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ORIGINAL ARTICLE

Home cannabis cultivation in the United States and differences by state-level policy, 2019-2020

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ABSTRACT

Background: As of 2022, all but two U.S. states with adult-use cannabis laws also allow home cultivation. Home cultivation has the potential to support or oppose public health measures, and research in U.S. states is nascent.

Objectives: 1) estimate the percentage of respondents who reported growing cannabis plants; 2) estimate the average number of plants grown; 3) examine the association between home cultivation, jurisdiction, and individual-level factors; and 4) examine the association between home cultivation and state-level policies in adult-use states.

Methods: Repeat cross-sectional survey data come from U.S. respondents aged 21–65 in 2019 and 2020. Respondents were recruited through online commercial panels. Home cultivation rates were estimated among all U.S. respondents (n = 51,503; 46–52% male). Additional analyses were conducted on a sub-sample of respondents in states that allowed adult-use home cultivation (n = 29,100; 50% male).

Results: A total of 6.8% and 7.3% of U.S. respondents reported home cultivation in 2019 and 2020, respectively. Respondents in states that allowed adult-use home cultivation had higher odds of reporting home cultivation than respondents in states without medical or adult-use cannabis laws (AOR = 1.48, 95% 1.26, 1.75). Among respondents in states that allowed adult-use home cultivation, the median number of plants that respondents reported growing was below state cultivation limits.

Conclusion: Home cultivation rates in the U.S. were higher in states that allowed adult-use home cultivation; however, other evidence suggests these same states had higher rates predating adult-use legalization. Further work is needed to examine how home cultivation relates to public health measures in adult-use states.

Introduction

Cannabis regulations vary across the United States (U.S.) Cannabis is illegal at the federal level; however, as of August 2022, 37 states had medical cannabis laws, and 19 of those states and the District of Columbia (DC) had legalized cannabis for non-medical use (hereafter "adult-use") (1,2).

In 2021, approximately 70% of U.S. residents had access to legal cannabis, either for medical or adult-use. Depending on state law, residents can access cannabis via retail stores, delivery, sharing among friends and family, or growing their own personal supply (home cultivation). In states that have legalized adult-use cannabis, limits vary as to the number of cannabis plants each resident can grow on their property. Most adult-use states allow six plants in total (i.e., flowering and non-flowering), some states allow more than six plants (e.g., Maine allows up to 18 plants, including six

flowering and 12 non-flowering), some states allow fewer than six plants (e.g., Oregon allows up to four), and Washington State and Illinois prohibit home cultivation for adult use (3–5). Regulations vary further on limits per resident or for the property. Among medical-only cannabis states, most prohibit home cultivation except for Hawaii, Missouri, Oklahoma, Rhode Island, South Dakota, and West Virginia (2,5,6).

Home cultivation can support or oppose public health measures in medical and adult-use states. Home cultivation allows residents to self-supply, whether for personal preference, because they are not able to access legal cannabis elsewhere, or because they cannot access a specific strain of cannabis. In theory, home cultivation reduces contact with the illegal market (7,8). Growing cannabis plants is also more affordable and allows personalization and control over strains and potency (9). However, allowing home cultivation can increase access

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to cannabis among children if not stored securely, home cultivated products are not subjected to required state regulations around testing for contaminants and by-products, and home cultivation may lead to diversion to the illicit market (5,10–12). In jurisdictions that have legalized cannabis for adult use, not all allow home cultivation. For example, in addition to Washington State and Illinois in the U.S., Canadian provinces Manitoba and Quebec prohibit home cultivation.

Previous research has examined individual characteristics of home cultivators. A study using National Study of Drug Use and Health (NSDUH) data examined the prevalence of home cultivation and characteristics of U.S. cultivators in 2010–2014 (11). A total of 1.8% of past-year cannabis consumers aged 21 and older reported growing cannabis in the past year and home cultivation was more common among respondents who were male, multiracial, and daily cannabis consumers (11). Other studies outside the U.S. have also suggested that males are more likely to grow cannabis; however, younger ages were more prominent (9,11).

Other research in the U.S. has explored home cultivation and state-level policies (11,13–15). In a study using NSDUH data from 2010–2014, respondents from Maine, California, and Michigan reported higher rates of home cultivation compared to the national average (11). Using cross-sectional data in 2016, researchers examining the relationship between legal cannabis laws in the U.S. and home cultivation demonstrated that respondents in states that allowed home cultivation were more likely to grow their own cannabis than respondents in legal states that prohibited home cultivation (13). In a study examining the relationship between home cultivation, state-level policies, and size of cultivation site in the U.S., authors demonstrated that residents who lived in states with more restrictive home cultivation policies reported smaller cultivation sites than those who lived in states with medical cannabis laws (14). Similar conclusions were demonstrated in Canada: provinces where home cultivation was prohibited had lower reported rates of home cultivation than provinces where up to four plants were allowed (16).

Research on home cultivation in U.S. states across individual- and state-level characteristics is nascent and is important to understand both potential public health benefits (e.g., reduction in illegal market) and potential risks (e.g., underage access, contaminated products). This study seeks to examine whether home cultivation rates vary based on cannabis laws, and how home cultivation varies across individual states that allow adult-use home cultivation. We hypothesize that home cultivation rates will be higher in states that allow adult-use home

cultivation due to the removal of penalties for growing cannabis and to perceived increases in affordability. However, home cultivation rates may also be attenuated by greater access to legal cannabis from alternate sources; therefore, reducing the need to self-supply.

The aims of the current study were to: 1) estimate the percentage of respondents who reported growing cannabis plants in 2019 and 2020 across jurisdiction; 2) estimate the average plants grown in 2019 and 2020 across jurisdiction; 3) examine the association between home cultivation, jurisdiction, and individual-level factors in states that allow adult-use home cultivation; and 4) examine the association between home cultivation and state-level policies in states that allow adult-use home cultivation.

