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Attitudes and knowledge about cannabis and cannabis-based therapies among US neurologists, nurses, and pharmacists

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ABSTRACT

Use of cannabinoid therapies is on the rise in the United States, but responses of healthcare professionals and their knowledge of these therapies have been mixed. More information is needed about factors associated with healthcare professionals' attitudes and knowledge about medical cannabis. We conducted an online survey of US-based neurologists, nurse practitioners (NPs)/nurses, and pharmacists in August–September of 2018 (n = 451). We constructed perceived knowledge and attitudes scales and a knowledge index from multiple items and assessed state cannabis laws, participant's sociodemographics, workplace type and policies, and patient population. We used ordinary least-squares regression to examine associations among study variables. Over 80% of participants supported use and legalization of medical cannabis, especially cannabidiol (CBD) for epilepsy and when prescribed by a medical provider, but 40–50% (depending on item) felt unfamiliar with cannabinoid pharmacology and clinical applications. A total of 43% favored legal recreational cannabis. Pharmacists scored higher on the knowledge test than neurologists and NPs/nurses, but NPs/nurses had more favorable attitudes than neurologists and higher perceived knowledge than pharmacists. Both knowledge indicators predicted attitudes. State cannabis access and favorable workplace policies were associated with higher knowledge and more favorable attitudes. Healthcare professionals see potential in cannabis therapies but report significant knowledge gaps. Professional cannabinoid education is needed to address growing patient and provider demand for knowledge about cannabinoid therapies.

1. Introduction

There is a growing interest in cannabis for therapeutic purposes. *Cannabis sativa* L, also referred to as marijuana or hemp, has been used as material and medicine by humans for over 5000 years [1]. Over 120 phytocannabinoids and 200 terpenes have been identified in cannabis, many of which have pharmacological properties [2]. The primary phytocannabinoid constitutes are delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD). While THC has psychoactive (mood altering) properties and may have harmful effects on the developing brain, CBD is nonintoxicating and devoid of psychoactive effects. Thousands of studies [3] suggest that cannabis/cannabinoid-containing products with a variety of THC:CBD ratios can be effective in treating some of the symptoms associated with human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), cancer, glaucoma, multiple sclerosis, epilepsy, pain, sleep, anxiety, trauma, and other conditions – but there are also risks and much that remains unknown about cannabis-based products/therapies.

US public support and state-based legalization of cannabis for medical or recreational (adult) use are spreading. A total of 93% percent of Americans support medical use [4], and over 60% support legal recreational adult use [4–6]. As many as 34 states, District of Columbia (DC), Guam, Puerto Rico, and US Virgin Islands have comprehensive, publicly

Abbreviations: THC, delta-9-tetrahydrocannabinol; CBD, cannabidiol; HIV, human immunodeficiency virus; AIDS, acquired immunodeficiency syndrome; DC, District of Columbia; HCPs, healthcare professionals; FDA, US Food and Drug Administration; NP, nurse practitioner; SE, standard error; CME, continuing medical education.

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available medical cannabis programs, and 12 states allow use of low THC, high CBD products for limited medical purposes; only four states have no public cannabis access programs [7]. Ten states and DC have legalized adult (21 years+) cannabis use, and nine states regulate cannabis production and sales, including taxing. Two US territories (Guam, Northern Mariana Islands) have also legalized adult use and passed laws to tax and regulate sales [8]. However, at the federal level, cannabis remains classified as a controlled substance, and its distribution, with few exceptions, is a federal offense [9,10]. In 1985, dronabinol was approved by the US Food and Drug Administration (FDA) for use in patients with AIDS and cancer. In 2018, the FDA approved plant-derived highly-purified CBD (Epidolex®, Greenwich Biosciences, Inc.) oral solution for the treatment of seizures associated with Lennox–Gastaut and Dravet syndromes, and later that year, the Farm Bill excluded hemp from the Controlled Substances Act (CSA) definition of "marihuana" [10]. Per FDA, CBD cannot be legally sold as a supplement or food until the agency determines how it should be regulated. Other medical cannabis applications remain in a legal limbo [11]. The key policy issue is how to regulate medical cannabis, especially in terms of its recommendation and dispensing [7].

