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Knowledge, attitudes, and practices towards monkeypox during the 2022 outbreak: An online cross-sectional survey among clinicians in Ohio, USA

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ABSTRACT

Background: Controlling monkeypox effectively requires clinicians have knowledge of monkeypox, attitudes supporting of controlling it, and intentions to adopt practices to address it. Little is known, however, about levels of knowledge, attitudes, and practices (KAPs) in clinician populations in Ohio, United States.
Methods: A cross-sectional, internet-based questionnaire assessed knowledge related to monkeypox, attitudes toward ability to control monkeypox and the threat of monkeypox, and prior relevant practices of having received a smallpox vaccine or having knowledge of monkeypox before 2022, intentions to adopt preventive practices, and demographics. Frequency reporting was used to assess overall knowledge and attitudes. Binary logistic regression was used to predict which KAPs were associated with behavioral intentions.
Results: A total of 197 clinicians participated. No demographic factor was associated with KAPs. Clinicians had relatively poor levels of knowledge. Participants expressed mixed attitudes about eventual control of monkeypox and about threat posed by monkeypox. About one in four participants reported previous knowledge of monkeypox, and about 40 % had received a smallpox vaccine Clinicians reported insufficient levels of intention to adopt preventive practices. Binary regression analysis suggests only perceptions of the threat of monkeypox to public health were associated with intentions to vaccinate self or others.
Conclusions: Educational interventions with clinicians should address inadequate knowledge to support correct diagnosis and treatment. Efforts to enhance the perception of threat of monkeypox to public health may support adherence to preventive recommendations.

Introduction

Monkeypox, a zoonotic disease, was first diagnosed in a human in 1970 in the Democratic Republic of Congo (DRC) [1]. The disease became endemic in the DRC and spread to neighboring countries in Centra and West Africa [2]. The first case outside of Africa was reported in 2003, but that case was associated with the importation of infected exotic animals [3]. Although monkeypox was thought to be largely contained in Africa, a systematic review published in early 2022 noted that, due to waning immunity from discontinuing smallpox vaccination and greater human-wildlife interactions, outbreaks of human-to-human monkeypox were increasingly likely and that "the public health importance of monkeypox disease should not be underestimated" [4].

In May 2022, this outbreak occurred [5]. Since the beginning of the year, cases of monkeypox were found in more than 100 countries and in all 6 World Health Organization (WHO) regions [6]. The WHO reported that, as of September 19, 2022, more than 61,000 laboratory-confirmed cases of monkey pox had been identified [6]. The United States was the most impacted country, experiencing 22,957 of these cases. 187 of these cases were in Ohio as of September 19. Although monkeypox is not as deadly as some diseases, the case fatality rate was initially estimated to be around 3–6 %, making the rising number of cases a concern [7]. Fortunately, standard

Abbreviations: KAPs, Knowledge, attitudes, and practices

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protective practices help to prevent the spread of monkeypox, and effective vaccinations and treatments exist [8,9].

Although vaccines and treatments are available, the WHO argues that human-to-human spread of monkeypox can best be controlled by effective public health surveillance and through early diagnosis and effective care provided by clinicians [10]. This recommendation, however, requires that clinicians have sufficient knowledge to diagnose and treat monkeypox [11]. The WHO, as well as national and local health agencies, have sought to distribute information to make clinicians more knowledgeable [12]. Prevention and treatment of infectious disease often requires going beyond providing information [13–15]. Adoption of preventive measures, particularly in the context of infectious disease, is largely determined by knowledge of the disease, attitudes toward prevention, and intentions to adopt recommended practices [16–20]. Collectively, knowledge, attitudes, and practices are referred to as KAPs.

In this study, we explored KAPs related to monkeypox in a clinician population in the US state of Ohio to inform the design of effective clinician education and disease control strategies in the context of the current outbreak.