Methods

Data are from Waves 2–3 of the International Cannabis Policy Study (ICPS), repeat cross-sectional surveys conducted in Canada and the United States. Data were collected via self-completed web-based surveys September-October in 2019 and 2020 from respondents aged 16–65. A non-probability sample of respondents was recruited through the Nielsen Consumer Insights Global Panel and their partners' panels. The Nielsen panels are recruited using a variety of probability and non-probability sampling methods. For the ICPS surveys, Nielsen draws stratified random samples from the online panels, with quotas based on age and state/province of residence. Nielsen e-mails panelists an invitation to access the ICPS survey via a hyperlink; respondents are unaware of the survey topic prior to accessing the link. Respondents confirm their eligibility and provide consent before completing the survey. Upon completion, respondents receive remuneration in accordance with their panel's usual incentive structure. Monetary incentives have been shown to increase response rates and decrease response bias in subgroups underrepresented in surveys (17).

Surveys were conducted in English and median survey time was 25 min in 2019 and 21 min in 2020. The survey had an American Association for Public Opinion Research cooperation rate of 61% in 2019 and 64% in 2020 among U.S. respondents (64%) (18,19). The current study reports data from U.S. respondents aged 21 and older.

The study was reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#31330). A full description of the study methods can be found in the ICPS Technical Reports and methodology paper (20–23).

Measures

Cannabis policy measures

Home cultivation laws. Home cultivation policies vary across the states. Using records from National Conference of State Legislatures (2), ProCon (1) and state regulatory documents (e.g., 3,4), states were categorized according to their cannabis laws and home cultivation laws at the time of survey (September 2019). "Illegal" states were defined as states without medical or adult-use cannabis laws (though note that some of these states had policies in place legalizing low-THC and/or CBD cannabis products). "Medical" states were defined as those with medical cannabis laws in place on or before the survey: "Medical, cultivation prohibited" were medical-only states that prohibited home cultivation and "Medical, cultivation allowed" were medical-only states that allowed home cultivation. "Adult-use" states were defined as those with adult-use cannabis laws on or before the survey in each year, further categorized to "adult-use, cultivation prohibited" and "adult-use, cultivation allowed." At the time of survey, states such as Arizona had not yet legalized adult-use cannabis and so were coded as medical states for these analyses. Please see Supplemental Table S1 for full categorization.

Home cultivation limits. Adult-use states were categorized according to their total adult-use plant limit (i.e., including non-flowering and flowering plants) per resident: "Less than six plants," "Six plants," "More than six plants." Nevada permits home cultivation of up to six plants per resident, only if they live more than 25 miles from a retail store. Nevada was categorized to "Six plants." Please see Supplemental Table S2 for plant limits across non-medical states.

Adult-use retail stores. In all adult-use states, there has been a delay between the date of legalization and the date retail stores open, typically of between 12–24 months (12); therefore, adult-use states that allowed home cultivation were categorized into a binary variable to those that had retail stores on or before the survey in 2019 (Alaska, California, Colorado, Nevada, Oregon) and those without (Maine, Massachusetts, Michigan, Vermont, District of Columbia). Further, we include a continuous variable measuring time (in years; e.g., 18 months = 1.5 years) since adult-use retail sales began compared to the date of the survey.

Survey-derived measures

Socio-demographic measures. Sex at birth, age, ethnicity/race, highest education level, perceived income adequacy, suspected device type used to complete survey,

and state of residence. Sex at birth and gender were collected separated in the survey; however, sex at birth was included to retain all respondents (gender included missing data and very small cell sizes for non-cis individuals, which would not be included in analyses). Income adequacy is assessed by the question: "Thinking about your family's income, how difficult or easy is it to make ends meet?," where "making ends meet" means having enough money to pay for the things your family needs.

Cannabis use status. Cannabis use status was categorized to: "Non-consumer" (Never; Consumed more than 12 months ago), "Non-daily consumer" (Less than monthly consumer but used in the past 12 months; Monthly consumer; Weekly consumer), and "Daily consumer" (Daily or almost daily consumer).

Home cultivation. All respondents were asked, "Did you grow any marijuana plants in the past 12 months?" (Yes, No). Those who answered, "Don't know" were categorized to "No" (n = 250), because if someone does not have knowledge that they had grown a plant, it is reasonable to assume they had not done so. Those who answered "Yes" to growing plants in the past 12 months were asked, "In total, how many marijuana plants did you grow in the past 12 months?" Extreme values/outliers were excluded (i.e., respondents who grew over 1,000 plants [n = 15]). Although the question does not include "home cultivation" we refer to these data as "home cultivation" throughout the study.

Medical cannabis recommendation. Respondents who had ever received a recommendation for medical cannabis were asked, "Did you have a recommendation to use medical marijuana at any time in the past 12 months?" (Yes, No). All respondents who had never received a recommendation or answered, "Don't know" were categorized as "No" (n = 102), because if because if someone does not have knowledge that they had received a recommendation, it is reasonable to assume they had not.

Self-reported time to nearest cannabis retail store. Respondents were asked "How long would it take you to get to the nearest store that sells cannabis using your usual mode of transportation?" Responses began at "Less than five minutes" and increased in five-minute increments up to one hour and ended with "More than an hour" and "I don't know any stores near to where I live." This measure included both illegal and legal retail stores. Responses were categorized to "Under 30 mins,"

"Over 30 mins" and "I don't know any stores near to where I live."

All questions included "Don't know" and "Refuse to answer" options. Except "perceived income adequacy," all "Refuse to answer" options were set to missing. Except in measures described above, all "Don't know" options were set to missing.

