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Cannabis legalization and childhood asthma in the United States: An ecologic analysis

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Abbreviations

MCL: medical cannabis laws
 RCL: recreational cannabis laws
 DID: difference-in-difference
 STS: Secondhand tobacco smoke
 SCS: secondhand cannabis smoke
 NSCH: National Survey on Children's Health
 FPL: federal poverty level
 NH: non-Hispanic
 US: United States

Abstract

Cannabis use is increasing among adults with children in the home particularly in states with cannabis legalization for medical (MCL) and/or recreational use (RCL), relative to states where cannabis use remains illegal at the state level. Exposure to secondhand smoke is a key risk factor for asthma among children. The objective of the current study was to investigate the relationship between MCL and RCL and the state-level prevalence of asthma among children in the United States (US). This ecological study used data from the 2011-2019 National Survey on Children's Health, a representative sample of the population of minor children in the US. Changes in the annual prevalence of pediatric asthma by RCL/MCL over time were estimated using difference-in-difference (DID) analysis. Overall, a statistically significant decrease of 1.1% in the prevalence of pediatric asthma was observed from 2011-2012 to 2018-2019. Adjusting for sociodemographic characteristics, overall reductions in asthma over time were generally greater in states with no RCL or recent MCL, but the rate of decline did not differ statistically by RCL/MCL status. Relative to 2011-2012 and to states where cannabis is illegal at the state level, the prevalence of asthma increased among youth 12-17 years old (2018-2019 DID=2.56, $p=.028$) and youth in some minoritized race/ethnicity identity groups (2016-2017 DID=3.88, $p=.013$ and 2018-2019 DID=4.45, $p=.004$) in states with RCL. More research is needed to estimate the potential consequences of increased adult use of cannabis in the community for children's respiratory health.

Introduction

Affecting approximately 5 million children, asthma is the most common chronic condition affecting children in the United States (US) (CDC, 2019). The national prevalence of pediatric asthma is approximately 7% with state-level prevalence ranging from 7.1% to 11.8% in 2019 and substantial health inequities in asthma by race/ethnicity (Sullivan et al., 2017). Asthma is more common among Black and Hispanic youth, as is uncontrolled asthma which disproportionately affects Black and Hispanic youth in the US (Sullivan et al., 2017; CDC, 2019b; Geier et al., 2019). Black and Hispanic individuals also experience disproportionately greater consequences of asthma-related morbidity in the short-term (e.g., more missed days from school) and the long-term (greater premature mortality) than White individuals (Forno and Celedón, 2012; Guilbert et al., 2019; Lieu et al., 2002). The vast majority of asthma cases can be well-controlled (Global Initiative for Asthma, 2022), and with an effective asthma treatment plan, youth can live symptom-free. Avoidance of asthma triggers is an essential component of an effective asthma treatment plan.

The relationship between secondhand tobacco smoke (STS) exposure and increased asthma exacerbation among youth is well-established (Fagnano et al., 2008; Gerald et al., 2009). Specifically, numerous studies have shown that exposure to STS in the home is associated with greater child asthma symptom frequency, missed school days (Freeman et al., 2003; Gilliland et al., 2003), hospitalizations (Abulhosn et al., 1997; Evans et al., 1987), and use of the emergency department (Teach et al., 2006; Vargas et al., 2007). Due in part to tobacco control efforts, cigarette smoking overall, and specifically in homes with children, has been steadily decreasing over the past several decades (U.S. Department of Health and Human Services, 2014; Goodwin

et al., 2018). In contrast, cannabis use and daily cannabis use have been increasing among adults with minor children in the home and are higher among those who live in states where cannabis is legalized for recreational use and commercialized. A recent study by this group (Goodwin et al., 2021) found that, among US parents with minor children, cannabis use was observed in states with RCL (11.9%), followed by states with MCL (9.5%), with the lowest prevalence seen in states with no cannabis laws (6.1%). In this study, these patterns were consistent across demographic subgroups (e.g., age, gender, race, income, education), with the highest prevalence of cannabis use found among those age 18-25 in states with RCL (19.9%) and who identified as non-Hispanic Black in states with RCL (20.2%).

Alongside increases in cannabis legalization, commercialization and adult cannabis use, it is conceivable that exposure to secondhand cannabis smoke (SCS) may be increasing. There are already concerns about the effects of SCS on the health of young children in homes where cannabis is smoked (McKee et al., 2018; Wilson, 2016). Preliminary preclinical and laboratory findings suggest that cannabis smoke contains chemicals similar to those in STS (Chatkin et al., 2019; Holitzki et al., 2017; McKee et al., 2018; Wilson, 2016), and exposure to SCS may, in fact, be even more harmful than STS because the concentration levels of some toxic chemicals are higher in SCS than STS (Huber et al., 1991; Moir et al., 2008).

Increased adult cannabis use across the US may inadvertently impact asthma among youth. In the context of rapidly increasing legalization of adult (21 and older) use and commercialization in the US, an evidence base is urgently needed to inform legislators, policy makers clinicians and the public on the potential health impact of increasing SCS exposure among children. Yet, in

contrast to STS, no clinical nor public education regarding child exposure to SCS is available or routinely offered to parents. This may be due in part to lack of evidence base as well as lack of pediatrician comfort with and training in inquiring about substance use among parents regardless of legal status.

Ecological studies offer a critical first step in identifying key public health issues as they emerge in real world settings. This ecological study will facilitate the estimation of the potential impact of cannabis legalization (and widespread increase in cannabis use) on childhood asthma. First, the study estimated the overall prevalence of pediatric asthma in the US from 2011 to 2019. Second, the study investigated trends in pediatric asthma by state cannabis policy overall and by age, gender, and race/ethnicity.

