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Unintentional Pediatric Exposures to Marijuana in Colorado, 2009-2015

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IMPORTANCE As of 2015, almost half of US states allow medical marijuana, and 4 states allow recreational marijuana. To our knowledge, the effect of recreational marijuana on the pediatric population has not been evaluated.

OBJECTIVE To compare the incidence of pediatric marijuana exposures evaluated at a children's hospital and regional poison center (RPC) in Colorado before and after recreational marijuana legalization and to compare population rate trends of RPC cases for marijuana exposures with the rest of the United States.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study of hospital admissions and RPC cases between January 1, 2009, and December 31, 2015, at Children's Hospital Colorado, Aurora, a tertiary care children's hospital. Participants included patients 0 to 9 years of age evaluated at the hospital's emergency department, urgent care centers, or inpatient unit and RPC cases from Colorado for single-substance marijuana exposures.

EXPOSURE Marijuana.

MAIN OUTCOMES AND MEASURES Marijuana exposure visits and RPC cases, marijuana source and type, clinical effects, scenarios, disposition, and length of stay.

RESULTS Eighty-one patients were evaluated at the children's hospital, and Colorado's RPC received 163 marijuana exposure cases between January 1, 2009, and December 31, 2015, for children younger than 10 years of age. The median age of children's hospital visits was 2.4 years (IQR, 1.4-3.4); 25 were girls (40%) . The median age of RPC marijuana exposures was 2 years (IQR, 1.3-4.0), and 85 patients were girls (52%). The mean rate of marijuana-related visits to the children's hospital increased from 1.2 per 100 000 population 2 years prior to legalization to 2.3 per 100,000 population 2 years after legalization ($P = .02$). Known marijuana products involved in the exposure included 30 infused edibles (48%). Median length of stay was 11 hours (interquartile range [IQR], 6-19) and 26 hours (IQR, 19-38) for admitted patients. Annual RPC pediatric marijuana cases increased more than 5-fold from 2009 (9) to 2015 (47). Colorado had an average increase in RPC cases of 34% ($P < .001$) per year while the remainder of the United States had an increase of 19% ($P < .001$). For 10 exposure scenarios (9%), the product was not in a child-resistant container; for an additional 40 scenarios (34%), poor child supervision or product storage was reported. Edible products were responsible for 51 exposures (52%).

CONCLUSIONS AND RELEVANCE Colorado RPC cases for pediatric marijuana increased significantly and at a higher rate than the rest of the United States. The number of children's hospital visits and RPC case rates for marijuana exposures increased between the 2 years prior to and the 2 years after legalization. Almost half of the patients seen in the children's hospital in the 2 years after legalization had exposures from recreational marijuana, suggesting that legalization did affect the incidence of exposures.

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Despite the US Federal Schedule I status of marijuana, 4 states and Washington, DC, have passed legislation to legalize recreational marijuana as of 2014.[1,2] Twenty-three states have passed medical marijuana legislation; 4 of these states passed legislation between 2012 and 2014.[2] Colorado allowed medical marijuana in 2000, although the industry did not flourish until 2009, when the US Justice Department did not seek arrest of marijuana users and suppliers if they conformed to state laws, and recreational marijuana became available for purchase in January 2014.[3,4]

Medical and recreational marijuana is available in a variety of products: cigarettes/vaporizers, high-concentrated products, and infused edibles. In Colorado, the percentage of tetrahydrocannabinol (THC) in marijuana available for sale ranges between 19% and 30%, compared with the 3% to 6% of THC in marijuana available for research by the National Institutes of Health.[5,6] Colorado generated $573 million in revenue in the first year of recreational sales, and edible products accounted for 45% of the state's marijuana industry.[7,8]

In 2015, the American Academy of Pediatrics published a policy statement reaffirming its opposition to legalizing marijuana,[9] citing the potential harm to children and adolescents. States that decriminalized medical marijuana have shown an increase in emergency department (ED) visits and regional poison center (RPC) cases for unintentional pediatric marijuana exposures.[10-12] Based on this data, Colorado and Washington became the first states to pass preventive regulations: child-resistant packaging (CRP), warning labels, dose limitations, marketing limitations, and public health educational/media campaigns.[4,13] In Colorado, packaging rules (Rule R 1004.5) became permanent on October 30, 2014, with facilities and stores required to be in compliance by February 1, 2015[4]; Washington packaging rules (WSR 314-55-015) became effective June 20, 2015.[13] The objective of our study was to evaluate the effect of legalization of recreational marijuana on unintentional pediatric exposures.