Material and methods

Participants

All data for this study were collected online from September 2–11, 2022 in the state of Ohio. Ohio was chosen for two reasons. First, Ohio is often considered a representative state for the US, serving as a social and political bellwether for the country [21]. Second, Ohio was a relatively naïve site for monkeypox, having not yet experienced many cases. This naivety would make prior treatment of monkeypox by clinicians very unlikely, and Ohio's bellwether status may reflect how providers in other parts of the US are likely to respond to monkeypox. The Ohio Department of Health Monkeypox dashboard was updated for the first time on September 1, 2022 [22], while the first reported death directly attributable to monkeypox in the United States was reported on September 12 [23], making these appropriate bookends for data collection. A list of all preceptor clinicians associated with a university health system was obtained. All clinicians associated with the health system were emailed an invitation to participate on September 2, and a second invitation was sent September 5. Clinicians aged 18 or greater, interested in participating, were asked to click the link to an online description of the study hosted on a Qualtrics platform.

Participants were informed that the study was anonymous and voluntary. After reading an informed consent form approved by a University IRB (#22-E-211), participants were directed to the questionnaire. Following standard guidelines for binomial testing [24], to detect medium effects ($g \geq 0.15$) where statistical significance is set a $\alpha < 0.05$ and power at $\beta = 0.95$, a minimum sample size of 145 was required.

Measures

The KAP questionnaire employed in this study was based on measures developed for cross-sectional studies conducted among clinicians in Italy by Ricco and colleagues [25] and among the general public in Saudi Arabia by Ashrani and colleagues [26]. The English-language versions of their questionnaire items were adapted to the US context.

The first part of the questionnaire consisted of knowledge items see Table 1). Following Ricco et al., the knowledge component had 23 questions knowledge of prevention, diagnosis, treatment, and potential outcomes of monkeypox. For true/false questions, participants could answer "true", "false", or "do not know." For multiple choice questions, participants were asked to select the correct answer from a list of options. Each correct answer was assigned 1 point; incorrect answers or unknown answers were assigned 0 points. A participant could receive a total knowledge score ranging from 0 to 23; higher scores indicate better knowledge monkeypox.

The second part of the questionnaire assessed attitudes related to monkeypox. Although Ricco et al. used a single item each to assess attitudes about monkeypox risk and about optimism toward control of monkeypox, we followed Ashrani et al. in using three items to assess each attitude. These items were measured on a Likert-type scale ranging from (1) strongly disagree to (5) strongly agree scale. Participants were asked to rate their agreement with statements about their perceptions of the risk of monkeypox (i.e., "Monkeypox infection in the United States is a sever public health threat;" "I fear the monkeypox might become a worldwide pandemic;" "I fear that monkeypox will add extra burdens to our healthcare system"). The three items formed a reliable scale ($\alpha = 0.76$). The values reported by a participant were summed and divided by the number of items to create a composite mean for the scale of that participant's risk perceptions. Participants were also asked about their attitudes related to eventual control of monkeypox i.e., "I am confident that the world population can control monkeypox worldwide;" "I am confident that the US government can control monkeypox within the US;" and, "I am confident that state and local governments can control monkeypox locally"). These three items also formed a reliable scale ($\alpha = 0.87$). The values reported by a participant were summed and divided by the number of items to create a composite mean for the scale of that participant's perceptions of controllability.

Third, intended practices were assessed using 2 items regarding behaviors. Adapted from Ricco et al., we asked participants whether they would favor delivering the smallpox vaccine to their patients for the prevention of smallpox and whether they would personally receive the smallpox vaccine to prevent smallpox. These intentions were measured on a Likert-type (1) strongly disagree to (5) strongly agree scale.

The final part of the questionnaire consisted of demographic variables and self-reports of prior behaviors. These included year of birth, year of graduation from medical school, self-identified gender, self-identified race, and medical specialty. We also asked participants whether they had knowledge of monkeypox prior to 2022, if they had university or medical school instruction related to monkeypox, and whether they had been previously vaccinated for smallpox, COVID-19 and seasonal influenza. Previous vaccination for smallpox and knowledge of monkeypox prior to 2022 were treated as relevant prior practices to intentions related to giving or receiving the smallpox vaccine to prevent monkeypox.