Data

A total of 33,575 U.S. respondents in 2019 and 31,632 in 2020 completed the survey. After exclusions due to poor data quality ($n_{2019} = 1,430$; $n_{2020} = 1,543$), speeding ($n_{2019} = 9$; $n_{2020} = 64$), dishonesty ($n_{2019} = 470$; $n_{2020} = 671$), unidentified sex ($n_{2019} = 9$; $n_{2020} = 8$), duplicate entries ($n_{2019} = 194$; $n_{2020} = 1$) or returners ($n_{2019} = 983$), the analytical cross-sectional samples comprised of 30,479 respondents in 2019 and 29,345 in 2020. See Technical Reports for more detail on exclusions (20–22). The current analysis was based on respondents aged 21 and older. Respondents from Illinois ($n_{2019} = 734$; $n_{2020} = 2,020$) and West Virginia ($n_{2019} = 78$; $n_{2020} = 108$) were removed due to a change in cannabis legislation across 2019 to 2020. The final analytical sample totaled 51,503: 27141 respondents in 2019 and 24,362 in 2020

Missing data

Missing data were removed using case-wise deletion for home cultivation variable (n = 90). Respondents with missing data on home cultivation were more likely to be younger ($\chi^2 = 15.1$, $p = .001$), report lower education ($\chi^2 = 396.6$, $p < .001$), and not report their income adequacy ($\chi^2 = 224.1$, $p < .001$). Missing data were excluded using case-wise deletion for three variables used in regression models among respondents in adult-use home cultivation states: home cultivation (n = 49); self-reported time to nearest cannabis retail store (n = 174); and highest education level (n = 169).

Post-stratification sample weights were constructed based on the U.S. census estimates. Weights were constructed differently for adult-use states vs medical/illegal states due to larger sample sizes within the adult-use states and to allow by-state analyses. Respondents from adult-use states were classified into age-by-sex-by-state, education-by-state, region-by-race, and age-by-tobacco smoking status groups, while those from medical and illegal states were classified into age-by-sex, education, region-by-race, and age-by-tobacco smoking status groups. A raking algorithm was applied to the cross-sectional analytic samples to compute weights that were calibrated to these groupings and rescaled to the sample size for each year. All estimates are weighted unless otherwise specified.

Statistical analysis

First, descriptive statistics were used to describe the percentage of respondents aged 21–65 who grew their own cannabis plants in the past 12 months, stratified by cannabis policy and year. Second, a logistic regression model was examined to ascertain whether any observed differences across cannabis policy were statistically significant. Third, the median number of plants was estimated across states that allowed adult-use home cultivation. Fourth, binary logistic regression models were fitted to examine the association between home cultivation, individual characteristics, and state-level policies. Binary regression models were adjusted for survey year, self-reported time to nearest cannabis retail store, cannabis use status, medical cannabis recommendation, age, sex at birth, highest education level, ethnicity/race, income adequacy, and survey device type. Adjusted odds ratios (AORs) are reported with 95% confidence intervals (95% CI). Analyses were conducted using survey procedures in SAS (SAS version 9.4, SAS Institute Inc., Cary, NC, USA).

Results

Table 1 displays the weighted sample characteristics of respondents in illegal, medical, and adult-use states aged 21–65 in 2019 and 2020 (see Supplemental Table S3 for unweighted sample characteristics). In all jurisdictions, approximately half of respondents were male, three-quarters were white, and a third were past 12-month cannabis consumers.

Home cultivation in past 12 months

Figure 1 displays the percentage of respondents who reported growing their own cannabis plants in the past 12 months across home cultivation laws in 2019 and 2020. A total of 6.8% and 7.3% of U.S. respondents reported home cultivation in 2019 and 2020, respectively. Home cultivation ranged from 4.3% to 7.9% in 2019 and 5.1% to 8.8% in 2020, depending on state cannabis laws. Respondents in adult-use states where home cultivation was allowed had higher odds of reporting home cultivation in the past 12 months than respondents in illegal states (AOR = 1.48, 95% 1.26, 1.75; Supplemental Table S4). Analyses were repeated with Nevada categorized to home cultivation as prohibited and similar patterns emerged.

Home cultivation in states that allowed adult-use home cultivation

Figure 2 displays the percentage of respondents who reported growing their own cannabis plants in the past

Table 1. Weighted sample characteristics of respondents in U.S. states with different cannabis laws, 2019–2020 (n = 51,503).