Key Points

Question What is the effect of recreational marijuana legalization on pediatric marijuana exposures?

Findings This retrospective cohort study evaluating pediatric marijuana exposures at a children's hospital and regional poison center in Colorado before and after recreational legalization demonstrated that marijuana exposure visits and population rates at the children's hospital significantly increased in the 2 years following legalization compared with the 2 years prior to legalization; the regional poison center exposure call average and population rates also significantly increased.

Meaning With an increase in unintentional pediatric exposures after legalization of recreational marijuana in Colorado, continued surveillance is critical, as is evaluating effective preventative measures as more states consider legalization.

Methods

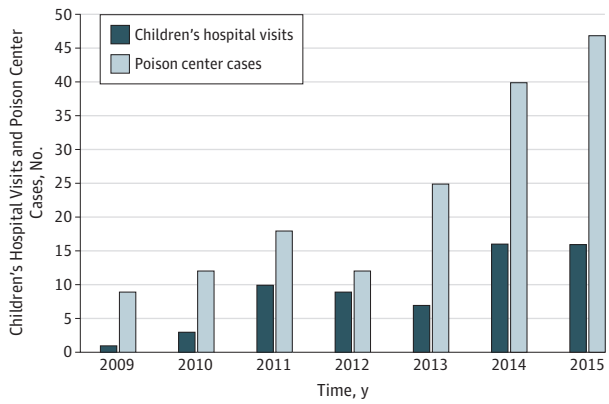
This was a retrospective study of cases presenting to Children's Hospital Colorado, Aurora, and exposure cases called to an RPC in Colorado, a state with medical and recreational marijuana legalization as of January 2014, between January 1, 2009, and December 31, 2015. The hospital is a tertiary care, freestanding children's hospital with an annual ED census of 65 000 visits (120 000 visits including its network of EDs and urgent care centers [UCs]). Children's hospital patient inclusion criteria were patients 0 to 9 years of age who were evaluated at that hospital's ED, UC, or inpatient units (inpatient ward or critical care unit) for a single-substance marijuana exposure. Hospital cases were identified using an electronic medical record search for patients with either a positive urine drug screen (UDS) for THC or an *International Classification of Diseases, Ninth Revision (ICD-9)* code for cannabis abuse (305.20), poisoning for psychodysleptics (969.9), or accidental poisoning by psychodysleptics (E854.1). For hospital admission rates, annual counts for *ICD-9* codes of poisoning by drugs, medicinals, and biological substances (960-979) and accidental poisoning by drugs, medicinal substances, and biologics (E850-E858) were obtained. In October 2015, hospital coding changed to the *ICD-10*. Equivalent *ICD-10* codes were generated from *ICD-9* search criteria: F12 (for 305.20), T40 (969.6), T15-19 (930-939), T36-50 (960-979, E850-858), T51-T65 (980-989, E860-869), and W65-74 and T21.0-21.0 (E910-919). Hospital cases were reviewed by a single investigator (G.S.W.), and variables were abstracted onto a standardized collection form. Hospital variables included age, sex, year of visit, whether history of exposure was available on presentation, exposure to medical or recreational marijuana, source and dose of marijuana if available, product, disposition, ancillary laboratory tests performed, hospital length of stay, and whether a social work consultation was obtained. The Colorado Multiple Institutional Review Board approved the study, granting a waiver of informed consent because the study was retrospective and investigators did not have direct contact with patients.

The RPC receives almost 100 000 human exposure calls annually. Regional poison center cases from Colorado were identified using the marijuana generic code (0083000) for single-agent exposures and closed cases for patients aged 0 to 9 years. Variables included age, sex, year of call, location of call, site of exposure, level of health care facility, exposure reason, route of exposure, caller-documented clinical effects (signs and symptoms), scenario, therapy, disposition, medical outcomes (classified as no, minor, moderate, or major effect as defined by the National Poison Data System), and coding for edible products (available only for 2013-2015).

