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Differences in Opinions About Marijuana Use and Prevalence of Use by State Legalization Status

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Objective: Beliefs about marijuana use and prevalence of use may be associated with the legalization status of the state of residence. We examined differences in views and rates of use of marijuana among residents in recreationally legal, medically legal, and nonlegal states.

Methods: We surveyed a nationally representative online panel of US adults (N = 16,280) and stratified results by marijuana legalization status of states. We compared views of residents of recreational states on benefits and risks of marijuana use to residents in other states.

Results: The response rate was 56.3% (n = 9003). Residents in recreationally legal states were more likely to believe marijuana could be beneficial for pain management (73% in recreationally legal states, 67% in medically legal states, 63% in nonlegal states; *P* value: <0.0001), provide relief from stress, anxiety or depression (52% in recreationally legal states, 47% in medically legal states, 46% in nonlegal states; *P* value: 0.01), and improve appetite (39% in recreationally legal states, 36% in medically legal states, 33% in nonlegal states; *P* value: <0.009). In addition, residents in recreational states were significantly more likely to believe that smoking 1 marijuana joint a day is somewhat or much safer than smoking 1 cigarette a day

(40.8% in recreationally legal states, 39.1% in medically legal states, and 36.1% in nonlegal states; *P* value: <0.0001). Residents of recreationally and medically legal states were more likely to believe second-hand marijuana smoke was somewhat or much safer than second-hand tobacco smoke (38.3% in recreationally legal states, 38.3% in medically legal states, and 35.7% in nonlegal states; *P* value: 0.003). Past-year marijuana use in any form (20% in recreational, 14.1% in medical, 12% in nonlegal) and past-year marijuana use of multiple forms (11.1% in recreational, 6.1% in medical, 4.9% in nonlegal) were highest among residents of recreationally legal states. Overall, prevalence of past-year use of any form of marijuana use was more common among residents of recreationally legal states compared with other states (20.3%, confidence interval [CI] 19.5, 21.1 in recreationally legal states; 15.4%, CI 14.7, 16.2 in medically legal states; 11.9%, CI 11.2, 12.6 in nonlegal states).

Conclusions: Residents in recreationally legal states were most likely to believe marijuana has benefits, marijuana smoke is safer than tobacco smoke, and have the highest rate of marijuana use. This is cause for concern, given the tide of commercialization, growing number of high-potency cannabis products, and favorable media coverage promoting use for health problems.

Key Words: legalization, marijuana, state-based differences

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Marijuana use is legal for medical or recreational purposes in 33 states and Washington, DC (National Conference of State Legislatures, 2019). Recreational legalization has ushered in rapid commercialization (Richter and Levy, 2014). Both Colorado and Washington—the first 2 states to legalize marijuana for recreational use—have seen retail sales exceed a billion dollars annually (Lewis, 2017). States with recreational marijuana have been inundated with mass marketing promoting marijuana use, and also an increase in novel marijuana products with tetrahydrocannabinol (THC) content at concentrations not evaluated for safety in humans (Steigerwald et al., 2018). Given the absence of federal regulations in managing the commercial marijuana market, individual states are developing regulations governing marijuana advertising, production, and sale (National Conference of State Legislatures, 2019).

In US adults, rates of recreational marijuana use and cannabis use disorders have increased considerably over the last several years (Charilaou et al., 2017; Hasin et al., 2017; Center for Behavioral Health Statistics and Quality, 2018).

Legalization for medical purposes has been accompanied with increased daily use and marijuana use disorders among US adults (Chu, 2014; Wen et al., 2015; Martins et al., 2016; Hasin et al., 2017; Hasin, 2018). Approximately 15% of the US adult population used marijuana in some form in 2017 (Keyhani et al., 2018). Between 2016 and 2017, past-month use of marijuana increased nearly 2% among adults aged 18 to 25 years and 1.2% among adults 26 years and older (Center for Behavioral Health Statistics and Quality, 2018). Additionally, national surveys suggest the perception of “great risk” from weekly marijuana use dropped from 50.4% in 2002 to 33.3% in 2014 (Compton et al., 2016) and has dropped further since (Center for Behavioral Health Statistics and Quality, 2018). Recent national surveys also demonstrate that the public attributes benefits to marijuana that are not supported by existing scientific evidence, such as relief from anxiety, stress, and depression, improved appetite, and improved sleep (Keyhani et al., 2018).

