odds Ratio; Ref., Reference.

driven by differences in racial/ethnic or socioeconomic makeup across states but rather differences in state policies and health care market characteristics.<sup>22</sup> Of the studied comorbidities, asthma, depression, ADHD, and AKI increased the likelihood of hospital admission. The greatest odds ratio was associated with AKI.<sup>23</sup> This was a sensible finding—pediatric patients are especially prone to fluid and electrolyte imbalances that lead to AKI. In turn, AKI is associated with greater mortality.<sup>24</sup> None of the comorbidities examined, including AKI, significantly affected LOS among admitted patients. This may seem to contradict epidemiological findings that AKI is associated with longer hospitalization in all children admitted to the hospital.<sup>25</sup> However, prerenal AKI, the most common AKI in pediatric patients,<sup>24</sup> can present with mild symptoms that are quickly corrected.<sup>26</sup> Additionally, the NEDS database does not distinguish between new and pre-existing secondary diagnoses. Thus, patients may have been included due to a history of AKI rather than active disease. Finally, our study analyzed children presenting to the ED with a primary diagnosis of cannabis intoxication and not the entire pediatric population.

Similarly, asthma, ADHD, and depression were predictors of admission but were not associated with increased LOS. This also may be due to an inclusion by history rather than concurrent presentation. Asthma as a secondary diagnosis has been shown to increase the likelihood of hospital admission but would not be severe enough to lead to a significantly greater LOS (as might be caused by an asthma exacerbation, which would warrant primary diagnosis).<sup>27</sup> Similarly, patients with a psychiatric history are more likely to be admitted to the hospital.<sup>28</sup> However, our results suggest anxiety was neither a predictor of admission nor greater LOS in our population. ADHD and depression may have led to greater likelihood for admission without greater LOS due to initial suspicion for higher exposure due to impulsivity and intended self-harm, respectively, with a subsequently benign workup.

Meanwhile, anxiety may have lacked association with both likelihood of admission and LOS due to potential physician bias that symptoms were more attributable to anxiety rather than pure cannabis exposure.

## Limitations

This study has noteworthy limitations. First, the reliance on ICD-10 codes for identifying cannabis-related exposures introduces the possibility of misclassification and coding errors. Differences in coding practices across hospitals, as well as the absence of clinical detail on the exact method of cannabis exposure, may lead to underreporting or overreporting of cases.<sup>29</sup> NEDS also does not provide data about specific pediatric EDs or the number of hospitals with pediatric inpatient services. Also, we only had data available from April to December 2020, a relatively short time frame. Next, geographic variability in healthcare practices also presents a challenge. As our results indicated, regional differences in admission rates and LOS may be influenced by local healthcare infrastructure and legal frameworks surrounding cannabis use, but NEDS does not provide detailed information on these factors. These variations could introduce bias and make it difficult to generalize findings across regions.<sup>30</sup> Next, unmeasured confounders such as socioeconomic status, family involvement in child protective services, admission to the hospital for child endangerment concerns or other social reasons, or access to specialized care, ED LOS or respiratory status may have influenced the outcomes, but are not captured in the NEDS dataset. Such unmeasured variables could impact both admission rates and the length of stay, introducing potential residual confounding. Another limitation was the decision to combine children ages 0–5 years old into one group. The original age stages referenced from the National Institute of Child Health and Human Development (NICHD) splits ages 0-5 years old into five separate stages.<sup>7</sup> By grouping these together,

**Table 3.** Multivariable negative binomial regression model of hospital length of stay (days), among patients admitted to the hospital of presentation (N=324).

| Variable                        | Incidence Rate Ratio (IRR) | 95% CI     | p      |
|---------------------------------|----------------------------|------------|--------|
| Age Category (Ref: 0-5 years)   |                            |            |        |
| 6-11 years                      | 1.10                       | 0.86, 1.41 | 0.450  |
| 12-18 years                     | 2.08                       | 1.64, 2.65 | <0.001 |
| 19-21 years                     | 2.16                       | 1.68, 2.77 | <0.001 |
| Sex (Ref: Male)                 |                            |            |        |
| Female                          | 0.97                       | 0.81, 1.17 | 0.778  |
| Race and Ethnicity (Ref: White) |                            |            |        |
| Black                           | 0.87                       | 0.69, 1.09 | 0.214  |
| Hispanic                        | 1.18                       | 0.92, 1.53 | 0.199  |
| None of the above               | 0.75                       | 0.52, 1.08 | 0.120  |
| Region (Ref: Northeast)         |                            |            |        |
| Midwest                         | 1.14                       | 0.86, 1.53 | 0.358  |
| South                           | 1.17                       | 0.89, 1.54 | 0.250  |
| West                            | 0.74                       | 0.58, 0.96 | 0.021  |
| Location (Ref: Metropolitan)    |                            |            |        |
| Non-metropolitan                | 0.97                       | 0.75, 1.26 | 0.839  |
| Comorbidities                   |                            |            |        |
| Asthma                          | 0.87                       | 0.62, 1.20 | 0.383  |
| Depression                      | 1.14                       | 0.80, 1.62 | 0.472  |
| Anxiety                         | 0.94                       | 0.68, 1.29 | 0.695  |
| ADHD                            | 0.96                       | 0.64, 1.44 | 0.828  |
| AKI                             | 0.87                       | 0.63, 1.20 | 0.406  |

ADHD, Attention Deficit/Hyperactivity Disorder; AKI, Acute Kidney Injury; CI, Confidence Interval; IRR, Incidence Rate Ratio; LOS, Length Of Stay; Ref., Reference.

associations with one subgroup may have been generalized to the entire age group. The last limitation was the inability to identify whether secondary diagnoses, specifically the comorbidities used, were pre-existing conditions or diagnosed during the ED visit.

## Conclusions

Overall, the findings of this study have important clinical and public health implications. Cannabis is legal in the US for medical use in 36 states and the District of Columbia and legal for recreational use for those over 21 years old in 12 states.<sup>31</sup> It has a wide range of established benefits for analgesic purposes,<sup>32</sup> but varying results in the setting of psychiatric comorbidities.<sup>33</sup> Combined with fluctuating legality and the lack of access for clinical research, physicians are left with a paucity of guidelines for management.<sup>34,35</sup> In this study, younger children were more likely to be admitted to the hospital after cannabis exposure, while older adolescents had longer hospital stays when admitted. These findings underscore the need for standardized, age-specific guidelines for evaluation and safe disposition for pediatric cannabis exposures. The longer LOS among older patients also emphasizes the need for comprehensive care approaches that address not only the physical but also the mental health needs of adolescents with cannabis exposure. Additionally, the regional variations in admission and LOS highlight the need for standardized guidelines to ensure consistent care across different geographic locations. Future studies should explore the pathophysiological and psychological mechanism of higher in-hospital mortality among children in the age range of 0-5 years and greater LOS among children in the age range of 6-11 years.

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