Descriptive statistics were calculated. Medians with interquartile ranges (IQRs) were reported for continuous outcomes; frequencies and percentages were calculated for categorical outcomes. Generalized linear modeling using a Poisson distribution was used to compare the number of pediatric marijuana cases per population, aged 0 to 9 years, over time for Colorado compared with the rest of the United States. Generalized linear modeling using a Poisson distribution was also used to compare the average proportion of total children's hospital pediatric visits owing to marijuana exposures in the 2 years prior to legalization (2012 and 2013) compared with the 2 years

after legalization (2014 and 2015). A log link was used for this analysis because it constrains predicted values to be greater than 0. Total ED visit rates for ingestions were scaled per 1000 cases in children aged 0 to 9 years. Estimated annual census data for children 0 to 9 years, from 2009 through 2014, were obtained from http://www.census.gov. Estimated census data for 2014 were used for 2015 because 2015 estimates were not available at the time of data analysis. Population rates were also calculated by dividing the total number of pediatric marijuana visits at the children's hospital by the Colorado pediatric population in each year from census data. Population rates were scaled per 100 000 children 0 to 9 years of age. Both rates convey valuable information: the total ED visit rates explain the changes in hospital admission patterns, and population rates describe overall changes. Similarly, total call and census population rates were compared using the poison center data. The *P* value for the change was determined by comparing the regression estimates with the Poisson distribution. All analyses were performed with SAS, version 9.3 (SAS Institute, Inc) and plotting was conducted using R, version 3.2.2 (R Foundation for Statistical Computing).

Figure 1. State Pediatric Marijuana Exposures



Annual children's hospital visits and regional poison center cases for unintentional marijuana exposures in children 9 years or younger in Colorado between 2009 and 2015. Children's hospital visits include emergency department visits, urgent care visits, and inpatient hospital admissions.

Results

Children's Hospital

Eighty-one patients evaluated at the children's hospital had either a positive UDS for THC or *ICD-9* code (or *ICD-10* equivalent) between January 1, 2009, and December 31, 2015. Nineteen patients were eliminated because marijuana exposure was not their primary diagnosis, leaving 62 patients for analysis. The annual numbers of exposures from 2009 to 2015 ranged from 1 visit in 2009 to 16 in 2015 (**Figure 1**). When compared with 2 years prior to legalization, the average marijuana exposure visits (4.3 to 6.4 per 1000 ED visits) and population rates (1.2 to 2.3 per 100 000 population) at the children's hospital increased compared with the 2 years after legalization. ($P = .19$ and $P = .02$, respectively) (**Table**).

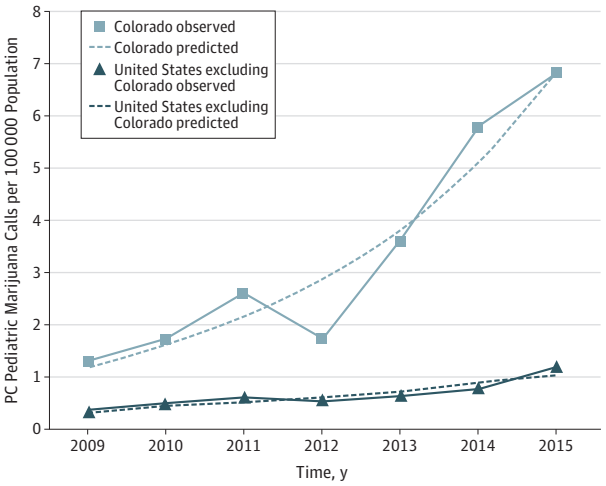
The median age of patients was 2.4 years (IQR, 1.4-3.4); 25 (40%) were girls. Three of the 16 patients in 2012 and 2013 (19%) presented with a history of marijuana exposure; in contrast, 18 of the 32 patients (56%) in 2014 and 2015 had a history of marijuana exposure on presentation. In 2012 and 2013, 11 patients (69%) had medical workups including at least 1 other test performed in addition to a UDS. In 2014 and 2015, 12 of the 32 patients (38%) had either no testing or only a UDS as part of their medical evaluation. Between 2009 and 2015, 21 of 62 exposures (34%) were from medical marijuana; 15 of the 32 exposures (47%) in 2014 and 2015 were from known recreational products. The sources of the marijuana were a parent (27), grandparent (8), neighbor/friend/babysitter (8), and other family member (7). Known marijuana products involved in the exposure included 30 infused edible products (48%): 17 baked goods (cookies, brownies, and cake), 10 candies, and 2 popcorn products. Forty patients (65%) were observed in the ED or UC, and 13 patients (21%) were admitted to an inpatient ward unit. An additional 9 patients (15%) were admitted to the intensive care unit. Two of these required respiratory support: a 3-year-old who was intubated for apnea and an 8-month-old who received continuous positive pressure for respiratory insufficiency. The median length of stay for all patients was 11 hours (IQR, 6-19 hours), including patients observed in the ED; the median length of stay for admitted patients was 26 hours (IQR, 19-38). Forty-nine patients (79%) received a