With these fast-pacing scientific, public opinion, and policy/legal developments, it is paramount to consider what healthcare professionals (HCPs) think and know about cannabis/medical cannabis use. Internationally, 76% of practicing physicians [12] and 82% of general practitioners (physicians, nurses, and allied health professionals) [13] expressed support for medical cannabis use in treating cancer and treatment-resistant epilepsy, respectively. However, only 48% of epileptologists/neurologists favored medical cannabis in the latter case. In Canada, where medical cannabis has been available since 1999, significant gaps in knowledge of cannabis have been reported among physicians [14]. Several US-based specialty and regional surveys have also been conducted [14–23]. As many as 94% of epilepsy providers in 2014 had patients seeking cannabis treatment for epilepsy, and 64% had patients using some form of cannabis, but 27% did not feel knowledgeable to make a recommendation and only 2% had knowledge/information on proper dosing [17]. Also, the majority of New York physicians were willing to refer patients to providers registered in the State Medical Marijuana Program but admitted low familiarity with the program and modest medical cannabis knowledge [23]. Many healthcare professionals/trainees across various groups and geographic areas feel uncertain about benefits and risks of medical cannabis and/or are uncomfortable and inconsistent when talking to patients [16,18,19,21,22].

Despite the growing literature, it remains unclear what HCPs across the United States know and think about cannabis/medical cannabis. The regional, specialty or disease specific, and single-site surveys suggest mixed knowledge and attitudes among HCPs and trainees, but broader contemporary information from across the country is limited. We conducted an online survey to examine attitudes and knowledge regarding cannabis for medical and recreational purposes among neurologists, nurse practitioners (NP)/nurses, and pharmacists. Based on the past literature, we hypothesized that NP/nurses and pharmacists would have more favorable attitudes toward cannabinoid therapies than neurologists. We also hypothesized that neurologists would be more knowledgeable than NP/nurses and pharmacists because they specialize in conditions (epilepsy, movement disorders, and pain) in which cannabis therapies are gaining traction. We further hypothesized that state and workplace restrictions on medical cannabis would be associated with lower knowledge and less favorable attitudes among HCPs and that knowledge would be predictive of attitudes.

2. Material and methods

2.1. Data

A targeted, national, and quota-based online survey of US-based neurologists, pharmacists, and NPs/nurses was conducted in August–September of 2018. An interdisciplinary panel of experts (this research team) developed an online questionnaire consisting of 29 structured items that tapped into attitudes/knowledge regarding CBD therapies (with a focus on epilepsy), medical cannabis more broadly, and recreational cannabis. The attitudes addressed perceived effectiveness of CBD/medical cannabis, regulation and availability of products, and stigma associated with recommending CBD treatment. The knowledge domains covered the endocannabinoid system, pharmacology, effects, clinical applications, and government regulation [24]. Sociodemographic, professional education, tenure, and work setting information was also collected from the survey respondents. The majority of questions on the survey had to be answered in order to complete the survey, in an aim to minimize missing or incomplete data. The University of Alabama at Birmingham Institutional Review Board approved this study.

The data were collected by Qualtrics/SAP (https://www.qualtrics.com/). Participants were recruited from HCP panels developed by Qualtrics. Panel member contact information was validated via third-party verification measures prior to their joining a panel. Panel members were sent an email invitation or were prompted on the respective survey platform to proceed with the survey using a provided hyperlink. Monetary incentive was offered (undisclosed amount determined by Qualtrics and varied by respondent). The targeted enrollment was 150 for each professional group: neurologists, NPs/nurses, and pharmacists. The estimated overall survey response rate (number of respondents invited versus number of respondents who started the survey) was 3%. The estimated incidence rate (number of people who took the survey compared with the number who actually qualified) was about 93%. The final sample size was 451.