Statistical analysis

Frequencies of correct answers were described (see Table 1). Independent-samples t-test and one-way analysis of variance (ANOVA), as appropriate, were used to compare members of different demographic grouping's knowledge scores and attitudes. Chi-square tests and Fisher's exact testing were used to compared different demographic groups on having already received a smallpox vaccine and having knowledge of monkeypox prior to 2022on. Prior to running any t-test, normality of data was assessed with the Kolmogorov-Smirnov test. All data were sufficiently normal ($p > .05$). Before running any ANOVA, homogeneity of variance was assessed. Medical specialty means and mean differences were not assessed because there was insufficient homogeneity of variance, likely owing to the large number of medical specialties assessed. For parallel structure, we did not assess associations between medical specialty and vaccination intentions.

We used binary logistic regression analyses to identify KAP factors associated with each practice. Continuous variables were knowledge and attitudes. Dichotomous variables of having received

Table 1
Knowledge related to monkeypox (N = 197).

Questions	Correct rate, % of total	Options[a]
Monkeypox is caused by a newly discovered virus	181, 91.9 %	True, **False**, Don't Know
The monkeypox virus circulates only among primates, including humans	85, 43.1 %	True, **False**, Don't Know
In most cases, monkeypox evolves in an uncomplicated influenza-like illness	57, 28.9 %	True, **False**, Don't Know
Monkeypox infections are associated with typical skin lesions	176, 89.3 %	**True**, False, Don't Know
Asymptomatic individuals are critical in circulating monkeypox	72, 36.5 %	True, **False**, Don't Know
Until recently, US cases of monkeypox have been mostly travel-related	160, 81.2 %	**True**, False, Don't Know
An effective vaccine against monkeypox is to date available	174, 88.3 %	**True**, False, Don't Know
Effective drugs targeted monkeypox are to date available	52, 41.6 %	**True**, False, Don't Know
Recipients of the smallpox virus vaccine do not need further vaccination shots to be protected against monkeypox	78, 39.6 %	True, **False**, Don't Know
Monkeypox may be transmitted through (a) respiratory droplets, (b) personal skin to skin contact, (c) bodily fluids, (d) touching objects (e.g., clothing, bedding, or towels) that have been used by someone with monkeypox, (e) all of the above	119, 60.4 %	A, B, C, D, **E**
The case fatality rate of monkeypox usually ranges between	144, 73.1 %	**4–11 %**, 14–19 %, 20–30 %, 30–40 %, Don't Know
Globally, monkeypox in the last decade (2010–2020) has caused around ____ cases	38, 19.3 %	< 1000, 1000–10,000, **> 10,000,** Don't Know
Monkeypox is associated with a high rate of systemic complications	19, 9.6 %	**True**, False, Don't Know
Monkeypox causes a less severe illness in children (age < 14 y.o.a.) than in adults	36, 18.3 %	True, **False**, Don't Know
Monkeypox infection is usually associated with (a) cervical and/or inguinal lymphadenopathy, (b) atypical, in axillary and/or groin nodes, lymphadenopathy, (c) a not noticeable lymphadenopathy	59, 29.9 %	**A**, B, C
The skin rash associated with monkeypox is usually asynchronous	46, 23.4 %	True, **False**, Don't Know
Surface extension and profusion of monkeypox-associated skin lesions are of prognostic value	76, 38.6 %	**True**, False, Don't Know
Monkeypox-associated skin lesions may be differentially diagnosed as which of the following according to their stage: (a) varicella/varicella-zoster, (b) typhus, (c) molluscum contagiosum/water warts, (d) syphilis, (e) herpes simplex, (f) all of the above	100, 50.8 %	A, B, C, D, E, **F**
Standard preventive measures are effective in preventing monkeypox infection	162, 82.2 %	**True**, False, Don't Know
You are presented with a clinical case characterized by: (1) atypical skin rash; (2) cervical lymphadenopathy, and, (3) patient-reported travel to countries endemic for monkeypox. This is a ________ case of monkeypox.	154, 78.2 %	Confirmed, **Probable**, Doubtful, Don't Know
You are presented with a clinical case characterized by: (1) generalized or localized skin rash, either maculopustular or vesicopustular; (2) umbilicated skin lesions; and, cervical lymphadenopathy. This is a ________ case of monkeypox.	106, 53.8 %	Confirmed, **Probable**, Doubtful, Don't Know
The case fatality rate of smallpox usually ranged between	16, 8.1 %	4–11 %, 14–19 %, 20–30 %, **30–40 %,** Don't Know
The monkeypox virus is able to survive for several days on contaminated surfaces	75, 38.1 %	**True**, False, Don't Know