Table. Marijuana-Related Hospital Visits and Poison Center Cases for Children 9 Years and Younger in the 2 Years Prior to Legalization (2012 and 2013) and 2 Years After Legalization (2014 and 2015)

Rate	Average Rate in 2012-2013 (95% CI)	Average Rate in 2014-2015 (95% CI)	Change From 2 Years Prior to Legalization to 2 Years After Legalization, % (95% CI)	*P* Value for Change
Hospital				
Marijuana visits per 1000 ED visits for ingestions	4.3 (2.6-6.9)	6.4 (4.5-9.0)	50.0 (−17.7 to 173.4)	.19
Marijuana visits per 100 000 population	1.2 (0.7-1.9)	2.3 (1.6-3.3)	100.4 (10.0-265.2)	.02
PC				
Marijuana cases per 1000 PC cases	0.9 (0.7-1.2)	2.3 (1.9-2.8)	156.3 (74.5-276.6)	<.001
Marijuana cases per 100 000 population	2.7 (1.9-3.7)	6.3 (5.1-7.8)	135.6 (60.4-246.1)	<.001

Abbreviations: ED, emergency department; PC, poison center.

Figure 2. Colorado Pediatric Marijuana Exposures vs US Pediatric Exposures



Comparison of unintentional marijuana exposure rates between Colorado and the remainder of the United States excluding Colorado per 100 000 population in children 9 years and younger between 2009 and 2015. The Colorado rate = 100 000 × $e^{-9.5896+0.2902\times time}$ and the United States rate = 100 000 × $e^{-11.4543+0.1732\times time}$, where time is −6 in 2009, −5 in 2010, −4 in 2011, −3 in 2012, −2 in 2013, −1 in 2014, and −0 in 2015. The rate difference was significant (P = .04). PC indicates poison center.

social work consultation. In 2012 and 2013, all 16 patients received a social work consultation, while in 2014 and 2015, 21 patients (66%) received a social work consultation.

Regional Poison Center

Colorado's RPC received 163 marijuana exposure cases between January 1, 2009, and December 31, 2015, for children younger than 10 years of age (Figure 1). The annual number of marijuana exposure cases increased more than 5-fold, from 9 in 2009 to 47 in 2015. Colorado had an mean increase in RPC cases for marijuana exposure of 34% (95% CI, 22%-47%; P < .001) per year, while the remainder of the United States had an average increase in cases of 19% (95% CI, 12%-27%, P < .001). The difference between Colorado compared with the remainder of the United States was significant (P = .04) (**Figure 2**). The RPC's mean marijuana exposure case and population rates significantly increased between the 2 years before (2012-2013) and the 2 years after legalization (2014-2015) (Table).