It is unknown whether adult residents of states where marijuana has been commercialized for recreational use are more likely to attribute benefits to marijuana use. Given the growing body of evidence that adverse consequences are associated with regular marijuana use (Whiting et al., 2015; Wang et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2017), determining whether residents of recreational states perceive marijuana use differently than residents of states without commercial legalization is an important consideration and may inform the needs for more investment in communications of potential risks to the public. In this study, we examine the differences in beliefs about marijuana use and rates of use across states defined by their marijuana legalization status (recreationally legal, medically legal, nonlegal).

METHODS

Survey Development

Survey questions were developed by identifying gaps in existing federally funded national surveys, including the National Survey on Drug Use and Health (NSDUH) and Monitoring the Future (MTF), and drafting questions to address those gaps. Questions were refined through interviews with marijuana industry professionals, dispensary staff, marijuana distributors, and mental health and substance use disorder experts. Survey items developed included individual opinions on the risks and benefits of marijuana use, comparisons of risks and benefits of marijuana to other psychoactive substances, and the form, amount, and frequency with which individuals use marijuana. In total, the survey included 29 questions assessing beliefs about the risks and benefits of marijuana and 54 questions assessing marijuana use. Answer options for all opinion questions used Likert scales to allow participants to respond with the answer most closely aligned with their beliefs. All questions were written at an 8th-grade reading level and were tested on a convenience sample of 40 adults to ensure readability and construct validity. Full details on survey development have been previously published (Keyhani et al., 2018). The survey tool is available in the supplementary material (Supplementary Questionnaire 1, <http://links.lww.com/JAM/A167>).

Sampling Strategy

We conducted a survey of a nationally representative sample of 16,280 US adults on risks and benefits of marijuana use. The survey was conducted using KnowledgePanel (GfK Custom Research North America)—a nationally representative panel of civilian, noninstitutionalized US adults aged 18 years and older that has been used to survey public opinion since 1999 (Fowler et al., 2013; McAfee et al., 2013; Hanauer et al., 2014; Tomlinson et al., 2015). GfK created a representative sample of US adults by random sampling of addresses (Fant et al., 1998). The address-based sampling covers 97% of the country and encompasses a statistical representation of the US population. Households without internet access are provided with an Internet connection and a tablet to ensure participation. All participants in the panel are sampled with a known probability of selection. No one can volunteer to participate. Participants are provided with no more than 6 surveys a month and are expected to complete an average of four surveys a month (further details on the sampling strategy of GfK’s KnowledgePanel is provided here: (https://www.gfk.com/fileadmin/user_upload/dyna_content/US/documents/KnowledgePanel_Methodology.pdf). Sampling was stratified by legalization status of marijuana in the state of residence (ie, recreational, medical, and nonlegal) (Supplementary Table 1, <http://links.lww.com/JAM/A168>). California residents and young adults aged 18 to 26 years old were oversampled to facilitate a future investigation into the role of recreational legalization on use patterns among young adults in California. Sampling weights were provided by GfK.

Survey Administration

The survey was launched on September 27, 2017 to a total of 16,280 US adults 18 years and older, and was completed on October 9, 2017. The survey was administered using an online format. This study was considered exempt from review by the Committee on Human Subject Research, University of California, San Francisco.

Statistical Analysis

The response rate, determined using methods outlined by the American Association for Public Opinion Research, was the ratio of respondents to all potential participants (The American Association for Public Opinion Research, 2016). Characteristics of the survey respondents were weighted using weights provided by GfK to approximate the US population based on age, sex, race, ethnicity, education, household income, home ownership, and metropolitan area. All analyses used weighting commands using the weight variable provided by GfK to generate national estimates. We first compared the sociodemographic characteristics of our respondents to that of the NSDUH—an annual, federally funded epidemiologic survey (Center for Behavioral Health Statistics and Quality, 2018). We then compared views and forms of marijuana use of residents across recreational, medical, and nonlegal states using chi-square statistics. Finally, we reported the prevalence of different forms of use stratified by legalization status of states and the associated 95% confidence interval (CI). In supplementary analyses, using logistic regression, we examined views of residents of recreational states compared with

other states after adjusting for baseline demographic characteristics including age, sex, race, employment status, and household size. All analyses were performed with R statistical software (version R-3.4.0).

RESULTS

Response Rate and Participant Characteristics

The response rate of the survey was 56.3% ($n = 9003$) and did not vary by status of legalization in state of residence (55.2%, 55.4%, 55.3% in recreationally legal, medically legal, and nonlegal states, respectively). The rate of missing or refused questions ranged from 0% to 3.9%. The sample was 52% female, 64% white, 12% black, 16% Hispanic, and 8% other race with a mean age of 48 years. Residents of the 3 state types did not differ by age. The residents of recreational states were predominantly white and less diverse than other state types (Supplementary Table 2, <http://links.lww.com/JAM/A169>). The residents of recreational states had higher rates of education and higher income levels compared with other state types. Sociodemographic characteristics of the respondents were largely similar to those of NSDUH, though our sample had a slightly higher average income (Supplementary Table 3, <http://links.lww.com/JAM/A170>).