[a] Correct answers bolded.

the smallpox vaccine or not and having knowledge of monkeypox before 2022 were coded where not having received the vaccine was coded as the reference group (i.e., no vaccine = 0, having received a smallpox vaccine = 1) and reporting no prior knowledge was coded as the reference group (i.e., no prior knowledge = 0 and having prior knowledge = 1). Knowledge, attitudes, smallpox vaccination status, and self-report of prior knowledge of monkeypox were entered as factors, and these factors were selected with an enter method to avoid both inflationary and deflationary effects. Odds ratios (ORs), and their 95 % confidence intervals (CIs), were used to assess the associations. All data analyses were conducted with SPSS version 26.0. The statistical significance level was set at $p < .05$.

Results

The recruitment email was sent to 2423 addresses of clinicians associated with the university health system. Of these, 628 addresses returned as invalid or undeliverable, resulting in a pool of 1795 potential participants. A total of 202 individuals consented to participate in the survey. After removing participants who skipped all substantive questions (n = 5), 197 individuals were retained. This final sample represented 10.97 % of the potential participants. The sample was majority male (113, 57.4 %) and mostly white (150, 76.1 %). Participants ranged from 26 to 75 years of age (Mean = 50.04, s.d. = 12.35). The clinicians had between 4 and 49 years of practice (Mean = 21.94, s.d. = 11.09). All medical specialties were represented, with the largest group being family practice clinicians (53, 26.9 %). A majority of participants (109, 55.3 %) reported not having been vaccinated against smallpox. In reference to prior relevant practices, most participants reported having no knowledge of monkeypox prior to 2022 (148, 75.1 %) and having received no university-level instruction on monkeypox (169, 85.8 %). Nearly all participants had been vaccinated against COVID-19 (191, 97.0 %) and seasonal influenza (188, 95.4 %). Full demographic characteristics are shown in Table 2.

The correct answer rates for the 23 questions on the monkeypox knowledge questionnaire ranged from very low (e.g., only 8.1 % answering correctly that the case fatality rate of smallpox usually ranged between 30 % and 40 %) to strong knowledge (with 91.9 % answering correctly that monkeypox is not a newly discovered virus). Table 1 reports correct answer rates for each item. The mean knowledge score, however, was a paltry 11.24 (s.d. = 3.36; range: 2–18), suggesting relatively poor knowledge related to monkeypox. No significant differences in knowledge among demographic groupings were found (see Table 3). Of particular concern to clinical practice are the high rates of incorrect answers related to the association of systemic complications with monkeypox, the transmission pathways for monkeypox, the existence of effective drugs that can target the monkeypox virus, of the efficacy of previous smallpox vaccination as a preventive, and the high rates of underdiagnosis of probable cases of monkeypox from clinical descriptions.