The median age of RPC marijuana exposures was 2 years (IQR, 1.3-4.0), and 85 patients were girls (52%). Of these exposure cases, 61 (37%) originated from their own residence while 97 (60%) were from a health care facility. The remaining cases were from a school (1 [<1%]), workplace (1 [<1%]), other (1 [<1%]), other residence (1 [<1%]), or unknown location (1 [<1%]). Most exposure sites were in the child's own residence (143 [88%]), followed by school (5 [3%]) and other (15 [9%]). Most exposures were unintentional (135 [83%]), but 2 exposures were intentional (1%), 5 were adverse drug reactions (3%), 4 were other contamination/tampering (3%), and 17 had unknown exposure reasons (10%). Ingestion (121 [74%]) was the most common route of exposure reported, followed by unknown route (19 [12%]), inhalation (18 [11%]), dermal (3 [2%]), and multiple routes of exposure (2 [1%]). Most children were treated at a health care facility (99 [61%]) or referred to a health care facility (38 [23%]); 22 patients (14%) were treated where the call originated (non-health care facility), and 4 (2%) were treated in unknown or other locations. Most children had either no (45 [28%]) or minor effects (75 [46%]). Eighteen children (11%) experienced moderate effects, and 4 (3%) had major effects. An additional 20 children (12%) had minimal effects, effects were not followed, or were unrelated. There was 1 reported death in an 11-month-old. The patient presented to the hospital unresponsive and in a wide complex tachycardia with a severe metabolic acidosis (pH of 6.7). The patient underwent cardiopulmonary resuscitation for 20 minutes without return of spontaneous circulation. Urine drug screen results were positive for THC and confirmed on postmortem analysis. The final diagnosis after autopsy was myocarditis.

Clinical effects reported were drowsiness/lethargy (80 [49%]), ataxia/dizziness (20 [12%]), agitation (13 [8%]), vomiting (8 [5%]), tachycardia (9 [6%]), dystonia/muscle rigidity (4 [2%]), respiratory depression (4 [2%]), bradycardia/hypotension (4 [2%]), and seizures (5 [3%]). Patients could have more than 1 clinical effect. For 17 exposure scenarios (10%), the product was not in a CRP and in an additional 51 scenarios (31%), poor child supervision or product storage were reported. Edible products were attributed to 51 of the 99 exposure cases (52%) from 2013 through 2015 (RPC coding for marijuana food products was initiated in 2013).

Discussion

Colorado's RPC rate of marijuana exposure cases increased by 34% between 2009 and 2015 and was significantly greater than the remainder of the United States. Both the children's hospital visits and the RPC's mean marijuana exposure census population–adjusted rates increased from the 2 years prior to the 2 years after legalization. Fifteen of the 32 exposures seen in the children's hospital in 2014 and 2015 were from recreational marijuana, suggesting that the legalization of recreational marijuana did affect the incidence of pediatric exposures.

These unintentional marijuana exposures represent a small fraction of the total pediatric ingestions and exposures presenting to the ED and RPC cases. In 2014, poison centers reported 1 031 927 exposures in children younger than 6 years.[14] Pharmaceuticals and household products still account for most toddler exposures because they are much more common and available in the household.[14] However, as marijuana becomes more available, exposures may continue to increase. Furthemore, compared with most unintentional pediatric exposures, symptoms after marijuana exposure can be severe: 35% of patients presenting to the hospital required admission, increasing the hospital burden and using more health financial resources. The severity of symptoms and need for medical evaluation seen in this study likely resulted from the combination of the age (toddler), the form (edible), and dose (THC) of marijuana. The reported death from myocarditis in

the 11-month-old child and causality in relationship to the child's positive THC is unclear.

Ingestion of edible products continues to be a major source of marijuana exposures in children and poses a unique problem because no other drug is infused into a palatable and appetizing form. These palatable products are often indistinguishable from the noninfused products. Dosing a drug in a "serving size" less than typically recommended for an equivalent food product also can be a source of confusion. For example, a marijuana chocolate bar can contain multiple 10-mg THC single-dose units. In adults, overconsumption of edible projects is associated with an increase in ED visits resulting from dysphoric reactions, panic attacks, and anxiety.[12] Edibles have also been blamed for 3 adult deaths in Colorado.[15,16]