2.2. Measures

The attitudes and knowledge regarding cannabis/medical cannabis were assessed using batteries of Likert-type and a few categorical items (Supplementary File, Table S1). The attitudinal items addressed regulation and clinical applications of cannabis-based products. The perceived knowledge items focused on properties of cannabinoids (endocannabinoid system, pharmacology) and clinical applications. Two additive scales were constructed for attitudes (13 items; Cronbach's alpha = 0.91) and perceived knowledge (27 items; Cronbach's alpha = 0.97). Higher scale scores reflected more favorable attitudes and higher perceived knowledge. In addition, a basic knowledge test (score: 0–5) was constructed from 5 items asking about the number of phytocannabinoids in the cannabis plant, adverse effects of cannabinoids, and regulation of cannabis-based products. Also, a single item asked whether there is a stigma associated with recommending CBD for treating epilepsy. This measure was nonnormally distributed and was dichotomized in bivariate analyses as "agree" (somewhat agree/agree/strongly agree) or "disagree" (strongly disagree/somewhat disagree/disagree/neither agree or disagree).

Provider type was assessed by asking the respondent to identify their profession as neurologist, nurse, or pharmacist. We dummy-coded each provider group for use in multivariable analyses. In addition, we identified a subsample of NPs by asking respondents about their highest professional degree. Professional tenure was assessed with the number of years of practicing as an independent provider. Age, sex, race, and ethnicity information was also collected.

Workplace categories included community hospital, academic hospital, private practice, or other type of setting. Options for workplace policies for medical cannabis administration included the following: "don't ask, don't tell;" nursing/med techs must administer; pharmacy must administer patient-provided product; patient must administer own supply; not allowed; other; and "don't know." Binary indicators for academic workplace, "no medical cannabis allowed," and 50%+ pediatric practice versus were constructed for bivariate/multivariable analyses.

We also created a variable indicating if the respondent practiced in a state that had legalized medical cannabis broadly; a state that had limited, compassionate access to medical cannabis for specific conditions; a state that had legalized any adult cannabis use; or a state where any cannabis use was illegal. State cannabis access [7] at the time of the study was assessed in multivariable analyses on a scale from 0 (no cannabis access laws) to 3 (adult recreational and medical use law). Finally, the survey asked about preferred methods for learning about cannabis/cannabinoid therapies.

2.3. Procedure of analysis

Bivariate associations were estimated using *t*-tests, chi-square tests, and Pearson correlations. Multivariable regression analyses examined the extent to which attitudes/knowledge about cannabis/medical cannabis were associated with respondent's professional and sociodemographic characteristics, workplace type and medical cannabis policy, and state law. Three ordinary least-squares regression models were estimated, one for each of the following dependent variables: knowledge test, perceived knowledge, and attitudes. The model predicting knowledge test included provider type, academic affiliation, workplace policy, state regulation level, and gender. Age and tenure were not included because they had no bivariate associations with the attitudes/knowledge measures. The model predicting perceived knowledge included knowledge test score in addition to the factors included in the knowledge test model. Finally, the model predicting attitudes included knowledge test and perceived knowledge in addition to the other factors. Statistical significance was assessed at alpha = 0.05.

2.3.1. Missing data

About 1.6% of respondents used the "N/A" (not applicable) response on one or more attitudinal/knowledge items, and 0.4% preferred not to respond on age. We used pairwise deletion in the analyses that included the scales and noted any reduced sample sizes in the tables. About 2% preferred not to respond on sex but were retained as a control. Also, 11.3% were missing on cannabis education preferences because the item did not force a response (survey error), but this item had a descriptive purpose and did not affect the overall analysis.

3. Results

The sample was 53% female, 83% white, and 4% Hispanic/Latinx; 65% reported 11 + years of professional tenure (Table 1). Twenty-four percent worked in academic hospitals, 11% in pediatric practices, and 45% in places that did not allow medical cannabis use. Fifty-eight percent resided in states with comprehensive marijuana laws.

The distributions of attitudinal and knowledge items (Fig. 1 and Appendix A, Supplementary Data, Tables S2–S4) indicate generally favorable attitudes but mixed levels of knowledge about CBD/medical cannabis. For example, over 80% of providers favored the federal government and states allowing medical cannabis, especially CBD for treating epilepsy and when prescribed by a medical provider. Fewer, 43%, supported legalization of recreational cannabis. A total of 20%–44% (depending on the item) considered themselves not knowledgeable at all about CBD/medical cannabis or were unfamiliar with issues related to regulation and availability of cannabis products. The test results showed gaps in knowledge: 26%–68% answered incorrectly or did not know the answer to a particular question (Appendix A, Table S4).