|	Illegal states % (n)		Medical states, medical cultivation prohibited % (n)		Medical states, medical cultivation allowed % (n)		Adult-use states, adult-use cultivation prohibited % (n)		Adult-use states, adult-use cultivation allowed % (n)	
	2019 (n = 3,666)	2020 (n = 4,666)	2019 (n = 3,722)	2020 (n = 4,985)	2019 (n = 925)	2020 (1,124)	2019 (n = 1,777)	2020 (1,305)	2019 (17,025)	2020 (12,307)
Age										
21-35	32.0 (1175)	32.8 (1531)	33.1 (1231)	31.0 (1545)	31.0 (287)	28.4 (319)	37.6 (668)	36.3 (473)	37.1 (6314)	35.2 (4333)
36-50	34.3 (1259)	33.5 (1564)	32.3 (1200)	33.4 (1667)	32.9 (304)	32.0 (360)	31.0 (551)	31.7 (414)	31.1 (5290)	31.9 (3930)
51-65	33.6 (1233)	33.7 (1571)	34.7 (1292)	35.6 (1773)	36.1 (334)	39.7 (446)	31.4 (558)	32.0 (418)	31.8 (5421)	32.9 (4043)
Sex at birth										
Female	54.5 (1998)	52.8 (2461)	48.0 (1786)	48.0 (2394)	53.7 (497)	50.3 (566)	49.5 (880)	48.8 (636)	50.2 (8547)	49.8 (6129)
Male	45.5 (1669)	47.3 (2205)	52.0 (1936)	52.0 (2591)	46.3 (428)	49.7 (559)	50.5 (897)	51.2 (669)	49.8 (8478)	50.2 (6178)
Ethnicity/race										
Non-Hispanic White	68.0 (2491)	71.0 (3315)	68.3 (2543)	71.9 (3583)	72.5 (671)	77.9 (876)	76.3 (1357)	76.9 (1003)	62.6 (10660)	66.9 (8229)
Hispanic White	7.8 (284)	6.5 (305)	6.5 (240)	5.7 (286)	7.7 (71)	5.8 (65)	6.8 (121)	5.2 (68)	13.8 (2344)	10.7 (1314)
American Indian or Alaskan Native	0.7 (26)	0.7 (33)	0.7 (26)	0.7 (36)	3.1 (29)	1.3 (14)	1.5 (27)	0.9 (12)	1.9 (330)	1.3 (165)
Asian	1.8 (67)	2.0 (93)	3.8 (141)	3.7 (183)	4.6 (42)	5.0 (56)	5.0 (89)	6.1 (80)	7.0 (1188)	7.7 (952)
Black or African American	18.2 (669)	16.6 (777)	16.9 (627)	15.1 (752)	5.9 (55)	4.9 (55)	3.0 (54)	4.9 (64)	8.0 (1355)	7.3 (902)
Native Hawaiian or Pacific Islander	0.2 (7)	0.2 (11)	0.3 (9)	0.3 (12)	0.7 (6)	0.3 (12)	0.4 (7)	0.3 (4)	0.5 (88)	0.6 (72)
Other/Multiracial	2.1 (77)	1.9 (88)	2.5 (93)	1.6 (78)	4.9 (45)	1.6 (78)	5.3 (95)	4.0 (52)	3.8 (646)	3.3 (401)
Unstated	1.3 (46)	1.0 (44)	1.1 (42)	1.1 (55)	0.6 (6)	1.1 (55)	1.6 (6)	1.7 (22)	2.4 (415)	2.2 (271)
Highest education level										
Less than high school	4.2 (153)	3.8 (176)	4.0 (149)	3.0 (148)	3.2 (29)	4.1 (46)	3.2 (57)	3.8 (49)	2.9 (496)	2.3 (278)
High school diploma	22.7 (833)	24.7 (1150)	24.0 (894)	24.8 (1234)	26.0 (240)	20.4 (229)	18.3 (325)	17.2 (224)	19.2 (3268)	18.8 (2308)
Some college or technical vocation	43.3 (1586)	40.6 (1893)	36.7 (1367)	36.7 (1830)	40.2 (372)	41.8 (469)	42.0 (747)	42.1 (550)	42.5 (7232)	42.3 (5207)
Bachelor's degree or higher	29.6 (1084)	30.5 (1423)	35.0 (1302)	35.3 (1758)	30.2 (279)	33.4 (375)	36.2 (643)	36.4 (475)	35.0 (5955)	35.9 (4418)
Unstated	0.3 (10)	0.5 (24)	0.3 (10)	0.3 (15)	0.5 (4)	0.4 (4)	0.3 (5)	0.5 (6)	0.4 (74)	0.8 (96)
Income adequacy										
Very difficult	10.6 (387)	9.8 (457)	11.2 (417)	9.5 (472)	11.3 (105)	10.2 (115)	11.5 (204)	8.8 (115)	10.3 (1760)	8.0 (987)
Difficult	23.6 (865)	19.6 (912)	23.1 (860)	17.9 (893)	25.7 (237)	19.3 (217)	24.1 (428)	18.3 (239)	22.7 (3863)	18.9 (2330)
Neither easy nor difficult	33.0 (1211)	33.9 (1583)	32.4 (1205)	34.8 (1735)	33.9 (314)	35.9 (404)	31.6 (561)	32.4 (443)	33.2 (5649)	35.7 (4399)
Easy	18.7 (687)	20.6 (961)	18.5 (690)	20.9 (1041)	17.0 (157)	18.3 (206)	18.8 (334)	22.6 (295)	19.7 (3358)	21.3 (2618)
Very Easy	12.2 (448)	13.6 (632)	12.1 (450)	14.4 (717)	10.7 (99)	14.3 (160)	11.8 (209)	15.8 (206)	11.1 (1887)	13.2 (1624)
Unstated	1.9 (69)	2.6 (120)	2.7 (100)	2.5 (125)	1.4 (13)	2.0 (22)	2.3 (41)	2.2 (28)	3.0 (508)	2.8 (349)
Cannabis use status										
Never	33.8 (1238)	38.9 (1813)	34.4 (1280)	39.8 (1983)	34.7 (321)	37.4 (421)	26.2 (466)	29.3 (382)	29.2 (4967)	33.5 (4117)
Used more than 12 months ago	37.0 (1357)	34.6 (1616)	34.5 (1283)	32.1 (1601)	33.4 (309)	32.9 (370)	30.9 (549)	31.6 (412)	32.0 (5446)	30.9 (3799)
Past year but less than monthly	7.0 (258)	6.4 (298)	7.4 (275)	6.7 (336)	9.0 (84)	6.5 (72)	10.6 (189)	9.1 (119)	9.8 (1661)	7.8 (963)
Monthly	5.7 (210)	5.2 (241)	6.2 (229)	5.3 (262)	5.9 (55)	4.4 (49)	6.8 (121)	6.3 (82)	6.2 (1047)	6.9 (850)
Weekly	4.4 (161)	4.8 (222)	5.2 (194)	4.2 (210)	4.3 (39)	4.1 (46)	6.3 (113)	7.0 (91)	6.4 (1092)	6.3 (776)
Daily/almost daily	12.1 (442)	10.2 (476)	12.4 (460)	11.9 (593)	12.7 (117)	14.8 (166)	19.2 (340)	16.8 (219)	16.5 (2813)	14.6 (1802)
Device used										
Smartphone	52.7 (1931)	53.2 (2484)	48.4 (1802)	48.3 (2409)	52.5 (485)	50.1 (563)	48.8 (866)	51.9 (677)	52.7 (8977)	51.5 (5342)
Tablet	6.7 (244)	5.0 (231)	6.4 (239)	5.0 (251)	6.7 (62)	4.0 (45)	7.0 (125)	3.3 (43)	6.0 (1016)	4.5 (550)
Computer	40.7 (1491)	41.8 (1950)	45.2 (1680)	46.6 (2325)	40.9 (378)	46.0 (517)	44.2 (786)	44.9 (586)	41.3 (7032)	44.0 (5415)
Medical cannabis recommendation										
Yes	4.0 (147)	4.8 (222)	7.7 (286)	8.4 (420)	7.1 (66)	10.2 (115)	6.0 (106)	4.9 (64)	7.4 (1259)	7.7 (943)
Self-reported time to nearest cannabis retail store										
Under 30 minutes	13.6 (496)	14.1 (652)	26.3 (973)	29.7 (1464)	49.4 (455)	47.1 (527)	85.5 (1516)	86.7 (1122)	63.9 (10808)	65.3 (7961)
30 mins +	19.6 (713)	20.7 (957)	21.0 (776)	18.6 (919)	15.3 (141)	17.1 (191)	8.2 (145)	6.3 (81)	14.9 (2514)	13.5 (1647)
I don't know any stores	66.7 (2427)	65.3 (3023)	52.6 (1945)	51.7 (2555)	35.3 (325)	35.8 (400)	6.3 (112)	7.1 (92)	21.3 (3596)	21.2 (2579)
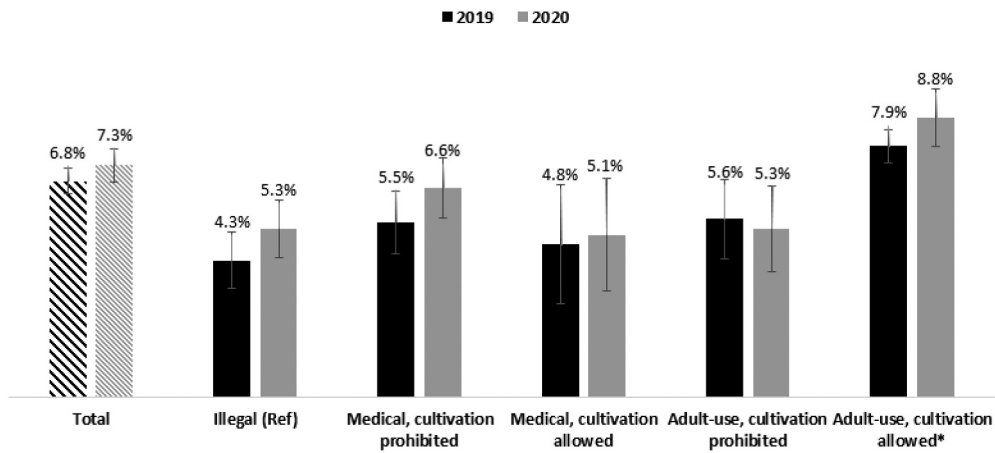
Figure 1. Percentage of home cultivation in past 12 months by jurisdiction and home cultivation laws in 2019 and 2020 (n = 51,413). Figure displays percentage of reported home cultivation in the past 12 months in each year. Weighted binary logistic regression model with any home cultivation in the past 12 months as outcome: asterisks denote significant differences (*$p < 0.001$) compared to reference group (illegal). Model was adjusted for survey year, frequency of cannabis use, medical recommendation in the past 12 months, sex at birth, age group, ethnicity/race, education, income adequacy, and device type. Interaction between survey year and home cultivation laws was not significant (F = 1.21, $p = 0.319$).