Beliefs Regarding Benefits Associated With Marijuana Use

Overall, residents of states where marijuana was legalized for recreational purposes were more likely to endorse the belief that marijuana had benefits compared with residents of other states (Table 1). Specifically, residents in recreationally legal states were more likely to believe marijuana could be beneficial for pain management (73% in recreationally legal states, 67% in medically legal states, 63% in nonlegal states; P value: <0.0001); provide relief from stress, anxiety, or depression (52% in recreationally legal states, 47% in medically legal states, 46% in nonlegal states; P value: 0.01); and improve appetite (39% in recreationally legal states, 36% in medically legal states, 33% in nonlegal states; P value: <0.009). Pain management was endorsed as the most important benefit regardless of state of residence (39.7% in recreationally legal states, 36.7% in medically legal states, 30.7% in nonlegal states; P value: <0.0001). Residents of nonlegal states were more likely to endorse the belief that marijuana had no benefits compared with those in recreationally legal states (14%, 16%, 19% in recreationally legal, medically legal, and nonlegal states, respectively; P value: <0.001). Multivariate analyses confirmed that residents of recreational states were less likely to believe marijuana had “no benefits” and more likely to believe that marijuana use had benefits in pain management, helped with reducing or stopping other medications, provided relief from stress, anxiety, and depression, improved sleep and appetite, and improved creativity compared with residents of medical and nonlegal states after adjusting for baseline characteristics (Supplementary Table 4, <http://links.lww.com/JAM/A171>).

Beliefs Regarding Risks Associated With Marijuana Use

The belief that marijuana use was associated with the development of addiction was similar across states (50% in recreationally legal states, 49% in medically legal states, 51% in nonlegal states; P value: 0.5) (Table 1). Residents of recreational, medical, and nonlegal states all endorsed addiction as the most important risk associated with use (19.3% in recreationally legal states, 22.1% in medically legal states, 20.5% in nonlegal states; P value: <0.0001). Multivariate analyses revealed that residents of recreational states were more likely to believe that marijuana use impaired memory, and also caused a decrease in intelligence and energy compared with residents of other medically legal and nonlegal states after adjusting for baseline characteristics (Supplementary Table 4, <http://links.lww.com/JAM/A171>).

Opinions of US Adults Regarding Public Health Domains Pertaining To Marijuana Use

Residents in recreational states were significantly more likely to believe that smoking one marijuana joint a day is somewhat or much safer than smoking 1 cigarette a day (40.8% in recreationally legal states, 39.1% in medically legal states, and 36.1% in nonlegal states) (Table 2). Residents of recreationally and medically legal states were more likely to believe second-hand marijuana smoke was somewhat or much safer than second-hand tobacco smoke (38.3% in recreationally legal states, 38.3% in medically legal states, and 35.7% in nonlegal states). Opinions regarding other relevant public health concerns were largely similar across states: most residents, regardless of legal status in state of residence, agreed that it is unsafe for children and adults to be exposed to second-hand marijuana smoke, and that marijuana use was unsafe for pregnant women. Multivariate analyses confirmed that residents of recreational states were more likely to believe that smoking 1 marijuana joint a day was safer than smoking 1 cigarette a day compared with residents of other medically legal and nonlegal states after adjusting for baseline characteristics (Supplementary Table 5, <http://links.lww.com/JAM/A172>). Residents of recreational states were also more likely to believe second-hand smoke from marijuana was safer than second-hand smoke from tobacco compared with residents of other medical and nonlegal states after adjusting for baseline characteristics (Supplementary Table 5, <http://links.lww.com/JAM/A172>).

Beliefs About The Preventive Health Benefits of Different Forms of Marijuana

Over half of US adults strongly or somewhat strongly agreed with the statement that marijuana, in the form of smoked, vaped, or edibles, had preventative health benefits. There were no significant differences in views on the preventative health benefits of different forms of marijuana between states (Table 3). Multivariate analyses demonstrated no differences across states in views on the preventative health benefits of different forms of marijuana (Supplementary Table 6, <http://links.lww.com/JAM/A173>).