METHODS

Data and Population

The National Survey on Children's Health (NSCH) provides data on the physical and mental health of non-institutionalized children in the US ages 0-17 years old. An earlier version of the NSCH was conducted three times (in 2003, 2007, and 2011/2012) using a telephone-based methodology. A revised mail and web-based version of the survey was conducted in 2016, 2017, 2018 and 2019. Survey data is weighted to be representative of the US population of non-institutionalized children. The survey response rate for interview completion were 47.7% in 2011-2012, 70.3% in 2016-2017 and 78.8% in 2018/2019. NSCH data was used to compute state-level prevalence of caregiver-reported pediatric asthma. Estimates were computed for years

2011-2012, 2016-2017 and 2018-2019, as these were the periods during which each wave of data was collected.

Measures

Pediatric asthma

The following question was used in 2011/2012: “Has a doctor or other health care provider ever told you that this child had asthma even if [X] does not have the condition now” and, if yes, “does this child CURRENTLY have the condition?” From 2016-2019, the question was “Has a doctor or other health care provider ever told you that this child had asthma even if [X] does not have the condition now”, if yes, “does [child] currently have asthma?”

Cannabis legalization

Cannabis legalization was defined by the adoption of MCL or RCL (See Diagram 1). Adoption of MCL was defined as the year the medical marijuana law became effective in a state (i.e. patients have legal protection to possess cannabis for medicinal purposes; (RAND-USC Schaeffer Opioid Policy Tools). Adoption of RCL was defined as the year recreational marijuana law became effective in a state (i.e. adults 21+ years old have legal protection to possess and use cannabis for recreational purposes). “RCL” states were defined as states that had MCL and adopted RCL between 2011-2018 (11 states: AK, CA, CO, DC, MA, ME, MI, NV, OR, VT, WA). “Recent MCL” states were defined as states that adopted MCL between 2011-2018 and did not adopt RCL by 2018 (14 states: AR, CT, DE, FL, IL, MN, MO, ND, NH, NY, OH, OK, PA, UT). “Established MCL” states were defined as states that had MCL before 2011 and did not adopt RCL by 2018 (7 states: AZ, HI, MD, MT, NJ, NM, RI). “No cannabis

legalization ” states were defined as state with no MCL or RCL by 2018 (19 states: AL, GA, IA, ID, IN, KS, KY, LA, MS, NC, NE, SC, SD, TN, TX, VA, WI, WV, WY). MCL status was separated into two groups based on time of adoption (pre-2011 vs. post-2011) due to previously reported heterogeneity observed among state MCLs (Williams et al., 2016).

Sociodemographic characteristics

Sociodemographic characteristics included child age (0-5, 6-11, 12-17), gender (male, female), race/ethnicity (Non-Hispanic (NH) White, NH Black, Hispanic, NH Other which consisted of NH minoritized race/ethnicity groups the numbers of which were too small here to examine separately including mixed race/ethnicity, Asian/Pacific Islander, and American Indian/Alaskan Native), poverty level (0-99% income below federal poverty level (FPL), 100-199% FPL, 200-399% FPL, 400% or more FPL), and insurance coverage (insured, not insured). There was no substantial difference in sociodemographic characteristics across time points, except for an increase in proportion of those with 400% or more FPL (Supplemental Table 2).

Analyses

First, weighted estimates of pediatric asthma prevalence were computed by RCL/MCL status (RCL, recent MCL, and established MCL, no cannabis legalization) in the total sample and stratified by sociodemographic characteristics (i.e., age, gender, race/ethnicity, poverty level, insurance coverage). Second, trends in pediatric asthma prevalence within RCL/MCL status were compared (2011-2012 vs. 2016-2017, 2011-2012 vs. 2018-2019 and 2016-2017 vs. 2018-2019) using paired t-tests. Third, difference-in-difference (DID) models were used to compare the magnitude of the change in pediatric asthma from 2011-2012 to 2018-2019 in states that

passed RCL/MCL compared with states without legalization overall and by sociodemographic characteristics (i.e., age, gender, race/ethnicity). Models included time indicator for year (2011-2012, 2016-2017, 2018-2019), law status (RCL, recent MCL, established MCL, no cannabis legalization during the study period) and their interaction. All analyses were conducted using SAS (Version 9.4). P-values <0.05 were considered statistically significant.

RESULTS

Sample

The analytic sample consisted of n=227,451 US children age 0-17 years old. The mean age was 8.56 (standard deviation (SD)=0.24), 50.9% of children were male, and 59.6% of the children identified as NH White (Hispanic, 16.7%, NH Black 12.3%, additional minoritized race/ethnicity groups, 11.3%). A substantial minority of children lived in a household with income below 100% FPL (19.7%) and without insurance coverage (7.3%).

Overall prevalence of pediatric asthma, 2011-2019

Overall, in the US, the prevalence of pediatric asthma was 8.9% in 2011-2012, 8.0% in 2016-2017 and 7.8% in 2018-2019. The prevalence of pediatric asthma decreased significantly between 2011-2012 and 2016-2017 (-0.94, $p<.05$) and remained stable thereafter (-0.18, $p>.05$).

Trends in prevalence of pediatric asthma by MCL/RCL status, 2011-2019

Relative to 2011-2012, pediatric asthma prevalence decreased significantly ($p<.05$) in states with recent MCL (-1.07 and -1.41 in 2016-2017 and 2018-2019, respectively) and states with without cannabis legalization (-1.14 and -1.55). Reductions were slight ($p>.05$) in states with established MCL (-.64 and -.66) and states with RCL (-.60 and -.28). Notably, in RCL states, pediatric

asthma prevalence increased between 2016-2017 and 2018-2019 (+.32). Overall, while reductions were generally greater in states without cannabis legalization or recent MCL, the rate of reductions were not statistically different by RCL/MCL status (Table 1, Figure 1 and Supplemental Table 1).

Trends in prevalence of pediatric asthma by MCL/RCL status, 2011-2019 by sociodemographics

Age

Among youth ages 0-5, relative to 2011-2012, pediatric asthma prevalence decreased significantly ($p<.05$) in states with RCL (-1.80 in 2016-2017), recent MCL (-1.95 and -2.33 in 2016-2017 and 2018-2019, respectively) and states without cannabis legalization (-2.03 in 2018-2019). Among youth ages 6-11, reductions were significant in states with recent MCL (-1.84 in 2018-2019) and states without cannabis legalization (-1.99 in 2018-2019). In these age groups while reductions in the prevalence of pediatric asthma were generally greater in states without cannabis legalization or MCL compared to states with RCL, the rate of reductions were not statistically different between the states with different RCL/MCL status.