There were some differences in attitudes/knowledge by professional group (Table 2). Nurse practitioners/nurses had higher scores on attitudes than neurologists and pharmacists, and NPs/nurses and neurologists had higher perceived knowledge than pharmacists. However, pharmacists scored higher on the knowledge test than neurologists and NPs/nurses. Agreement that there is stigma attached to recommending medical cannabis ranged from 74% among neurologists to 88% among all nurses and 92% among NPs. Significant bivariate associations were observed for knowledge test, perceived knowledge, and attitudes; state access and knowledge test; workplace policy and perceived knowledge; and gender and both knowledge indicators (Appendix A, Table S5). Bivariate associations between other provider's characteristics and attitudes/knowledge were generally nonsignificant.

In the regression analysis, provider type showed independent associations with knowledge test, perceived knowledge, and attitudes (Table 3). Specifically, neurologists and NPs/nurses had, on average, lower scores on the knowledge test than pharmacists, other things equal ($b = -0.504$, standard error [SE] = 0.145, $p = 0.001$ and $b = -0.378$, SE = 0.147, $p = 0.011$; Model 1). In addition, state access was associated with a higher knowledge score ($b = 0.215$, SE = 0.078, $p = 0.006$), and women had a lower knowledge score than men ($b = -0.285$, SE = 0.130, $p = 0.029$).

Furthermore, knowledge test, provider type, work setting, and sex were all significant predictors of perceived knowledge (Model 2). Each point on the test was associated with a 4-point increase in perceived knowledge ($b = 4.101$, SE = 0.897, $p < 0.001$), other things equal. Nurse practitioners/nurses scored, on average, higher than pharmacists on perceived knowledge ($b = 7.217$, SE = 2.795, $p = 0.010$), but neurologists and pharmacists reported similar levels of perceived knowledge. Also, providers in settings that did not allow medical cannabis scored, on average, lower on perceived knowledge than providers in settings with more open medical cannabis policies ($b = -8.298$, SE = 2.207, $p < 0.001$). Further, women scored, on average, lower than men on perceived knowledge ($b = -6.219$, SE = 2.455, $p = 0.012$).

As expected, both knowledge indicators were significant predictors of attitudes (Model 3). Higher perceived knowledge and test scores were associated with more favorable attitudes, independently of each other and of other factors ($b = 0.240$, SE = 0.027, $p < 0.001$ and $b = 1.096$, SE = 0.519, $p = 0.035$). Neither neurologists nor NPs/nurses differed from pharmacists in attitudes, but after rotating the reference category, NPs/nurses had, on average, more favorable attitudes than neurologists ($b = 4.944$, SE = 1.678, $p = 0.003$). Women had, on average, less favorable attitudes than men ($b = -2.749$, SE = 1.392, $p = 0.049$).

Continuing medical education (CME), webinar, and lecture were the top choices for cannabis/medical cannabis education followed by medical journal, colleagues, legal counsel, practice administrator, and other method. However, NPs/nurses (all), NPs (alone), and pharmacists preferred webinar over CME.

4. Discussion

This study examined attitudes/knowledge about cannabis/medical cannabis in a contemporary sample of US-based neurologists, NPs/nurses, and pharmacists. The results showed generally favorable attitudes about medical cannabis use, especially FDA-approved CBD, but perceived and actual knowledge were mixed, partly based on provider type. The study also documented multivariable associations among knowledge, attitudes, provider type, and contextual factors, such as state cannabis law and workplace policies. As expected, actual knowledge predicted perceived knowledge, and both knowledge indicators predicted attitudes. State access and workplace permissions were associated with higher levels of knowledge and more favorable attitudes. The study's main strengths include a national sample, specialty-group comparisons, comprehensive data collection, and multipronged analysis.