12 months across states that allowed adult-use home cultivation in 2019 and 2020. In 2019 and 2020, 8.1% and 9.6% of respondents in states with adult-use retail stores and 7.5% and 6.8% of respondents in states without adult-use retail stores reported home cultivation in the past 12 months, respectively.

Figure 3 displays the median number of self-reported cannabis plants that respondents grew in the past 12 months in states that allowed adult-use home cultivation. The median number of cannabis plants participants reported growing ranged between 2.9 and 6.8 in 2019 and 2.3 and 5.2 in 2020. Respondents from
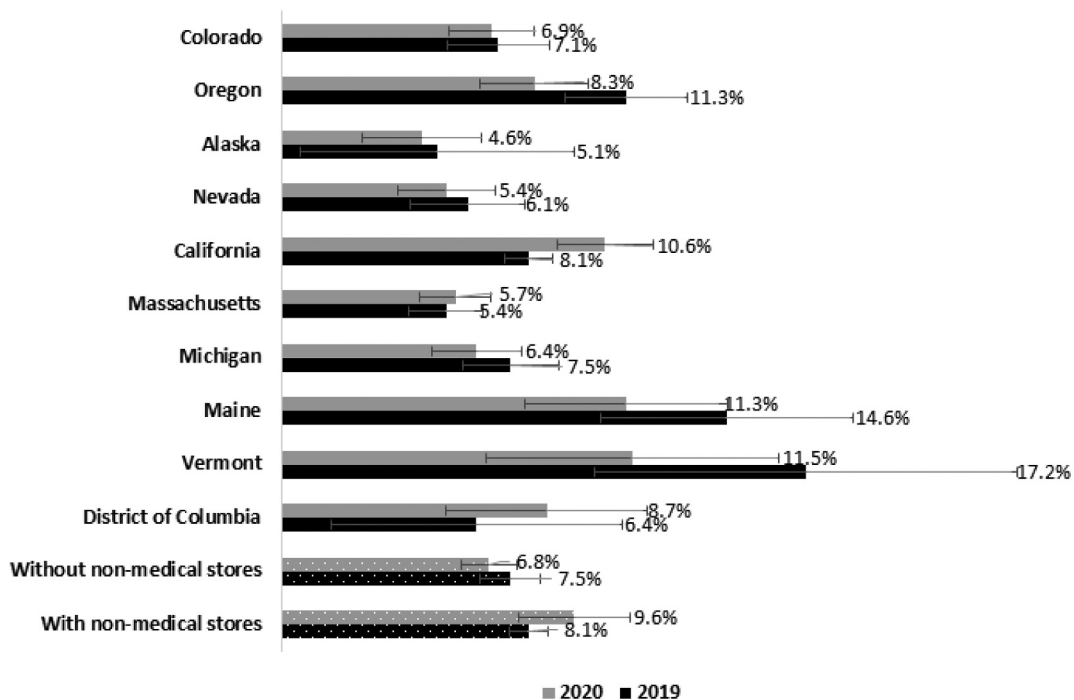