Among youth ages 12-17, the prevalence of asthma increased in states with cannabis legalization, particularly in states with RCL and during recent time periods (+1.86 between 2016-2017 and 2018-2019). This increase in asthma in RCL states was statistically significantly greater compared with states without legalization (DID=2.56, $p=.028$; see Table 1, Figure 2).

Sex

Relative to 2011-2012, reductions in pediatric asthma prevalence were significant ($p < .05$) among females and males in states with recent MCL (males -1.62 and females -1.12 in 2018-2019), established MCL (males -1.43 in 2016-2017) and states without cannabis legalization (males -1.03 and -2.14 in 2016-2017 and 2018-2019, respectively; females -1.23 in 2016-2017, see Table 1). Reductions were small ($p > .05$) in states with RCL (males -.50 and -.51 in 2016-2017 and 2018-2019, respectively; females -.65 and -.08), however, the prevalence of pediatric asthma increased among females between 2016-2017 and 2018-2019 (+.57). Overall, while reductions in the prevalence of pediatric asthma were generally greater in states without cannabis legalization or MCL compared to states with RCL, the rate of reductions were not statistically different between the states with different RCL/MCL status (see Table 1, Figure 3).

Race/ethnicity

Among youth ages 0-5, relative to 2011-2012, pediatric asthma prevalence decreased significantly ($p < .05$) in states with RCL (-1.80 in 2016-2017), recent MCL (-1.95 and -2.33 in 2016-2017 and 2018-2019, respectively) and states without cannabis legalization (-2.03 in 2018-2019). Among youth ages 6-11, reductions were significant in states with recent MCL (-1.84 in 2018-2019) and states without cannabis legalization (-1.99 in 2018-2019). In these age groups while reductions in the prevalence of pediatric asthma were generally greater in states without cannabis legalization or MCL compared to states with RCL, the rate of reductions were not statistically different between the states with different RCL/MCL status.

Relative to 2011-2012, reductions in pediatric asthma prevalence were significant ($p < .05$) among NH White in states with recent MCL (-1.14 and -2.04 in 2016-2017 and 2018-2019, respectively)

and states without cannabis legalization (-1.05 in 2016-2017). Reductions were significant among NH Black in states without cannabis legalization (-3.71 in 2018-2019) and NH other minoritized racial/ethnic groups in states with recent MCL (-3.54 in 2016-2017) and states without cannabis legalization (-3.74 and -4.83 in 2016-2017 and 2018-2019, respectively). Among Hispanic youth, asthma prevalence increased slightly ($p>.05$) relative to 2011-2012 in all state groups. Relative to 2016-2017, pediatric asthma prevalence increased slightly ($p>.05$) among all racial/ethnic groups in states with RCL (+1.13, +.45, +.36 and +.08 among Hispanic, NH White, NH Black and other minoritized racial/ethnic groups, respectively). This trend was also observed among NH Black and other minoritized race/ethnicity group-identifying youth in states with recent MCL (+1.71 and +.42) and among NH White and Black youth in states with established MCL (+.57 and +6.00). Overall, increases in pediatric asthma were significantly greater among the NH other minoritized race/ethnic group-identifying youth in states with RCL and established MCL, relative to states without legalization (DID=3.88, $p=.013$ and DID=4.45, $p=.004$; see Table 1, Figure 4).

DISCUSSION

The goal of this paper was to examine whether legalization of cannabis for adult use was associated with child asthma indicators at the state-level in the US. Our findings suggest that, in recent years (i.e., 2018-2019, relative to 2016-2017), the overall prevalence of pediatric asthma is no longer declining in the US. In terms of trends by state-level RCL and MCL, declines in pediatric asthma observed in states with no MCL/RCL or states with MCL adopted after 2011 appeared more rapid on visual inspection, compared with states with RCL adoption and states that adopted MCL prior to 2011 though these differences were not statistically different by RCL/MCL status. In fact, increases in pediatric asthma were observed in states with RCL in recent years. Increases were observed in states with RCL relative to states without legalization. In addition, relative to 2011-2012 and to states where cannabis remained illegal at the state level, in RCL states, asthma prevalence increased among older children (ages 12-17), and among youth in some minoritized race/ethnicity identity groups. In sum, our results provide preliminary evidence suggesting that legalization of adult cannabis use may be related to increasing asthma prevalence, especially among older youth and those who identify as members of some minoritized race/ethnicity groups, at the state-level.

Little is known about the risks associated with exposure to SCS and asthma, though there has been a call for more research on the impact of cannabis legalization on children and adolescents and a number of studies have documented possible consequences in terms of accidental ingestion (Wang, 2017). Preclinical and laboratory research suggest that cannabis smoke contains similar chemicals to tobacco smoke, that individuals exposed to SCS show metabolites of smoke in their systems and report subjective effects of exposure (e.g., reporting feeling “high” or greater drug effects), and that SCS has negative physiologic (e.g., cardiovascular, respiratory) and cognitive

effects on exposed individuals (Chatkin et al., 2019; Holitzki et al., 2017; McKee et al., 2018; Wilson, 2016). Yet, to our knowledge, this study is the first to examine the relationship between changes in cannabis policy and children's asthma.

Tremendous progress has been made in asthma management in concert with tobacco control over the past several decades. The possibility that increased adult cannabis use may pose new risks, despite this progress, requires more in-depth study. Results of the current ecological study can provide some initial signals on where to focus our efforts. For example, it is plausible that increases in use of cannabis among adults living with minor children, which have been documented in states with RCL relative to those without RCL (Goodwin et al., 2021), may lead to increased exposure to SCS which, in turn, will exacerbate asthma. Given the cross-sectional nature of these data, it is not possible to determine a sequential or cause-and-effect relationship. As such, use of longitudinal data toward obtaining new information about the potential impact of cannabis legalization and commercialization on adolescents' respiratory health is needed.