TABLE 1. Views on Risk and Benefits of Marijuana Use among US Adults 18 Years and Older Categorized by State Legalization Status*

	Total US Population (N = 9003)	Recreationally Legal States (n = 772)	Medically Legal States (n = 5009)	Nonlegal States (n = 3222)	P
What do you believe are the benefits of marijuana?					
Pain management	5920 (66%)	563 (73%)	3331 (67%)	2025 (63%)	<0.0001
Treatment of disease (such as epilepsy or multiple sclerosis)	4315 (48%)	374 (48%)	2359 (47%)	1582 (49%)	0.2
Relief from stress, anxiety, or depression	4219 (47%)	403 (52%)	2338 (47%)	1478 (46%)	0.01
Improved appetite	3156 (35%)	301 (39%)	1786 (36%)	1069 (33%)	0.009
Improved sleep	2604 (29%)	258 (33%)	1480 (30%)	866 (27%)	0.002
Help decreasing or stopping other medicines	2095 (23%)	210 (27%)	1178 (24%)	706 (22%)	0.01
Improved creativity	1463 (16%)	141 (18%)	842 (17%)	479 (15%)	0.04
Improved focus or concentration	956 (11%)	81 (10%)	536 (11%)	339 (11%)	0.9
Increased energy	732 (8%)	62 (8%)	430 (9%)	240 (7%)	0.2
Other benefit	464 (5%)	34 (4%)	263 (5%)	167 (5%)	0.6
Marijuana has no benefits	1547 (17%)	107 (14%)	826 (16%)	615 (19%)	0.001
Refused	201 (2%)	14 (2%)	103 (2%)	83 (3%)	0.3
Which benefit of marijuana do you believe is most important? (respondents pick one choice from above)					
Pain management	3063 (34.8%)	301 (39.7%)	1801 (36.7%)	961 (30.7%)	<0.0001
Treatment of disease (such as epilepsy or multiple sclerosis)	2215 (25.2%)	165 (21.9%)	1190 (24.3%)	860 (27.4%)	
Relief from stress, anxiety, or depression	1026 (11.7%)	102 (13.5%)	543 (11.1%)	380 (12.1%)	
Help decreasing or stopping other medicines	210 (2.4%)	20 (2.6%)	113 (2.3%)	77 (2.5%)	
Improved appetite	193 (2.2%)	18 (2.4%)	117 (2.4%)	58 (1.8%)	
Improved sleep	94 (1.1%)	12 (1.6%)	54 (1.1%)	28 (0.9%)	
Improved focus or concentration	27 (0.3%)	0 (0.1%)	17 (0.3%)	9 (0.3%)	
Improved creativity	14 (0.2%)	2 (0.3%)	10 (0.2%)	2 (0.1%)	
Increased energy	21 (0.2%)	2 (0.3%)	15 (0.3%)	3 (0.1%)	
Other benefit	368 (4.2%)	26 (3.4%)	208 (4.3%)	134 (4.3%)	
Marijuana has no benefits	1547 (17.6%)	107 (14.1%)	826 (16.9%)	615 (19.6%)	
Refused	15 (0.2%)	1 (0.2%)	6 (0.1%)	8 (0.2%)	
What do you believe are the risks of marijuana?					
Legal Problems	4666 (52%)	367 (48%)	2464 (49%)	1834 (57%)	<0.0001
Addiction to marijuana	4499 (50%)	386 (50%)	2479 (49%)	1635 (51%)	0.5
Impaired memory	3785 (42%)	378 (49%)	2028 (40%)	1379 (43%)	0.0001
Increased use of other drugs	3365 (37%)	297 (38%)	1801 (36%)	1267 (39%)	0.01
Personal or relationship problems	3135 (35%)	311 (40%)	1632 (33%)	1192 (37%)	<0.0001
Decrease in Intelligence (IQ)	2577 (29%)	256 (33%)	1387 (28%)	934 (29%)	0.01
Decrease in energy	2466 (27%)	276 (36%)	1353 (27%)	838 (26%)	<.0001
New or worsening health problems	1625 (18%)	170 (22%)	843 (17%)	611 (19%)	0.001
Increase in stress, anxiety, or depression	1354 (15%)	167 (22%)	730 (15%)	457 (14%)	<.0001
Disrupted sleep	1017 (11%)	111 (14%)	548 (11%)	358 (11%)	0.03
Other risk	500 (6%)	57 (7%)	281 (6%)	162 (5%)	0.04
Marijuana has no risks	795 (9%)	59 (8%)	470 (9%)	266 (8%)	0.2
Refused	190 (2%)	15 (2%)	99 (2%)	77 (2%)	0.4
Which risk of marijuana do you believe is most important? (respondents pick one choice from above)					
Legal problems	1826 (20.7%)	114 (15%)	950 (19.4%)	762 (24.2%)	<0.0001
Addiction to marijuana	1873 (21.3%)	146 (19.3%)	1084 (22.1%)	643 (20.5%)	
Impaired memory	675 (7.7%)	70 (9.2%)	403 (8.2%)	202 (6.4%)	
Increased use of other drugs	1584 (18%)	135 (17.8%)	884 (18%)	564 (18%)	
Personal or relationship problems	419 (4.8%)	51 (6.7%)	202 (4.1%)	166 (5.3%)	
Decrease in intelligence	458 (5.2%)	53 (7%)	242 (4.9%)	164 (5.2%)	
Decrease in energy	249 (2.8%)	25 (3.3%)	156 (3.2%)	68 (2.2%)	
New or worsening health problems	336 (3.8%)	41 (5.4%)	178 (3.6%)	117 (3.7%)	
Increase in stress, anxiety, or depression	189 (2.1%)	19 (2.5%)	104 (2.1%)	66 (2.1%)	
Disrupted sleep	25 (0.3%)	3 (0.4%)	14 (0.3%)	8 (0.2%)	
Other risk	363 (4.1%)	39 (5.2%)	212 (4.3%)	111 (3.5%)	
Marijuana has no risks	795 (9%)	59 (7.8%)	470 (9.6%)	266 (8.5%)	
Refused	14 (0.2%)	4 (0.5%)	2 (0%)	8 (0.3%)	