Figure 2. Percentage of home cultivation in past 12 months among respondents in U.S. adult-use states where home cultivation is allowed, positioned in order of length of time with legal retail sales, 2019–2020 (n = 29,051). U.S. states are positioned in order of time with legal retail sales. Michigan did not have adult-use retail sales until December 2019 and Maine did not have adult-use retail sales until October 2020.
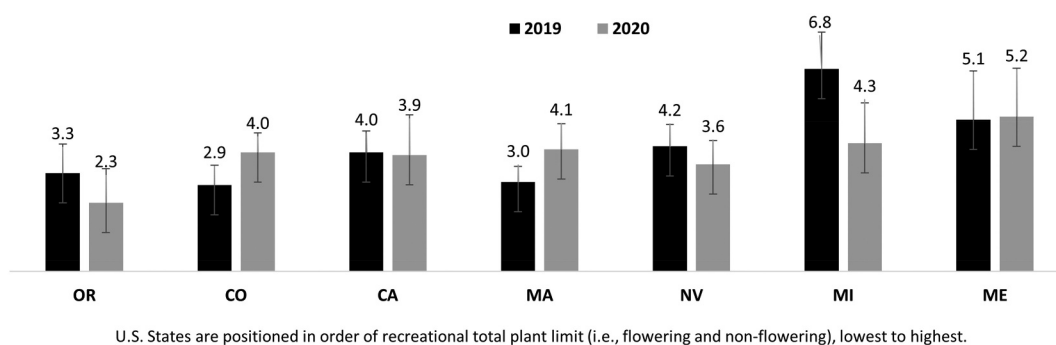
U.S. States are positioned in order of recreational total plant limit (i.e., flowering and non-flowering), lowest to highest.

Figure 3. Median number of cannabis plants grown in the past 12 months among respondents in U.S. adult-use states where home cultivation is allowed, positioned in order of adult-use total plant limit, 2019–2020 (n = 1,007). OR = Oregon; CA = California; CO = Colorado; MA = Massachusetts; NV = Nevada; ME = Maine; MI = Michigan Error bars represent standard errors. Nevada's position reflects the regulations if residents live more than 25 miles from a retail store. Respondents from Alaska ($n_{2019} = 6$; $n_{2020} = 25$); District of Columbia ($n_{2019} = 5$; $n_{2020} = 23$); and Vermont ($n_{2019} = 30$; $n_{2020} = 20$) are not shown individually due to low sample size.

Michigan and Maine had the highest average number of plants grown in both years.

A binary logistic regression model was fitted to examine the relationship between home cultivation, state of residence, and individual characteristics in states that allowed adult-use home cultivation (Table 2). Respondents in Vermont, Maine, Oregon, California, and Michigan had higher odds of growing plants in the past 12 months than respondents in Colorado.

As shown in Table 2, individual characteristics with higher odds of home cultivation in the past 12 months were past 12-month cannabis consumers (vs. non-consumers); those who reported living 30 minutes or more from their nearest cannabis retail stores (vs. under 30 minutes); had a medical recommendation for cannabis (vs. no medical recommendation); male (vs. female); aged 50 or younger (vs. 51–65 years); less than high school education (vs. high school and above); of Hispanic or American Indian or Alaskan Native ethnicity/race (vs. White); found it difficult to make ends meet (vs. neither easy or difficult); and used a computer to complete the survey (vs. smartphone or tablet).

State-level policies in states that allowed adult-use home cultivation

Three additional binary logistic regression models were fitted to examine the relationship between home cultivation and state-level policies in states that allowed adult-use home cultivation (Supplemental Table S5). The first model examined home cultivation and whether a state had adult-use retail stores: the presence of adult-use retail stores was not associated with growing cannabis plants (AOR = 1.08, 95%CI: 0.94, 1.25). The second model examined home cultivation and the time since legal adult-use retail stores opened: each additional year with adult-use retail stores was associated with lower odds of growing cannabis plants (AOR = 0.96, 95%CI: 0.93, 0.99). The third model examined home cultivation and state adult-use adult-use cultivation limits: compared to respondents in states with cultivation limits of less than 6 plants, respondents in states with cultivation limits of 6 plants (AOR = 0.68, 95%CI: 0.57, 0.82), or more than 6 plants (AOR = 0.77, 95%CI: 0.62, 0.96) had lower odds of growing cannabis plants. Analyses were repeated with Nevada categorized to home cultivation as prohibited and similar patterns emerged.