This study confirms and extends past literature. Modest to moderate rates (18–60%) of support (opinion or practice) for medical cannabis have been reported in other samples [14–16,19,25,26] with several studies reporting higher rates (71–86%) [12,18,22,23]. In our study, over 80% of HCPs favored legalization of medical cannabis, especially CBD for treating epilepsy and when prescribed by a medical provider. When considering neurologists specifically, only 48% of epileptologists/neurologists

Table 1
Percentage distributions of sociodemographic, professional, and contextual characteristics of US healthcare professionals (n = 451) surveyed in August–September, 2018 – all respondents and by specialty.

	All	Neurologists[a]	NP/nurses[b]	NPs[c]	Pharmacists[b]
Sex					
Female	52.5	24.5	86.0	80.0	47.3
Male	45.9	73.5	13.3	20.0	50.7
Prefer not to respond	1.6	2.0	0.7	0.0	2.0
Age group					
24–44 years	47.0	43.7	39.3	43.3	58.0
45–55 years	29.3	25.2	37.4	38.3	25.3
56–75 years	23.3	30.4	22.6	18.3	16.7
Prefer not to respond	0.4	0.7	0.7	0.0	0.0
Race					
White	82.9	66.9	90.0	88.3	92.0
Black/African-American	3.5	3.3	5.3	6.7	2.0
Asian	10.9	24.5	3.3	3.3	4.7
Other[d]	3.5	4.0	1.3	1.7	1.3
Hispanic or Latino/a					
Yes	3.8	3.3	4.0	1.7	4.0
No	96.2	96.7	96.0	98.3	96.0
Professional tenure					
Resident/trainee	5.8	4.0	11.3	3.3	2.0
<5 years	13.1	15.2	10.7	15.0	13.3
6–10 years	18.6	19.2	15.3	18.3	21.3
11–20 years	32.4	32.5	33.3	40.0	31.3
21+ years	30.2	29.1	29.3	23.3	32.0
Work setting[e]					
Community hospital	24.8	23.2	27.3	26.7	24.0
Academic hospital	24.2	40.4	17.3	18.3	14.7
Private practice	39.0	47.7	50.7	48.3	18.7
Other	20.0	2.6	10.7	10.0	46.7
State law/cannabis access[f]					
No marijuana access laws	3.3	2.6	6.0	3.3	1.3
CBD/low THC product law	22.4	17.2	22.0	15.0	28.0
Comprehensive medical marijuana law	57.9	57.0	59.3	70.0	57.3
Adult and medicinal use regulated law	16.4	23.2	12.7	11.7	13.3
Work setting policies regarding use of cannabis-based therapies					
"Don't ask, don't tell"	6.7	11.9	4.0	1.7	4.0
Nursing or med techs must administer patient-provided product	5.1	2.0	11.3	10.0	2.0
Pharmacy must administer patient-provided product	9.8	13.9	10.7	15.0	4.7
Patient must administer own supply	18.4	25.8	17.3	20.0	12.0
Not allowed	45.7	27.8	43.3	43.3	66.0
Other	4.4	5.3	2.7	1.7	5.3
Do not know	10.0	13.2	10.7	8.3	6.0
50%+ pediatric practice	11.3	17.2	14.7	8.3	2.0

Note. NP = nurse practitioner; CBD = cannabidiol; THC = delta-9-tetrahydrocannabinol.
[a] n = 151.
[b] n = 150.
[c] Nurse subsample n = 60.
[d] American Indian or Alaskan Native, Native Hawaiian, Pacific Islanders, and "other" race.
[e] Multiple responses were possible. Percentage distributions do not add up to 100.
[f] As of July 1, 2018. Source: www.ncsl.org.

in 2014 would advise using medical marijuana in severe cases of epilepsy [13]. In the current study, over 60% of neurologists agreed/strongly agreed and 23% somewhat agreed that CBD is effective for epilepsy. Furthermore, 48% favored/strongly favored and 29% somewhat favored CBD as a method of treating epilepsy. Similar rates were noted for opinions regarding CBD's effectiveness in reducing seizure frequency and severity. This suggests growing, though still uneven, agreement among neurologists about CBD use for treating epilepsy.