Colorado, Washington, Oregon, and Alaska passed several regulations to prevent pediatric exposures including CRP. Child-resistant packaging is a proven successful method of exposure prevention and is required by the Poison Prevention Packaging Act for prescription medications, scheduled drugs, and hazardous household chemicals.[17-20] Requiring CRP from the marijuana industry would seem like a logical step in prevention. However, CRP is a deterrent and does not guarantee that a child is unable to open the container and is not a substitute for proper safe storage. Child-resistant packaging only functions when the product is kept in the original packaging and the child-resistant system remains intact with repeated package access. State packaging regulations only apply to purchased products and will not be of any benefit to families who are not educated about proper home storage techniques (eg, up and out of reach/sight) or those who create home products. At the time of the exposure, marijuana products were not in CRP in 9% of exposures, and in an additional 34%, the marijuana products were inappropriately stored (eg, in plain site or left out) or the child was not being supervised. This was not consistently documented by the RPC, so the true number of exposures associated with inappropriate storage or lack of CRP use is unknown. The effectiveness of CRP to prevent unintentional marijuana exposures is unclear because the rate of exposure continued to rise. However, state implementation of this requirement did not become mandatory until 2015. Furthermore, the increased public availability of marijuana products may be the predominant driving factor for the rising number of exposures. As of March 2016, commericialization of marijuana has led to 424 retail marijuana stores, 503 marijuana cultivators, 173 product manufacturers, and 15 testing facilities in Colorado.[21] Other preventive measures may need to be emphasized including public health campaigns, regulations that limit home production, or further evaluation of lower dose limitations in commercial products.[22,23]

Families of patients in Colorado disclosed a history of marijuana exposure on presentation to the hospital more frequently after legalization of recreational marijuana. In 2014 and 2015, 18 patients (56%) presented with a known history of marijuana exposure compared with 3 patients (19%) in 2012 and 2013. This comfort level of disclosure may be owing to the perception that there will be fewer legal and social ramifications because of legalization. The history of marijuana exposure facilitates timely and appropriate care. Without history of exposure or when the diagnosis is unclear, children have received unnecessary laboratory testing, procedures, and radiographic imaging because exposures can mimic other central nervous system depressants.[10] As health care professionals become more familiar with the pediatric marijuana toxidrome, unnecessary expensive diagnostic workups may decrease. In 2014 and 2015, one-third of the patients were treated with observation and less extensive testing.

Social work consultations decreased from 28 exposures (93%) from 2009 through 2013, including every patient in 2012 and 2013, to 21 (66%) in 2014 and 2015. Similar to other unintentional ingestions and exposures of legal products such as pharmaceuticals, ethanol, or household chemicals, there is no standard on reporting marijuana exposures. However, allowing access to high-potency marijuana products can be deemed negligent, similar to allowing access to potentially harmful pharmaceuticals, household products, or ethanol. Whether to report marijuana exposures to social services continues to be a source of debate without consensus among medical professionals, child welfare agencies, law enforcement, and the public. Regardless of the exposure, we would advocate reporting if concerns of neglect, abuse, caregiver impairment, or behavior that would be a risk to the child is noted. Besides unintentional exposures, important issues for the pediatric population that need to be addressed include the risk of prenatal and breast feeding exposures, secondhand marijuana smoke, the effect on adolescent and mental health population, and medicinal uses (eg, pediatric seizures).

Our study has some limitations. This was a retrospective review at a tertiary care hospital and RPC, so our results may not be generalizable to other institutions or states. The abstractor was not blinded to the study question. Both the electronic medical record and RPC data may have had missing information and details about the case including source, product, and details of the clinical case. There also may have been missed patients based on our inclusion and search criteria. Regional poison center data are a self-reporting database and may underestimate the true number of exposures within a population.

Conclusions

There was an increase in unintentional pediatric exposures during the first 2 years after legalization of recreational marijuana in Colorado. Continued surveillance is critical in evaluating the effect marijuana legislation has on the pediatric population. Edible marijuana products continue to be a significant source of pediatric exposures given their attractiveness and palatability to children. Identifying successful preventive strategies requires further investigation. As more states pass laws legalizing recreational marijuana, legislators and health care professionals will need to consider strategies to decrease its effect on the pediatric population.

ARTICLE INFORMATION

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Study concept and design: Wang, Deakyne, Bajaj, Roosevelt.
Acquisition, analysis, or interpretation of data: Wang, Le Lait, Deakyne, Bronstein, Roosevelt.
Drafting of the manuscript: Wang, Roosevelt.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Le Lait, Roosevelt.
Administrative, technical, or material support: Deakyne, Bronstein, Roosevelt.
Study supervision: Wang, Bajaj, Roosevelt.

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