Discussion

The current study provides an examination of home cultivation in the U.S. in 2019 and 2020, with an additional focus on individual- and state-level characteristics of home cultivation in states that allowed adult-use home cultivation. A total of 7% of respondents aged 21–65 reported growing their own cannabis plants in the past 12 months in 2020. U.S. home cultivation rates were stable in the current study between 2019 and 2020 but were higher than home cultivation rates reported by older U.S. studies that used different data sources (11). For example, research examining home cultivation using NSDUH data in 2010–2014, estimated 2% of past-year cannabis consumers aged 21 and older grew their own plants in the past year (11). There are a few possibilities for the higher estimates in the current study. First, the NSDUH estimates were collected approximately a decade earlier – the cannabis landscape has changed substantially since that time, including increases in overall cannabis prevalence among U.S. adults, medical cannabis legalization in an additional 21 states, and adult-use cannabis legalization in

Table 2. Weighted binary logistic regression analysis for correlates of home cultivation in the past 12 months among respondents in U.S. states that allow adult-use home cultivation, 2019–2020 (n = 28,894).

	Did you grow any cannabis plants in the past 12 months? Yes (vs No)	
	Weighted % (Unweighted n)	AOR (95% CI)
Survey wave		
2019	7.9 (1127)	REF
2020	8.8 (792)	**1.26 (1.08, 1.46)**
State of residence		
Vermont	14.8 (55)	**3.68 (2.56, 6.00)**
Maine	13.2 (108)	**2.33 (1.66, 3.27)**
Oregon	10.0 (279)	**1.69 (1.30, 2.18)**
California	9.1 (635)	**1.49 (1.19, 1.86)**
Michigan	7.1 (225)	**1.31 (1.01, 1.70)**
District of Columbia	7.4 (37)	1.00 (0.55, 1.81)
Massachusetts	5.5 (225)	0.92 (0.71, 1.20)
Nevada	5.8 (107)	0.83 (0.61, 1.15)
Alaska	4.9 (37)	0.77 (0.40, 1.46)
Colorado	7.0 (211)	REF
Self-reported time taken to nearest retail store		
Under 30 minutes	9.1 (1403)	**REF**
30 mins +	14.9 (423)	**1.52 (1.28, 1.81)**
I don't know any stores	1.5 (82)	**0.31 (0.22, 0.44)**
Cannabis use status		
Non-consumer	4.0 (504)	REF
Non-daily consumer	9.7 (543)	**1.91 (1.59, 2.28)**
Daily consumer	23.6 (872)	**4.62 (3.83, 5.59)**
Medical recommendation in past 12 months		
Yes	37.6 (545)	**4.88 (4.07, 5.86)**
No	5.9 (1374)	REF
Sex at birth		
Female	5.8 (1119)	REF
Male	10.8 (800)	**1.59 (1.38, 1.83)**
Age		
21-35	10.2 (724)	**1.58 (1.30, 1.90)**
36-50	9.4 (673)	**1.46 (1.22, 1.76)**
51-65	5.1 (522)	REF
Highest education level		
Less than high school	17.2 (91)	REF
High school	9.0 (401)	**0.51 (0.35, 0.73)**
Some college	7.3 (769)	**0.43 (0.31, 0.61)**
Degree or higher	8.5 (650)	**0.50 (0.35, 0.72)**
Ethnicity/race		
Non-Hispanic White	7.7 (1290)	REF
Hispanic White	13.2 (270)	**1.47 (1.18, 1.82)**
American Indian or Alaskan Native	19.4 (65)	**2.79 (1.91, 4.07)**
Asian	3.1 (45)	**0.52 (0.35, 0.75)**
Black or African American	9.2 (107)	0.99 (0.74, 1.32)
Native Hawaiian or Pacific Islander	8.2 (11)	0.82 (0.34, 1.99)
Other/Multiracial	9.3 (99)	1.02 (0.68, 1.50)
Unstated	3.7 (32)	**0.43 (0.22, 0.86)**
Income adequacy		
Very/Difficult	9.4 (708)	REF
Neither easy nor difficult	6.2 (538)	**0.69 (0.57, 0.83)**
Very/Easy	9.8 (645)	1.10 (0.93, 1.31)
Not stated	3.8 (28)	**0.46 (0.25, 0.85)**
Device used		
Smartphone	8.1 (1051)	**0.81 (0.70, 0.95)**
Tablet	5.9 (98)	**0.73 (0.54, 0.99)**
Computer	8.9 (770)	REF

11 states and the District of Columbia (24–26). Indeed, respondents in states that allowed adult-use home cultivation had higher odds of reporting home cultivation than respondents in illegal states. Second, the current study only includes adults up to 65 years of age, whereby the older population may have lower rates of home cultivation, as they do with overall cannabis prevalence (27). Third, overall prevalence rates in the current study tend to be higher than rates in the NSDUH (20–22), which would increase our estimates as frequent consumers were found to be more likely to cultivate cannabis than non-consumers. Higher rates of home cultivation in legal markets are not necessarily a cause for concern due to potential public health benefits, such as reduction in the illegal market. Conversely, home cultivation could also increase the illegal market through diversion. Further research is needed to understand the relationship between home cultivation and public health measures.

Home cultivation rates were higher in adult-use states that had medical cannabis laws dating prior to 2010. In the current study, Maine, Oregon, California, and Michigan had among the highest rates of home cultivation, mirroring the pattern and order of states in the study of NSDUH data in 2010–2014 (11). If rates of home cultivation have indeed increased in the past decade, these increases may be due to the length of time medical cannabis has been legal in each state (11). A greater proportion of respondents with a medical recommendation reported home cultivation compared to those without in the current study. This finding was also demonstrated in previous research, where close to half of cannabis growers reported having a medical recommendation (11).