However, neurologists' attitudes in our study were not as favorable as those of NPs/nurses and pharmacists. This is similar to the 2014 study, where general practitioners, nurses, allied professions, patients, and advocates all had more favorable attitudes toward CBD than epileptologists/neurologists [13]. These findings are consistent with qualitative research [27] reporting differences in "interpretations of the value of medical cannabis use and who should have access to it" by stakeholder type (patients, general practitioners, specialty providers, and the state; p. 115). In addition, the rates of support for CBD/medical cannabis among all providers in our study were lower than those of the American public's (93%) [4], and support for legalization of recreational cannabis (43%) was lower than the general public (60%) [4–6] or Colorado medical students (64%) [18].

Our study also asked providers about stigma of recommending CBD for epilepsy. Over 82% of the providers agreed that such stigma exists. Reasons for social stigma of medical cannabis use have previously been highlighted [27,28], including negative views of cannabis as a recreational drug, criminal sanctions associated with cannabis use, and use of cannabis in the context of existing illness or disability (which can have their own stigma) [28]. Stigma of medical cannabis use threatened or harmed people's social, professional, and family relationships, sometimes leading to social isolation, estrangement from family/friends, and relocation to another city. It is quite possible that similar mechanisms – from legal liability to social shunning or discomfort – are at play in recommending medical cannabis by a HCP. Providers who support medical cannabis use may be more comfortable practicing in places where medical cannabis/cannabis is legalized (states) or accepted (work settings) and decide to relocate for that reason. Almost half of

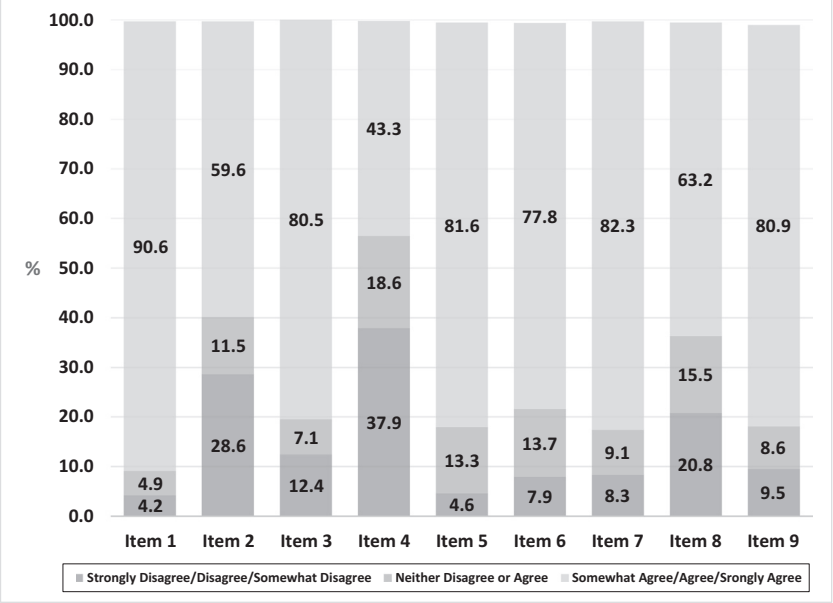

Fig. 1. Percent distributions of responses to statements about cannabis/medical cannabis among US healthcare professionals (n = 451) surveyed in August–September, 2018. Note: "NA" responses (<1%) are not shown. Items 1–9 correspond with the following statements: *Item 1*: I support the legalization of the FDA-approved and regulated version of CBD prescribed by healthcare professionals for treatment of epilepsy. *Item 2*: I support the full legalization of all CBD products including non-FDA (artisanal) products available through dispensaries. *Item 3*: The use of any cannabis products for medical purposes if it is prescribed by a medical provider should be legal. *Item 4*: The use of cannabis for recreational purposes should be made legal. *Item 5*: I believe that CBD is effective for epilepsy. *Item 6*: I favor the use of CBD as a method of treating epilepsy. *Item 7*: There is stigma associated with recommending CBD for treating epilepsy. *Item 8*: I have sufficient knowledge of CBD treatment for epilepsy. *Item 9*: I need further education about CBD treatment for epilepsy.

providers in our study practiced in work settings that did not allow medical cannabis use, which means that stigmatizing settings are common and could affect many providers. Further research on medical cannabis-related stigma among HPCs and in healthcare settings is warranted.