The participants, overall, had middling attitudes related to monkeypox. Participants neither agreed nor disagreed that monkeypox was a substantial risk (M = 3.07, s.d. = 1.01). Participants also expressed neither confidence nor lack of confidence in the eventual control of monkeypox (M = 3.00, s.d. = 1.11). No significant differences were found in either attitude among demographic groupings (see Table 3). To examine practice intentions related to public

Table 2
Demographic characteristics.

Characteristics	No. (%)
Gender	
Male	113 (57.4 %)
Female	69 (35.0)
Non-binary/Third gender	4 (2.0)
Declined	3 (1.5)
Racial identification	
White	150 (76.1 %)
Black/African American	7 (3.6 %)
American Indian or Alaskan Native	1 (0.5 %)
Asian or Asian American	13 (6.6 %)
Other	14 (7.1 %)
Declined	12 (6.1 %)
Medical Specialty	
Anesthesiology	4 (2.0 %)
Dermatology	2 (1.0 %)
Emergency Medicine	26 (13.2 %)
Family Practice	53 (26.9 %)
Internal Medicine	25 (12.7 %)
Neurology & Psychiatry	8 (4.1 %)
Neuromusculoskeletal Medicine	1 (0.5 %)
Obstetrics & Gynecology	9 (4.6 %)
Ophthalmology & Otolaryngology	2 (1.0 %)
Orthopedic Surgery	2 (1.0 %)
Pediatrics	16 (8.1 %)
Preventive Medicine	1 (0.5 %)
Surgery	16 (8.1 %)
Something Else	23 (11.7 %)
Declined	9 (4.6 %)
Received university-level instruction on monkeypox	
Yes	17 (8.6 %)
No	169 (85.8 %)
Don't Know/Declined	10 (5.1 %)
Had knowledge of monkeypox before 2022	
Yes	49 (24.9 %)
No	148 (75.1 %)
Don't Know/Declined	0 (0.0 %)
Received smallpox vaccine	
Yes	80 (40.6 %)
No	109 (55.3 %)
Don't Know/Declined	8 (4.1 %)
Received COVID-19 vaccine	
Yes	191 (97.0 %)
No	4 (2.0 %)
Don't Know/Declined	2 (1.0 %)
Received seasonal influenza vaccine in 2021	
Yes	188 (95.4 %)
No	7 (3.6 %)
Don't Know/Declined	2 (1.0 %)
Year of Birth (Range 1947–1996)	Median = 1972, s.d. 12.35 y
Year of Graduation from Medical School (Range 1973–2018)	Median = 2000, s.d., 11.09 y

vaccination, strongly disagreeing with, disagreeing with, or being neutral about delivering the smallpox vaccine to the public for the prevention of monkeypox infection were coded as not intending to deliver it. Agreeing with or strongly agreeing with delivering the vaccine to the public was coded as intending to deliver it. A majority of the participants (n = 114; 57.9 %) intended to deliver the vaccine. Respondent's intentions to deliver the vaccine did not differ by any demographic variable (see Table 4). Their intentions to deliver the vaccine did not differ on relevant prior practices of having received a smallpox vaccine or having prior knowledge of monkeypox. The only significant association was that individuals who had been vaccinated against COVID 19 were more likely to be willing to vaccinate others. Although this difference was statistically significant, the effect size was nearly non-existent (Cramer's v = 0.0052). Overall, the binary logistic regression model applying KAP factors successfully classified 67.7 % of cases and explained about 12 % of all variance in intentions to deliver the vaccine to the public (Nagelkerke R^2 =.123). Binary logistic regression revealed that actual knowledge related to monkeypox, attitudes related to the control of monkeypox, self-reported prior knowledge of monkeypox, and previous vaccination with the smallpox vaccine were unrelated to practice intentions (see Table 5 for a full report of these results). Of KAP variables, only attitudes related to the perceived risk of monkeypox on public health were related to practice intention. Persons who saw monkeypox as a higher risk were more likely to intend to deliver the smallpox vaccine to the public for prevention of monkeypox (OR: 1.64; (95 % CI: 1.17, 2.28), p = .004).