In addition, it is not known why increases in the prevalence of asthma in RCL states appear more prominent among youth from certain racial/ethnic groups. Prior work examining trends among adults residing with a minor child by state-level MCL/RCL legal status showed that the prevalence of past-month cannabis use was higher among NH Black versus NH White parents (8.3%, 12.8%, 20.2% of NH Black parents versus 6.3%, 9.9%, and 15.6% of NH White parents in states with no cannabis laws, with MCLs, and with RCLs, respectively) and lower among Hispanic (3.92%, 7.0%, 8.4% of Hispanic parents in states with no cannabis laws, with MCLs, and with RCLs, respectively) versus NH White parents though the speed with which cannabis use increased did not differ between these groups (Goodwin et al., 2021). The greatest increase

in pediatric asthma overall in states with RCL was among Hispanic youth. The next steps in untangling this finding should include looking at exposure among specific groups of Hispanic youth (e.g., Puerto Rican youth), as there are pronounced differences in asthma prevalence among different subgroups of youth who self-identify as Hispanic (Lara et al., 2006; Pate et al., 2021). In addition, the “other” race/ethnic group was a heterogeneous group consisting of a range of races and ethnicities. The groups within the “other” race/ethnicity group have been shown to vary in tobacco use behaviors (Mattingly et al., 2020); future research with more refined detail on race/ethnicity should investigate variations in asthma, cannabis exposure, and cannabis laws. Together, this information could be useful in understanding differences in asthma prevalence, as well as allowing culturally appropriate, community-oriented approaches within prevention programs. Acquisition of new knowledge is needed to develop an evidence base that can inform appropriate education and prevention strategies aimed at protecting youth health while avoiding criminalizing use among adults.

There are a number of limitations related to an ecological design. The findings here do not establish a direct link between cannabis policy status and pediatric asthma, as the use of state-level data prohibits a conclusion of this nature. Rather, the current study provides a first step in identifying a population-level link between cannabis policy and pediatric asthma at the state-level. This relationship merits further investigation of cannabis use among parents (as well as other adults, youth, and peers), SCS, childhood asthma, and in the context of continually changing cannabis policies in the US and other countries. It should be noted that cannabis legalization was defined based on when states adopted cannabis-related laws though how and when the laws were implemented (e.g., when sales began) may have differed across states. In addition, future studies that control for secondhand tobacco smoke, which is a key confounder

that we could not examine in this investigation, are needed. There are a number of other factors potentially related to childhood asthma and cannabis that should also be examined in future research such as child cannabis use and peer-to-peer SCS exposure, factors that might help to understand differences found for older versus younger children, as well as black-market sources of cannabis. The current study included state-level RCL/MCL laws through 2019. Yet, there are additional limitations to the exclusive reliance on state-level legislation in terms of drawing conclusions about the impact of policy on the population. These include differences between and within states on features of cannabis regulation and enforcement of those regulations. In this state-level ecological study, these cannot be examined, but are recommended next steps in understanding the possible linkages observed here. In addition, cannabis products and modes of use are becoming increasingly diversified (Gunn et al., 2020; Hammond et al., 2020) and may have differential relationships to child asthma (e.g., smoking cannabis joints versus using vaping cannabis). Finally, NSCH survey methodology changed substantially from telephone-based surveys in 2011-2012 to mail and web-based surveys in 2016 and thereafter, raising concerns about comparability of estimates over time. However, despite this change and related differences in survey response rates, NSCH estimates are consistent with the National Health Interview Survey estimates for pediatric current asthma in the years reported in this paper (CDC 2022).

Critical next steps in this line of research include examining whether SCS is associated with increases in asthma morbidity, such as symptom frequency, use of rescue medicines, impairment (e.g., missed school), and emergency medical services, to provide insight into the extent to which increased exposure to SCS is affecting youth health and functioning across domains.

Conclusion

Increases in asthma prevalence were found among adolescents and youth in some minoritized racial/ethnic groups in states that have legalized cannabis for recreational use. This suggests that rapid changes in state-level cannabis policy could have downstream effects for children's asthma. A better understanding of the potential impact of changes in state-level cannabis policy and increased adult use of cannabis in the community, on children and adolescent health overall and especially among those with asthma, is urgently needed to reduce potential harms for children's health.

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(NOTE: Colors should be used in print)

Figure 1. Trends in the prevalence of current pediatric asthma 2011 to 2019 by state-level cannabis policy, National Survey on Children's Health