*Weighted counts and percentages.

TABLE 2. Views of Americans on Important Public Health Domains Pertaining to Marijuana Use*

	Total US Population (N = 9003)	Recreationally Legal (n = 772)	Medically Legal (n = 5009)	Nonlegal (n = 3222)	P
How does smoking one marijuana joint a day compare to smoking one cigarette a day?					<0.0001
Much less safe	1609 (17.9%)	98 (12.7%)	909 (18.2%)	601 (18.7%)	
Somewhat less safe	1345 (14.9%)	107 (13.9%)	734 (14.7%)	503 (15.6%)	
As safe as	2305 (25.6%)	229 (29.7%)	1220 (24.4%)	855 (26.5%)	
Somewhat safer	1691 (18.8%)	178 (23%)	930 (18.6%)	584 (18.1%)	
Much safer	1744 (19.4%)	137 (17.8%)	1028 (20.5%)	579 (18%)	
Refused	309 (3.4%)	23 (2.9%)	187 (3.7%)	99 (3.1%)	
How addictive is marijuana?					0.01
Very addictive	2329 (25.9%)	169 (21.9%)	1267 (25.3%)	893 (27.7%)	
Somewhat addictive	4511 (50.1%)	415 (53.7%)	2511 (50.1%)	1585 (49.2%)	
Not at all addictive	2015 (22.4%)	181 (23.5%)	1151 (23%)	683 (21.2%)	
Refused	148 (1.6%)	7 (0.9%)	80 (1.6%)	61 (1.9%)	
How safe is it for pregnant women to use marijuana?					0.1
Completely unsafe	6865 (76.3%)	595 (77.1%)	3769 (75.2%)	2501 (77.6%)	
Somewhat unsafe	1418 (15.8%)	125 (16.3%)	818 (16.3%)	475 (14.7%)	
Somewhat safe	449 (5%)	41 (5.3%)	254 (5.1%)	155 (4.8%)	
Completely safe	209 (2.3%)	8 (1.1%)	130 (2.6%)	71 (2.2%)	
Refused	61 (0.7%)	2 (0.3%)	39 (0.8%)	20 (0.6%)	
How does driving under the influence of marijuana compare to driving under the influence of alcohol?					0.01
Much less safe	1365 (15.2%)	82 (10.7%)	785 (15.7%)	498 (15.4%)	
Somewhat less safe	853 (9.5%)	80 (10.4%)	454 (9.1%)	319 (9.9%)	
As safe as	4001 (44.4%)	392 (50.7%)	2211 (44.1%)	1398 (43.4%)	
Somewhat safer	1538 (17.1%)	137 (17.7%)	853 (17%)	549 (17%)	
Much safer	945 (10.5%)	60 (7.8%)	537 (10.7%)	347 (10.8%)	
Refused	302 (3.4%)	21 (2.7%)	170 (3.4%)	111 (3.5%)	
How safe is it to expose adults to second-hand smoke from marijuana?					0.2
Completely unsafe	4438 (49.3%)	372 (48.2%)	2441 (48.7%)	1626 (50.5%)	
Somewhat unsafe	2870 (31.9%)	274 (35.4%)	1597 (31.9%)	1000 (31%)	
Somewhat safe	1048 (11.6%)	87 (11.2%)	598 (11.9%)	363 (11.3%)	
Completely safe	577 (6.4%)	37 (4.8%)	331 (6.6%)	210 (6.5%)	
Refused	69 (0.8%)	3 (0.4%)	43 (0.9%)	23 (0.7%)	
How safe is it to expose children to second-hand smoke from marijuana?					0.4
Completely unsafe	6558 (72.8%)	583 (75.6%)	3605 (72%)	2369 (73.5%)	
Somewhat unsafe	1700 (18.9%)	139 (18%)	962 (19.2%)	599 (18.6%)	
Somewhat safe	465 (5.2%)	36 (4.7%)	271 (5.4%)	158 (4.9%)	
Completely safe	214 (2.4%)	11 (1.4%)	130 (2.6%)	73 (2.3%)	
Refused	65 (0.7%)	2 (0.3%)	41 (0.8%)	22 (0.7%)	
How does second-hand smoke from marijuana compare with second-hand smoke from tobacco?					0.003
Much less safe	1476 (16.4%)	93 (12%)	836 (16.7%)	548 (17%)	
Somewhat less safe	1198 (13.3%)	94 (12.1%)	644 (12.9%)	461 (14.3%)	
As safe as	2679 (29.8%)	270 (34.9%)	1443 (28.8%)	966 (30%)	
Somewhat safer	1867 (20.7%)	179 (23.2%)	1045 (20.9%)	643 (20%)	
Much safer	1493 (16.6%)	117 (15.1%)	871 (17.4%)	505 (15.7%)	
Refused	290 (3.2%)	21 (2.7%)	171 (3.4%)	99 (3.1%)	
How does smoking 1 marijuana joint a day compare with drinking 1 glass of wine a day?					0.059
Much less safe	2887 (32.1%)	209 (27.1%)	1629 (32.5%)	1048 (32.5%)	
Somewhat less safe	2134 (23.7%)	195 (25.3%)	1152 (23%)	786 (24.4%)	
As safe as	2521 (28%)	246 (31.9%)	1385 (27.6%)	890 (27.6%)	
Somewhat safer	557 (6.2%)	53 (6.9%)	308 (6.1%)	196 (6.1%)	
Much safer	653 (7.3%)	48 (6.2%)	397 (7.9%)	208 (6.4%)	
Refused	252 (2.8%)	20 (2.6%)	138 (2.7%)	94 (2.9%)	