Similarly, to examine personal intentions to become vaccinated, strongly disagreeing with, disagreeing with, or being neutral about receiving the smallpox vaccine were coded as not intending to receive it. Agreeing with or strongly agreeing with receiving the vaccine to the public was coded as intending to receive it. Just over half of the participants (n = 101; 51.7 %) intended to not receive the vaccine. Respondent's intentions to receive the vaccine did not differ by any demographic variable or prior practice variable (see Table 4). Overall, the binary logistic regression model applying KAP factors successfully classified 65.6 % of cases and explained about 21 % of all variance in intentions to receive the vaccine (Nagelkerke R^2 =.214). Similar to intentions to deliver the vaccine, binary logistic regression revealed that actual knowledge related to monkeypox, attitudes related to the control of monkeypox, self-reported prior knowledge of monkeypox, and previous vaccination with the smallpox vaccine were unrelated to practice intentions (see Table 6 for a full report of these results). Only attitudes related to the perceived risk of monkeypox on public health were related to practice intention. Persons who saw monkeypox as a higher risk were more likely to intend to receive the smallpox vaccine for prevention of monkeypox (OR: 2.49; (95 % CI: 1.71, 3.63), p < .001).

Discussion

This study was conducted during the early monkeypox outbreak in the United States, and at a point where the US represented a plurality of the worldwide cases of the disease. These findings outline areas that should be addressed among clinicians to help prevent the spread of monkeypox.

First, it seems likely that there are gaps in clinicians' understanding of monkeypox. Although intentions to vaccinated were not associated with knowledge, adequate knowledge of monkeypox is important to clinician's abilities to diagnose and treat the disease. On average, clinicians in this Ohio, USA sample correctly answered 48.9 % of the knowledge questions correctly (i.e., 11.23 correct answer out of 23 questions). Similarly, practitioners in Ricco et al.'s [25] Italian sample answered about 51.8 % of the knowledge questions correctly. Although Alsharani and colleagues used a different measure of knowledge in their study among Saudi physicians [27], they too found inadequate knowledge. Similar findings were found in Indonesia, where, only 36.5 % of general practitioners had adequate knowledge of monkeypox in a study that considered 70 % correct answers to be adequate knowledge [28]. Beyond identifying gaps in knowledge, it may be important to find the most relevant gaps in knowledge for the specific clade of monkeypox experienced by a particular nation. For example, Alsharani's study engaged a clade of monkeypox that is associated with zoonotic mechanisms of infection (e.g., migration, travel, and exotic animal trading) [27], while the American and European clade appears to be emerging as a sexually transmitted infection [29]. These different pathways may make different kinds of knowledge more relevant for prevention, diagnosis, and treatment of monkeypox in specific contexts.

Significantly, our findings indicate that multiple areas of physician practice should be addressed. Although the study teams led by Ricco [25], Alsharani [27] and Harapan [28] engaged in cross-sectional studies of a small set of the practitioners, mostly general

Table 3
Tests of difference in mean knowledge, risk attitudes, and controllability attitudes among demographic groupings.