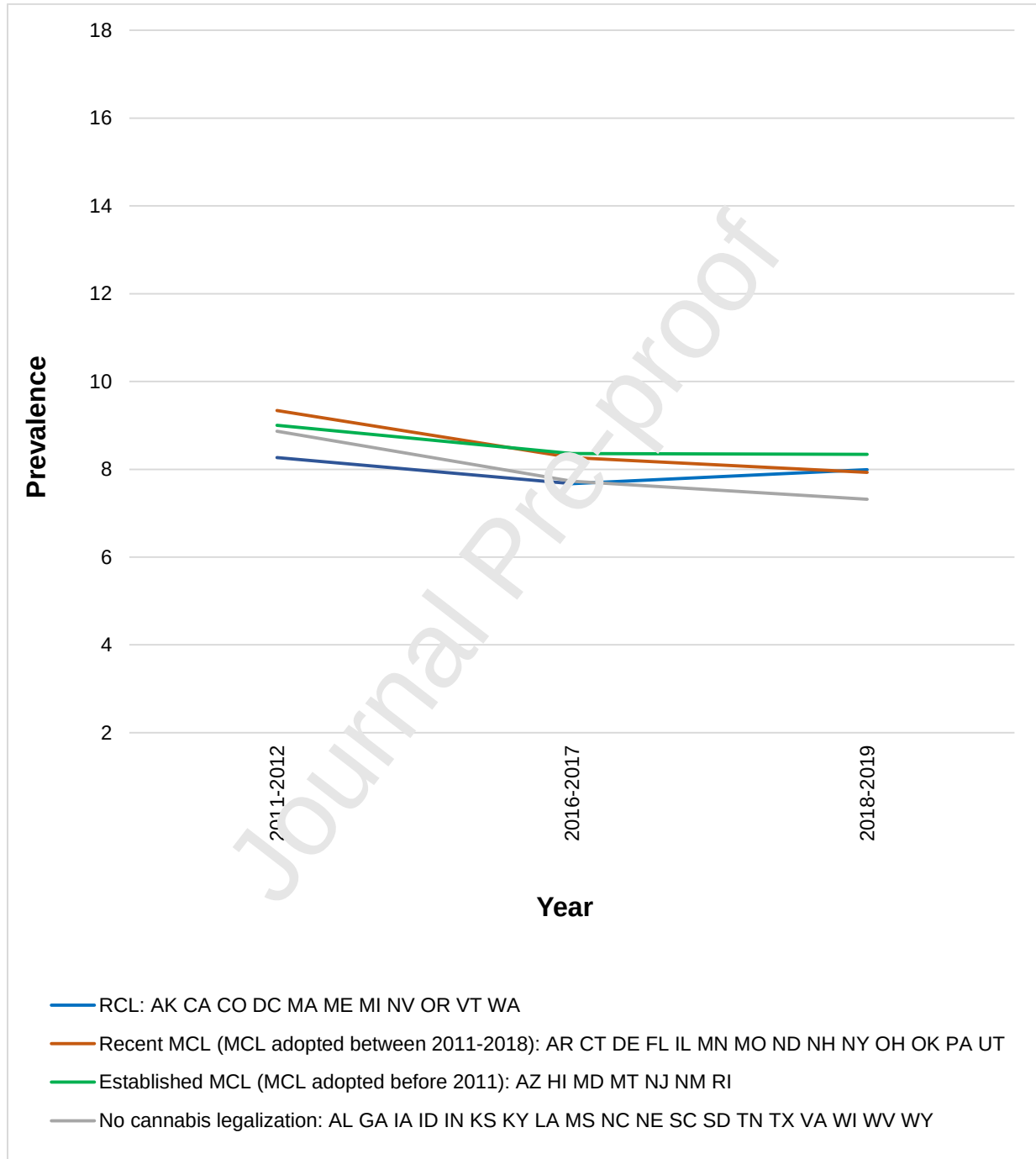


Figure 2. Trends in the prevalence of current pediatric asthma 2011 to 2019 by state-level cannabis policy and age, National Survey on Children's Health

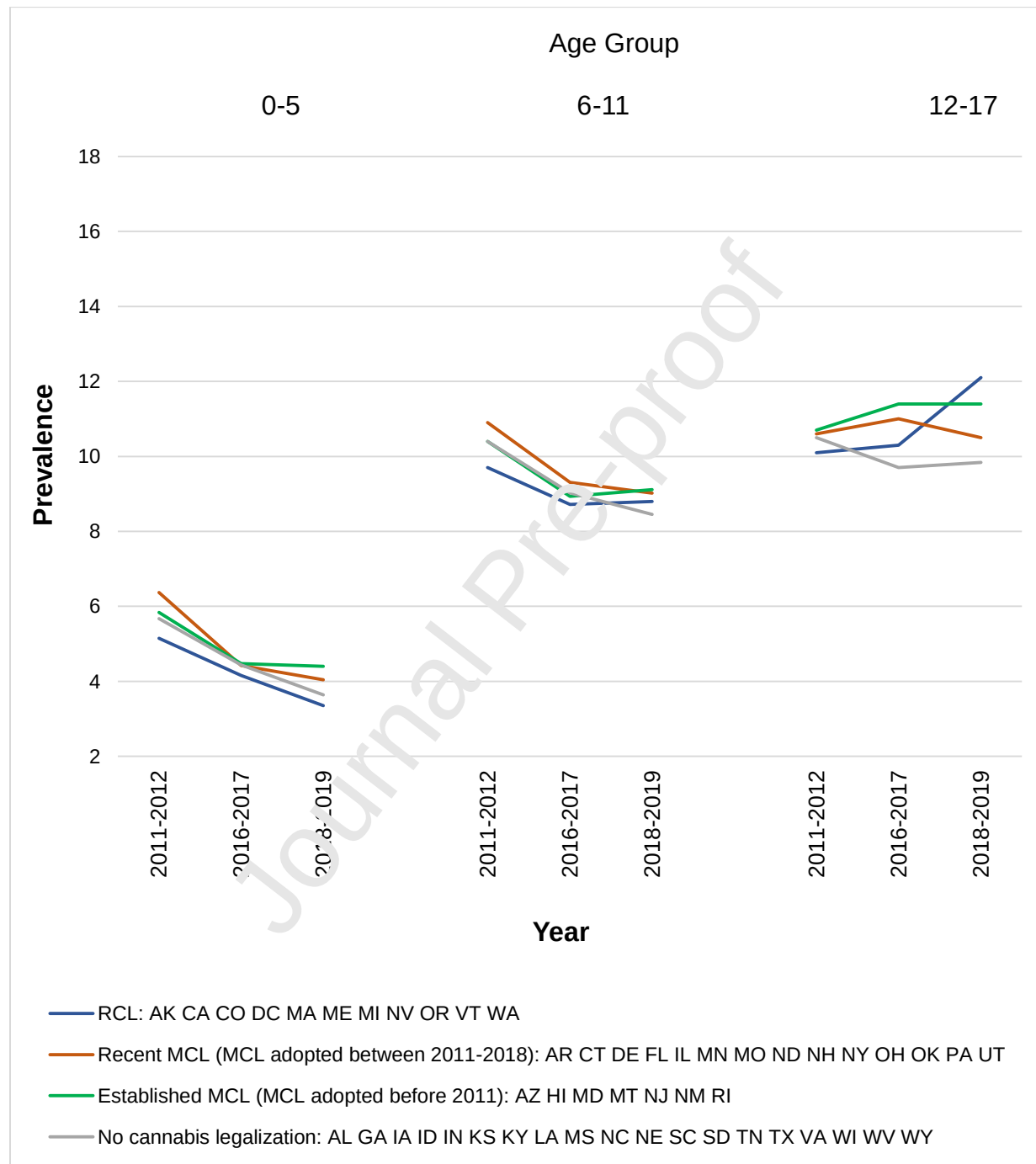


Figure 3. Trends in the prevalence of current pediatric asthma 2011 to 2019 by state-level cannabis policy and sex, National Survey on Children's Health