*Weighted counts and percentages.

TABLE 3. Views of US Adults on Different Forms of Marijuana Preventing Health Problems*

	Total US Population (N = 9003)	Recreationally Legal (n = 772)	Medically Legal (n = 5009)	Nonlegal (n = 3222)	P
Edible marijuana prevents health problems					0.18
Strongly disagree	111 (1.2%)	10 (1.3%)	63 (1.3%)	38 (1.2%)	
Somewhat disagree	2627 (29.2%)	238 (30.8%)	1440 (28.8%)	949 (29.4%)	
Somewhat agree	2944 (32.7%)	281 (36.5%)	1645 (32.9%)	1017 (31.6%)	
Strongly agree	2655 (29.5%)	198 (25.7%)	1478 (29.5%)	978 (30.4%)	
Refused	666 (7.4%)	44 (5.7%)	381 (7.6%)	240 (7.5%)	
Vaping marijuana prevents health problems					0.25
Strongly disagree	112 (1.2%)	8 (1%)	62 (1.2%)	43 (1.3%)	
Somewhat disagree	3216 (35.7%)	300 (38.8%)	1780 (35.5%)	1136 (35.3%)	
Somewhat agree	3049 (33.9%)	278 (36.1%)	1688 (33.7%)	1083 (33.6%)	
Strongly agree	2113 (23.5%)	148 (19.2%)	1184 (23.6%)	781 (24.3%)	
Refused	513 (5.7%)	38 (5%)	295 (5.9%)	179 (5.6%)	
Smoking marijuana prevents health problems					0.06
Strongly disagree	91 (1%)	5 (0.6%)	53 (1%)	33 (1%)	
Somewhat disagree	3529 (39.2%)	332 (43%)	1968 (39.3%)	1229 (38.1%)	
Somewhat agree	2755 (30.6%)	252 (32.7%)	1510 (30.1%)	992 (30.8%)	
Strongly agree	2062 (22.9%)	140 (18.2%)	1173 (23.4%)	749 (23.2%)	
Refused	567 (6.3%)	43 (5.5%)	305 (6.1%)	219 (6.8%)	

*Weighted counts and percentages.