Many providers in our study seemed to lack basic knowledge about the content, effects, and legality of cannabis/medical cannabis. The majority did not know how many different phytocannabinoids are present in the cannabis plant (68%) or whether medical use of isolated plant-derived cannabinoids (62%) or hemp (52%) was permitted per federal law. Some did not know if medical cannabis is legal per federal law (26%) or if effects of cannabis products depend on their content (CBD, THC, etc.; 16%). Perceived knowledge was also modest, with as many as 20%–44% admitting no knowledge at all on specific items. Some even felt unfamiliar with short- and long-term effects of recreational cannabis. These results confirm prior reports of significant gaps in knowledge [29], which, considering the growing access to and demand for medical cannabis, needs urgent attention. There have already been calls and proposals for incorporating cannabis education into medical [24,29,30] and pharmacy [31] curricula, emphasizing historical, botanical, physiological, clinical, and legal aspects to allow HCPs to engage in productive discussions with patients/families and other professionals [24]. In particular, providers need to be educated that "cannabis products vary considerably." Growing conditions, contamination, formulation/chemical constituents, delivery, and other factors greatly impact the content and end effects of cannabis. Furthermore, patient variability, food effects, condition specific considerations, and so on need attention when making treatment recommendations. The nuance of developing cannabis education is critical. Current generalizations (aside from law) seem to hamper both research and providers' (and others') understanding of medical cannabis.

It is notable that state laws had little association with participants' knowledge, suggesting that legalization of medical/recreational cannabis does not directly translate into greater knowledge among providers. In the future, the time from legalization might be important to consider. The piecemeal approach to legalizing medical cannabis creates gaps in knowledge [11], and the federal ban is a disincentive to developing cannabis education. However, provider's gaps in knowledge are already straining patient–provider relations [27] and limit clinical management. The growing demand for medical cannabis education among providers (because of patient demand) may be a game changer.

Our study had several limitations. The study sample may not be representative, and thus, the findings may not be generalizable to the larger population of HCPs, specialties outside of this study, and providers in other societal contexts. The NP/nurse sample was also not ideal. We would have preferred to sample NPs alone because they engage in patient care directly and can often prescribe treatments while other nurses cannot, but an NP-specific panel was not available within our multigroup study design. In addition, the survey instrument, though detailed, needs more refinement and testing in other samples and populations. Especially, the knowledge test was limited. This is partly a reflection of a still evolving knowledge of cannabinoids [32] and limited reliable educational tools [24], including test item batteries. Also, the content validity and psychometric properties of our compound measures need to be further established (e.g., using factor analysis [33]).

These limitations notwithstanding, our findings suggest growing support for medical cannabis among HCPs along with consistently mixed levels of knowledge. Some differences by provider type were noted, with general practitioners showing more enthusiasm than specialists. Nonetheless, the need for education among HCPs is high. With a few educational options currently available, future efforts should focus on the development of curricula for health professional schools, specialty training (e.g., board exams), and continuous education programs. In addition, further research using diverse designs, including qualitative/mixed-method [27,34] and stakeholder-engaged studies [35], is recommended to guide educational, clinical, and health system interventions. A growing number of patients nationwide are looking to HCPs to prescribe/guide them in the use of cannabinoid-based therapies. Many HCPs are not educated enough to counsel their patients and recommend specific products or dosing. Patients are often left on their own to seek/obtain products and figure out dosing. Self-treatment may be harmful. Properly educated HCPs can weigh potential benefits/

Table 2
Descriptive statistics for attitudes and knowledge measures among US healthcare professionals (n = 451) surveyed in August–September, 2018 – all respondents and by specialty.