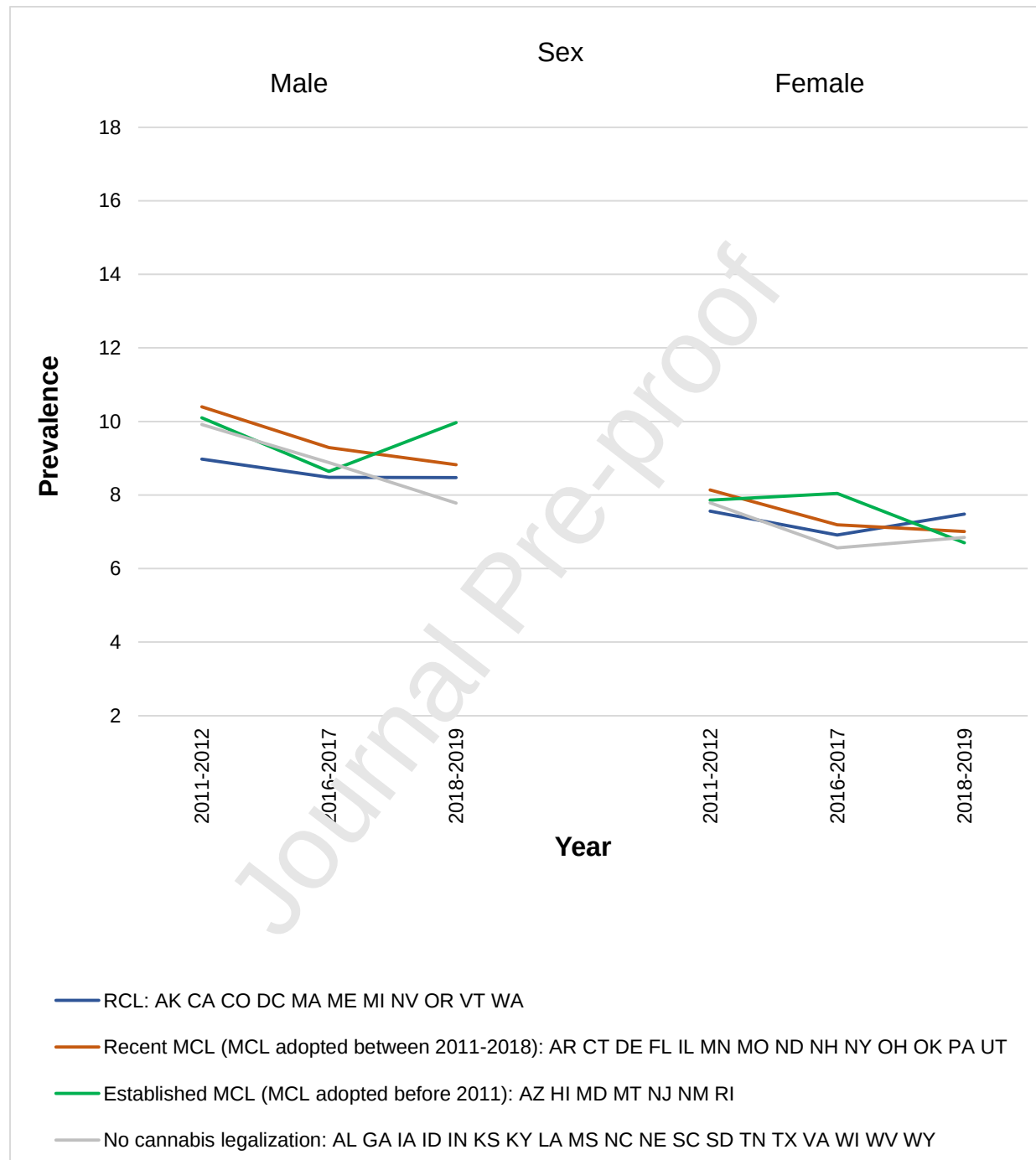


Figure 4. Trends in the prevalence of pediatric current asthma 2011-2019 by state-level cannabis policy and race/ethnicity, National Survey on Children's Health