Prevalence of Use of Different Forms of Marijuana Between Residents in States With Differing Legal Status

Overall, prevalence of past-year use of any form of marijuana use was more common among residents of recreationally legal states compared with other states (20.3%, CI 19.5, 21.1 in recreationally legal states, 15.4%, CI 14.7, 16.2 in medically legal states, 11.9%, CI 11.2, 12.6 in nonlegal states) (Table 4). Use of several individual forms was also more common among residents in recreationally legal states. For example, prevalence of past-year use of edibles by residents in recreationally legal states was 11.3% (CI 10.6, 11.9) compared with 6.3% (CI 5.8, 6.8) among residents in medically legal states and 4.2% (CI 3.8, 4.6) among residents in nonlegal states.

Likewise, prevalence of past-year use of multiple forms of marijuana was highest among residents in recreationally legal states (11.1%, CI 9.9, 12.4) compared with residents in medically legal states (7.2%, CI 6.2, 8.2) or nonlegal states (4.8%, CI 4.0, 5.7).

DISCUSSION

In this national study, we found that residents of states that had legalized recreational marijuana use more commonly

attributed some benefit to marijuana than residents of medically legal or nonlegal states. We also found that the perception of risks from marijuana use was similar across states. In addition, we found that residents of states where marijuana was legalized were more likely to believe that marijuana smoke was less harmful than tobacco smoke. Finally, use of all forms and multiple forms of marijuana was more common among residents of recreationally legal states.

Several national surveys, including the NSDUH and MTF, assess individual risk perception of marijuana use among national samples, and recent research suggests that risk perception has decreased nationwide (Carliner et al., 2017; Sarvet et al., 2018). Previous research demonstrates that marijuana legalization is associated with decreases in risk perception, as evident from studies examining California pre and postmedical legalization in 1999 (Khatapoush and Hallfors, 2004). More recent research supports this assertion (Carliner et al., 2017; Sarvet et al., 2018), and while research into the role of recreational legalization specifically is limited, initial data in adolescents suggest recreational legalization has been associated with a considerable decrease in risk perception (Cerdá et al., 2017). While such surveys have adequately examined the decrease in risk perception associated with marijuana, there exists no detail on the types of risks

TABLE 4. Prevalence of Past-year Marijuana Use by Form*

	Total US Population (N = 9003)	Recreational (n = 772)	Medical (n = 5009)	Nonlegal (n = 3222)
Any use	14.6 (13.9, 15.3)	20.3 (19.5, 21.1)	15.4 (14.7, 16.2)	11.9 (11.2, 12.6)
Smoking	12.9 (12.2, 13.6)	15.4 (14.7, 16.2)	13.5 (12.8, 14.2)	11.3 (10.6, 12)
Edible	6 (5.5, 6.5)	11.3 (10.6, 11.9)	6.3 (5.8, 6.8)	4.2 (3.8, 4.6)
Vaping	4.7 (4.3, 5.1)	6.7 (5.7, 7.7)	5.3 (4.4, 6.2)	3.2 (2.5, 3.9)
Concentrate	1.9 (1.6, 2.2)	3.9 (3.1, 4.7)	2 (1.4, 2.6)	1.3 (0.8, 1.8)
Topical	0.8 (0.6, 1)	1.9 (1.4, 2.5)	0.9 (0.5, 1.3)	0.3 (0.1, 0.6)
Multiple forms	6.7 (6.2, 7.2)	11.1 (9.9, 12.4)	7.2 (6.2, 8.2)	4.8 (4, 5.7)

*Weighted counts and percentages.

individuals associate with marijuana use or potential benefits individuals assign to marijuana use. Our results show that residents of states where marijuana has been legalized for recreational use have an overall more favorable view towards potential benefits of marijuana use and were more likely to attribute benefits to marijuana use that are not supported by evidence. For example, a majority of respondents endorsed pain relief as a benefit of marijuana use, despite only limited evidence supporting its effect in managing chronic neuropathic pain and no evidence in treating other types of chronic pain (Nugent et al., 2017). There is no evidence currently available that suggests second-hand marijuana smoke is safer than tobacco smoke and some evidence suggesting it is toxic (Wang et al., 2016). There is no data suggesting that marijuana is an effective and safe treatment for insomnia (Whiting et al., 2015). When taken in context with previous research demonstrating the decrease in risk perception associated with marijuana use, our findings are significant as they illustrate the need for targeted public health campaigns to combat misinformation specifically in states with recreational marijuana legalization.