	All	Neurologists	NP/nurses	NPs[a]	Pharmacists
Attitudes[b]					
Mean (SD)	54.4 (13.9)	52.9 (12.5)	56.3 (13.7)	57.4 (12.4)	58.8 (15.1)
Range	10–78	13–78	24–78	30–78	10–78
Valid n	445	148	147	59	150
Perceived knowledge[c]					
Mean (SD)	38.2 (23.0)	39.3 (23.3)	40.0 (24.0)	43.6 (25.5)	35.2 (21.4)
Range	3–112	7–112	8–109	9–109	3–109
Valid n	446	149	149	60	148
Knowledge test[d]					
Mean (SD)	2.8 (1.2)	2.7 (1.1)	2.6 (1.2)	2.6 (1.2)	3.0 (1.2)
Range	0–5	0–5	0–5	0–5	0–5
Valid n	451	151	150	60	150
Stigma[e]					
Proportion	0.8	0.7	0.9	0.9	0.9
Valid n	449	151	148	60	150

Note. NP = nurse practitioner.
[a] Nurse subsample.
[b] 13 items. Cronbach's alpha = 0.91. Higher values reflect more favorable attitudes.
[c] 27 items. Cronbach's alpha = 0.97. Higher values reflect higher perceived knowledge.
[d] 5 items (index = test score).
[e] Single item: proportion of respondents who agree (somewhat agree, agree, and strongly agree) that there is stigma associated with recommending cannabidiol (CBD) for treatment of epilepsy.

risks of medical cannabis for individual patients and help mitigate potentially unsafe practices. Thus, professional cannabinoid education nationwide is immensely needed.

Declaration of competing interest

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Table 3
Predictors of knowledge and attitudes regarding cannabis and cannabis-based therapies among US healthcare professionals (n = 451) surveyed in August–September, 2018.

	b	SE	P
Model 1 - knowledge test			
(Constant)	2.811	0.200	<**0.001**
Neurologist[a]	−0.504	0.145	<**0.01**
NP/nurse	−0.378	0.147	**0.01**
Workplace does not allow cannabis therapies	−0.041	0.117	0.73
State CBD/cannabis access level	0.215	0.078	**0.01**
Female[b]	−0.285	0.130	**0.03**
Sex not reported	−0.059	0.451	0.90
R-square = 0.058, adj. R-square = 0.045, df = 6, n = 450			
Model 2 - perceived knowledge			
(Constant)	30.576	4.552	<**0.001**
Knowledge test score	4.101	0.897	<**0.001**
Neurologist	1.221	2.762	0.66
NP/nurse	7.217	2.795	**0.01**
Workplace does not allow cannabis therapies	−8.298	2.207	<**0.001**
State CBD/cannabis access level	0.322	1.484	0.83
Female[b]	−6.219	2.455	**0.01**
Sex not reported	−3.560	8.427	0.67
R-square = 0.107, adj. R-square = 0.093, df = 7, n = 445			
Model 3 – attitudes			
(Constant)	42.816	2.698	<**0.001**
Perceived knowledge	0.240	0.027	<**0.001**
Knowledge test score	1.096	0.519	**0.04**
Neurologist	−2.040	1.564	0.19
NP/nurse	2.904	1.586	0.07
Workplace does not allow cannabis therapies	0.275	1.270	0.83
State CBD/cannabis access level	0.148	0.836	0.86
Female[b]	−2.749	1.392	<**0.05**
Sex not reported	8.748	5.108	0.09
R-square = 0.221, adj. R-square = 0.206, df = 8, n = 440			

Note. Estimates from ordinal least-square regression models are shown, each with a different dependent variable: knowledge test (Model 1), perceived knowledge (Model 2), and attitudes (Model 3). Results from 2-sided significance tests at P < 0.05 are listed in bold. NP = nurse practitioner; CBD = cannabidiol.
[a] Dummy-coded variables were created for 3 provider types: neurologist, NP/nurse, and pharmacist. "Pharmacist" was omitted in the models as a reference group. The models were also estimated rotating the reference category to derive all pair comparisons.
[b] Dummy-coded sex variables were created for three response categories: male, female, and "prefer not to respond." "Male" was omitted in the models as a reference group.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.yebeh.2020.107102.

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