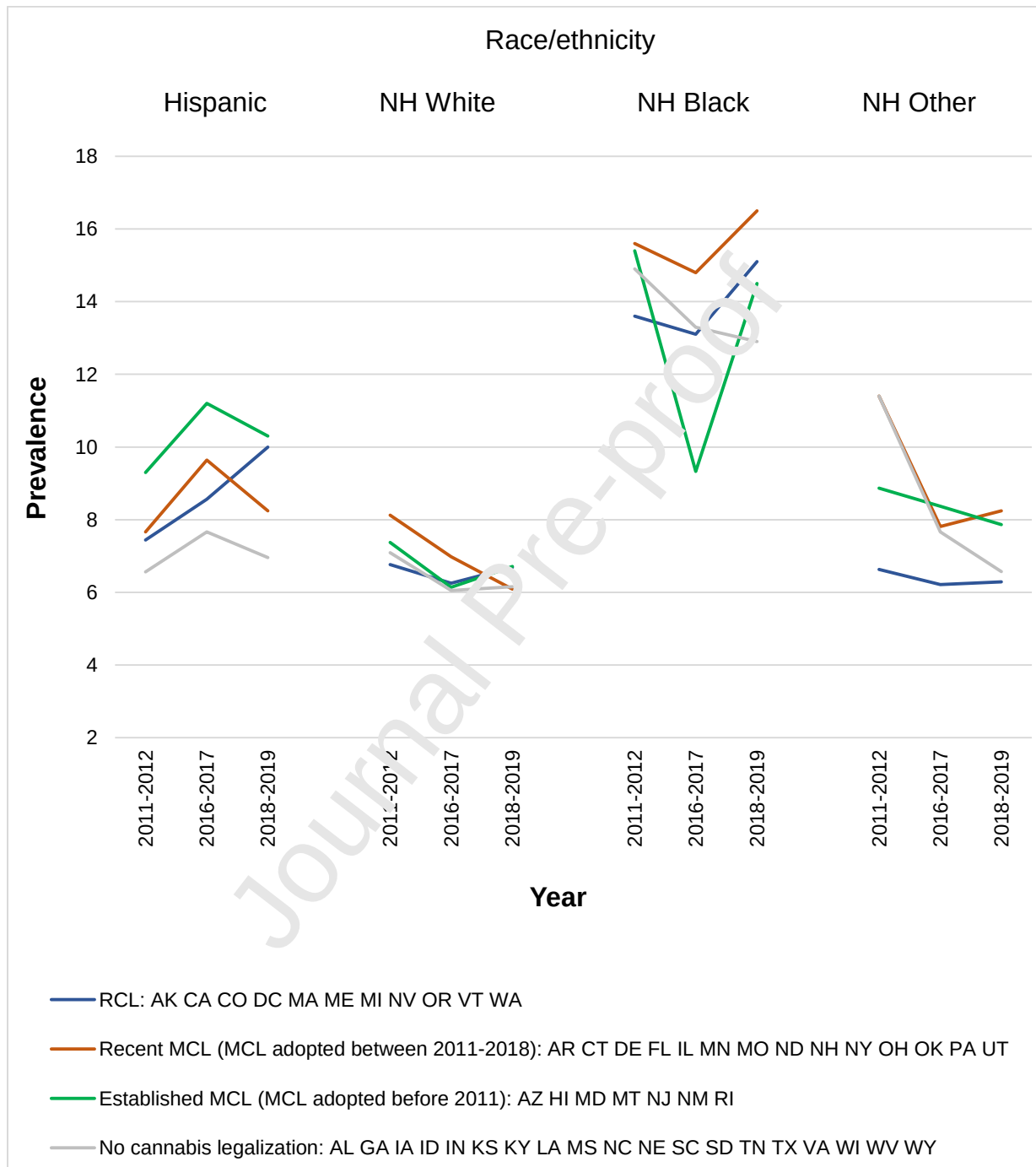


Diagram 1. Adoption of MCL and RCL by state (as of December 31, 2018).

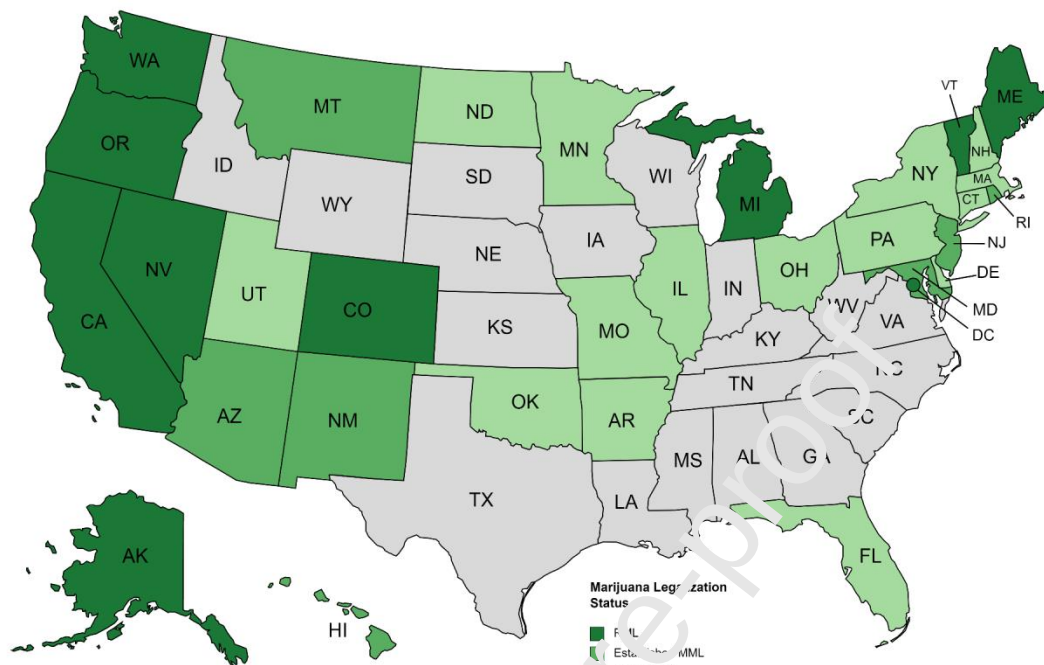


Table 1. Change in pediatric asthma prevalence over time by MCL/RCL status overall and by sociodemographic subgroups