We found that residents of recreationally legal states expressed less concern regarding second-hand marijuana smoke compared with second-hand tobacco smoke, and were more likely to believe that smoking marijuana is somewhat or much safer than smoking tobacco. These differences in perception are concerning, given the evidence that inhalation of particulate matter in any form (smog, second-hand tobacco smoke, or smoking) is associated with increased cardiovascular risk (Pope et al., 2011; Kim et al., 2015). The perception that marijuana smoke is relatively safe compared with tobacco smoke has been perpetuated by the spread of inaccurate information on the internet (Loria and Welsh, 2015). Some highly frequented internet sites suggest that smoking marijuana has many health benefits, such as improvement of lung health or the slowing of Alzheimer symptoms (Loria, 2018). There is currently no data to suggest that smoking marijuana improves lung health. On the contrary, recent evidence demonstrates smoking marijuana is associated with coughing, wheezing, and sputum production (Ghasemiesfe et al., 2018). The lack of a clear federal public health response to the growing legalization of marijuana and proliferation of pro-marijuana marketing has left a vacuum that is filled by commercial interests (Bierut et al., 2017).

Unlike the tobacco industry, the marijuana industry has remained largely unchallenged by a coordinated regulatory response, and is aggressively advertising its product in states with rapidly expanding commercial markets (Bierut et al., 2017; Krauss et al., 2017; Fiala et al., 2018; Glantz et al., 2018). Over half of adults living in states with recreational marijuana are frequently exposed to pro-marijuana advertising in numerous forms (Abraham et al., 2018; Fiala et al., 2018), and research indicates that greater exposure to pro-marijuana advertising is associated with heavier marijuana use among adolescents and heavier use among adult persons who use (D'Amico et al., 2015; Krauss et al., 2017). More stringent regulations of marijuana product marketing, and also a cohesive public health messaging campaign, are necessary to combat misinformation and communicate the potential

risks associated with marijuana use so consumers can make informed choices about use.

With the exception of smoking rates, which were roughly equivalent among residents in recreationally legal and medically legal states, prevalence of use among all forms of marijuana and use of multiple forms of marijuana was higher among residents in recreationally legal states. This is not surprising, given that novel forms of marijuana are more accessible in states with robust recreational markets. For example, in the first year with an active recreational marijuana market, Colorado dispensaries sold 4.81 million units of edible cannabis product (about 45% of the total annual sales) (Barrus et al., 2016). The popularity of marijuana products in forms other than smoking is a cause for some concern as such products are increasingly available with THC content at high levels not yet studied. Previous research suggests that some edible products exceed state-mandated THC thresholds and can reach as high as 7000 mg per package (Steigerwald et al., 2018). Given the growing popularity of marijuana in forms like edibles or extracts, increased focus should be directed towards understanding the health effects of THC at such concentrated levels. In the absence of evidence of harms, states may be reluctant to more stringently regulate the form and content of edible products.

There are several limitations to this study. The generalizability of our results may have been limited by the use of an internet survey as the population who choose to join an ongoing internet panel may be different from individuals who choose not to participate. However, GfK's KnowledgePanel has demonstrated no evidence of nonresponse bias in the panel on core demographic and socioeconomic variables (Heeren et al., 2008). We did not conduct reliability testing of the survey items. As a result, it is possible the interpretation of our questions might differ between participants. For example, though pain management was endorsed as the most important benefit across residents of all states, we did not distinguish between types of chronic pain, and this may have been interpreted differently between participants. Additionally, we did assess the extent of individual marijuana use among participants, medical reasons for use among marijuana users, and sources of information regarding beliefs about marijuana. However, the data were not sufficiently relevant when stratified by state legalization status. Furthermore, it is important to note that we did not differentiate between state legal status beyond the designation of "recreationally legal, medically legal, or nonlegal," and marijuana accessibility can vary greatly within states with the same legal status due to differences in state-based implementation. Nonetheless, we found clear differences in opinions of residents of recreationally legal states compared with other states. Finally, the study was cross-sectional. Therefore, it is unknown if people in states where marijuana was legalized for recreational use developed their beliefs before legalization, which then led to legalization in their state, or if the opinions assessed in this survey were a result of recreational legalization of marijuana.

CONCLUSIONS

The US adults residing in recreationally legal states were most likely to believe marijuana has benefits and that

marijuana smoke is safer than tobacco smoke. Residents of recreationally legal states had the highest rates of use of different forms of marijuana. The favorable views of residents in recreationally legal states are cause for concern given the tide of commercialization, growing number of unstudied high potency products, and the favorable media coverage promoting use.

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