The current study found conflicting results regarding the relationship between adult-use retail stores and home cultivation. The length of time retail stores had been operational in a state and a resident's perceived proximity to a retail store was associated with home cultivation but whether the state had retail stores operating was not. The lack of association between the presence of adult-use retail stores and growing cannabis plants suggests the policy alone is not the only factor in deciding to self-supply through home cultivation. It may be that stores with legal cannabis are perceived to be inaccessible or expensive, or do not stock preferred products (28). In the case of some of these states, retail stores were not yet open, which could have increased demand for home cultivation. Interestingly, consumers in "older" retail markets reported a lower odds of growing cannabis plants in the past 12 months. This was potentially driven by lower rates of home cultivation in Colorado, Alaska, and Nevada, where retail cannabis

markets opened in 2014, 2016, and 2017, respectively, compared to higher rates of home cultivation reported in Maine and Vermont, both states that had no retail stores open at the time of the current study in 2019.

In addition to the length of time a retail market has been opened, the perceived time taken to get to the nearest cannabis retail store was associated with home cultivation. For instance, Nevada residents are allowed to home cultivate; however, only if they reside more than 25 miles from a cannabis retail store. In the current study, respondents who reported living within 30 minutes of a retail store had lower odds of growing cannabis plants than those who lived further away. These results suggest that accessibility or availability of retail cannabis may be an important factor in the decision to self-supply through home cultivation. While not explored in this study, legal online sales and home delivery may also have an impact and warrant further exploration. Previous findings demonstrate that home cultivation is more likely among respondents residing in a rural location (11,16). An expectation is that increased access to legal cannabis would reduce the demand for illegal cannabis or the need to self-supply. However, further research is required to disentangle this relationship.

Home cultivators self-report abiding by state adult-use cultivation limits. In states that allowed adult-use home cultivation, the median number of plants that respondents reported growing was below the cultivation limit of their respective state laws. Michigan and Maine had the highest average number of plants grown in both years and had the highest adult-use cultivation limit. Research examining the effect of penalties among home cultivators in Canada and the U.S. demonstrated that individual state penalties regarding home cultivation was associated with the size of the cultivation site: more restrictive laws saw a reduction in the cultivation area (14). Interestingly, states with higher cultivation limits had lower odds of home cultivation than states with lower cultivation limits. This result may be driven by respondents in Oregon and Vermont, who have two of the three highest rates of home cultivation, but the lowest adult-use plant limit.

Respondents who had never consumed cannabis or who had not consumed in the past 12 months (i.e., non-consumers) reported home cultivation. Approximately 4% of non-consumers residing in states that allowed adult-use home cultivation reported home cultivation, suggesting that rather than for consumption, respondents may grow for other reasons such as sharing among friends, for pleasure, as a caregiver for someone with a medical recommendation, or for diversion to the illegal market. Indeed, diversion to the illegal market from home cultivation has been reported as a concern

among state regulators (29). Most states do not have adult-use cannabis laws. Diversion of illegal cannabis to neighboring states without adult-use or medical laws could contribute to the higher rates of home cultivation in adult-use states. Future research should address home cultivation and legalization through pre- and post-legalization studies in individual states, replicated across multiple states.

Limitations

This study is subject to limitations common to survey research. Respondents were recruited using non-probability-based sampling; therefore, the findings do not necessarily provide nationally representative estimates. The data were weighted by age, sex at birth, region, highest education level, cigarette smoking status, and region-by-race. However, compared to the national population, the U.S. sample had fewer respondents with low education levels and Hispanic ethnicity. Cannabis use estimates were generally lower than national estimates for young adults, and higher than national surveys. The ICPS sample also had poorer self-reported general health compared to the national population, which is a feature of many non-probability samples (30) and may be partly due to the use of web surveys, which provide greater perceived anonymity than in-person or telephone-assisted interviews often used in national surveys (31).

Self-reported data are subject to social desirability biases. At the time of study, cannabis was illegal at the federal level; therefore, patterns of cannabis use or participation in home cultivation (legal or illegal) may be underreported or misrepresented. Moreover, social desirability biases may vary across states: those residing in states with more restrictive cannabis laws may misrepresent cannabis behaviors more than those in states with more permissive cannabis laws. Indeed, cultivation limits may have biased the number of plants reportedly grown. However, the survey included a data integrity question wherein those who reported not answering questions honestly were excluded. In addition, this survey was self-administered online, which compared to interviewer assisted surveys, can reduce social desirability biases by providing anonymity (31).

Home cultivation laws vary across the U.S., and therefore categorizing states may lose the nuance of individual state laws. The current study focused on adult-use cannabis laws, with additional analyses on varying state policies to capture added detail. Indeed, as a sensitivity analysis, we recategorized Nevada to reflect the changing home cultivation policy depending on distance from state-licensed retail stores. Analyses were repeated with

Nevada categorized to home cultivation as prohibited (i.e., removed with Washington State) and similar patterns emerged. Another limitation is the current study did not model policy laws at the local level, where presence of retail stores can vary due to opt-outs. Finally, the wording of the survey does not mention "home;" therefore, there is a possibility that respondents who work for a commercial cannabis operation could misinterpret the question and provide answers referring to their work.

Conclusion

Home cultivation rates in the U.S. were higher in states that allowed adult-use home cultivation: 9% of respondents reported home cannabis cultivation in 2020. Although states allowing adult-use home cultivation had higher rates of home cultivation, previous research using different data sources suggests the same states also had higher rates a decade ago. The contribution of legalization in the decision to participate in home cultivation requires further research, potentially through pre- and post-legalization studies in individual states, replicated across multiple states. In legal markets, home cannabis cultivation may increase due to the removal of penalties for home growing but could potentially decrease over time if legal cannabis is pervasive, accessible, and affordable. Future research should examine how home cultivation relates to public health measures across states with adult-use cannabis laws, including whether home cultivation supports public health measures (e.g., through reductions in the illicit market, access to specific medical products) or opposes them (e.g., through increased underage access, issues with contaminated products, or diversion to the illicit market).

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