		RCL		Recent MCL		Established MCL		No cannabis legalization	
		2016-2017	2018-2019	2016-2017	2018-2019	2016-2017	2016-2017	2016-2017	2018-2019
	Overall								
Change in prevalence relative to 2011-2012		-0.60	-0.28	-1.07*	-1.41*	-0.64	-0.66	-1.14*	-1.55*
relative to 2016-2017		--	0.32	--	-0.34	--	-0.02	--	-0.41
DID estimate		1.12 (-0.38, 2.61)	1.31 (-0.17, 2.80)	0.42 (-0.96, 1.81)	0.01 (-1.37, 1.4)	0.97 (-0.86, 2.61)	0.84 (-0.88, 2.57)	--	--
	Age Group								
Change in prevalence relative to 2011-2012	0-5	-0.99	-1.80*	-1.95*	-2.33*	-1.37	-1.44	-1.23	-2.03*
	6-11	-0.98	-0.9	-1.54	-1.84*	-1.47	-1.29	-1.41	-1.99*
	12-17	0.13	1.99	0.32	-0.15	0.63	0.64	-0.76	-0.62
relative to 2016-2017	0-5	--	-0.81	--	-0.32	--	-0.07	--	-0.81
	6-11	--	0.08	--	-0.29	--	0.19	--	-0.58
	12-17	--	1.86*	--	-0.48	--	0.01	--	0.14
DID estimate	0-5	0.52 (-1.16, 2.21)	0.25 (-1.43, 1.94)	-0.65 (-2.21, 0.91)	-0.33 (-1.90, 1.24)	0.18 (-1.79, 2.15)	0.65 (-1.31, 2.61)	--	--
	6-11	0.84 (-1.76, 3.45)	1.13 (-1.77, 3.94)	-0.03 (-2.44, 2.39)	0.11 (-2.31, 2.53)	0.29 (-2.75, 3.33)	0.85 (-2.18, 3.87)	--	--
	12-17	1.27 (-1.01, 3.55)	2.56 (0.28, 4.83)	1.28 (-0.83, 3.39)	0.31 (-1.81, 2.42)	1.88 (-0.78, 4.54)	1.18 (-1.47, 3.83)	--	--
	Sex								
Change in prevalence relative to 2011-2012	Male	-0.50	-0.51	-1.16	-1.62*	-1.43*	-0.10	-1.03*	-2.14*
	Female	0.65	-0.08	-0.94	-1.12*	0.19	-1.16	-1.23*	-0.94
relative to 2016-2017	Male	--	-0.01	--	-0.46	--	1.33	--	-1.10
	Female	--	0.57	--	-0.18	--	-1.34	--	0.29
DID estimate	Male	1.06 (-0.99, 3.12)	1.78 (-0.27, 3.82)	0.07 (-1.83, 1.98)	0.5 (-1.40, 2.40)	-0.12 (-2.52, 2.28)	2.07 (-0.31, 4.46)	--	--
	Female	1.19 (-0.39, 2.77)	1.06 (-0.51, 2.62)	0.54 (-0.92, 2.00)	-0.16 (-1.61, 1.29)	1.80 (-0.03, 3.64)	-0.23 (-2.05, 1.60)	--	--
	Race/ethnicity								
Change in prevalence relative to 2011-2012	Hispanic NH	1.44	2.56	1.98	0.59	1.94	0.96	1.09	0.39
	White NH	-0.52	0.07	-1.14*	-2.04*	-1.23	-0.66	-1.05*	-0.95
	Black**	-2.13	-1.08	-1.19	0.52	-5.37	-1.95	-3.74	-3.71*

relative to 2016-2017	NH Other	-0.42	-0.34	-3.54*	-3.12	-0.50	-1.01	-3.74*	-4.83*
	Hispanic	--	1.13	--	-1.39	--	-0.99	--	-0.70
	NH White	--	0.45	--	-0.89	--	0.57	--	0.10
	NH Black**	--	0.30	--	1.71	--	6.00	--	0.06
	NH other	--	0.08	--	0.42	--	-0.51	--	-1.09
DID estimate	Hispanic	0.13 (-3.78, 4.05)	2.18 (-1.72, 6.08)	0.97 (-2.66, 4.60)	0.18 (-3.45, 3.80)	1.3 (-3.25, 5.85)	0.29 (-4.24, 4.82)	--	--
	NH White	1.02 (-0.54, 2.59)	0.98 (-0.58, 2.55)	0.35 (-1.10, 1.81)	-1.19 (-2.65, 0.26)	-0.2 (-2.03, 1.62)	0.11 (-1.71, 1.92)	--	--
	NH Black**	1.21 (-5.75, 8.17)	2.48 (-5.10, 10.06)	1.17 (-4.99, 7.34)	2.52 (-3.74, 8.77)	-2.6 (-11.73, 6.06)	1.65 (-6.70, 10.01)	--	--
		3.88 (0.81, 6.95)	4.45 (1.39, 7.50)	0.73 (-2.12, 3.57)	1.45 (-1.41, 4.29)	3.64 (0.07, 7.21)	3.50 (-0.06, 7.05)	--	--
	NH Other							--	--

Abbreviation: DID, difference-in-difference; FPL, federal poverty line; MCL, medical cannabis legalization; NH, non-Hispanic; RCL, recreational cannabis legalization

NH Other included individuals who identified as mixed race/ethnicity, Asian/Pacific Islander, and American Indian/Alaskan Native

*=statistically significant (paired t-tests), bolded DID estimates are significant at $p < .05$; DID estimates are relative to 2011-2012 and states with no MCL/RCL

**Pediatric asthma estimates for NH Black children were unavailable in the following states in 2016-2017: AK, AZ, HI, ID, IA, ME, MT, NH, NM, ND, OR, SD, UT, VR, WV, WY; and in 2018-2019: AK, CO, HI, ID, IA, ME, MT, NE, NH, NM, ND, OR, SD, UT, VR, WA, WV, WI, WY

State group:

RCL: AK, CA, CO, DC, MA, ME, MI, NV, OR, VT, WA

Recent MCL (MCL adopted between 2011-2018): AR, CT, DE, FL, IL, MN, MO, ND, NH, NY, OH, OK, PA, UT

Established MCL (MCL adopted before 2011): AZ, HI, MD, MT, NJ, NM, RI

No cannabis legalization: AL, GA, IA, ID, IN, KS, KY, LA, MS, NC, NE, SC, SD, TN, TX, VA, WI, WV, WY

CRedit author statement

Renee D. Goodwin conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. Katarzyna Wyka designed and supervised analyses, and revised the manuscript. Man Luo carried out the analyses. Andrea H. Weinberger drafted and revised the Results section and critically reviewed the manuscript for important intellectual content, Meyer Kattan critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Highlights

- Childhood asthma prevalence was stable from 2017-19 after declining from 2011-17
- Childhood asthma is more common in recreational cannabis legal (RCL) states
- Childhood asthma declined more rapidly among children in states without RCL
- Asthma increased among youth of minoritized race/ethnicity identity in RCL states
- Childhood asthma increased among adolescents in RCL states