Characteristics	Knowledge Mean, s.d.	*t/F*	Risk Attitudes Mean, s.d.	*t/F*	Controllability Attitudes Mean, s.d.	*t/F*
Gender		0.695		-1.044		-0.241
Male	11.35, 3.29		3.03, 1.02		3.00, 1.012	
Female	10.99, 3.53		3.19, 1.04		3.04, 1.10	
Racial identification		0.782		1.654		0.125
White	11.04, 3.44		3.03, 1.05		3.07, 1.09	
Black/African American	11.29, 2.93		3.05, 0.41		3.14, 0.86	
American Indian or Alaskan Native	14.00, 0.00		3.67, 0.00		3.67, 0.00	
Asian or Asian American	12.31, 3.75		3.56, 1.13		3.00, 1.37	
Received university-level instruction on monkeypox		1.344		-1.285		0.096
Yes	12.41, 2.76		3.74, 0.93		3.02, 1.04	
No	11.28, 3.35		3.08, 1.04		2.99, 1.13	
Had knowledge of monkeypox before 2022		2.008		0.786		-1.157
Yes	11.35, 2.91		3.17, 0.97		2.79, 10.7	
No	10.58, 3.22		3.04, 1.03		3.07, 1012	
Don't Know/Declined						
Received smallpox vaccine		1.099		-0.037		1.780
Yes	11.66, 3.39		3.05, 1.03		3.17, 1.16	
No	11.13, 3.23		3.06, 1.01		2.88, 1.08	
Received COVID-19 vaccine		-0.893		-0.771		-0.443
Yes	11.36, 3.40		3.12, 0.99		3.00, 1.12	
No	12.25, 1.50		3.50, 0.64		3.25, 0.74	
Received seasonal influenza vaccine in 2021		0.090		1.247		-1.230
Yes	11.26, 3.36		3.10, 1.00		2.99, 1.12	
No	11.14, 4.22		2.62, 1.18		3.56, 1.05	

Note: Third gender, "other" ethnic identification, "something else" and "other" medical specialization and all don't know and declined answers removed from analysis. Significant differences/associations are in bold.

Table 4
Tests of associations between intention to vaccinate outcomes with demographic and prior practice variables.

Characteristics	Willing to Vaccinate Others	Not Willing	Chi-Square Value	Willing to Vaccinate Self	Not Willing	Chi-Square Value
Gender			0.010			2.100
Male	68	45		53	60	
Female	41	28		40	29	
Racial identification			5.943†			1.829†
White	59	91		75	75	
Black/African American	1	6		3	4	
American Indian or Alaskan Native	1	0		0	1	
Asian or Asian American	8	5		8	5	
Received university-level instruction on monkeypox			0.247			1.084
Yes	9	8		6	11	
No	100	69		82	87	
Had knowledge of monkeypox before 2022			1.254			1.244
Yes	25	24		20	29	
No	89	59		74	74	
Received smallpox vaccine			1.054			2.470
Yes	50	30		43	37	
No	60	49		46	63	
Received COVID-19 vaccine			**5.748†**			3.801†
Yes	114	77		94	97	
No	0	4		0	4	
Received seasonal influenza vaccine in 2021			0.005†			1.121†
Yes	110	78		92	96	
No	4	3		2	5	

Note: Third gender, "other" ethnic identification, "something else" and "other" medical specialization and all don't know and declined answers removed from analysis. Totals will not add to 197. *Where cell counts < 5, **†** = Fisher's exact test used to assess significance. Significant associations are in bold.

Table 5
Binary logistic regression of predictors for delivering vaccine to prevent monkeypox.

Predictor	B	SE	Wald	Sig.	Exp (B)	95 % CI
Knowledge	0.094	0.051	3.368	0.066	1.099	0.994–1.216
Risk Attitudes	0.492	0.170	8.379	0.004†	1.635	1.172–2.281
Control Attitudes	-0.012	0.150	0.007	0.0935	0.988	0.737–1.325
Smallpox Vaccination Status (ref = unvaccinated)	-0.231	0.323	0.512	0.474	0.794	0.422–1.494
Pre-2022 Knowledge (ref = no prior knowledge)	0.743	0.392	3.579	0.059	2.101	0.974–4.535

*model Nagelkerke R^2 = .123.
†relationship significant at $p < .05$

Table 6
Binary logistic regression of predictors for receiving vaccine to prevent monkeypox.

Predictor	B	SE	Wald	Sig.	Exp (B)	95% CI
Knowledge	0.025	0.052	0.221	0.638	1.025	0.925–1.135
Risk Attitudes	0.912	0.192	22.491	< 0.001†	2.489	1.707–3.627
Control Attitudes	0.204	0.157	1.688	0.194	1.227	0.901–1.669
Smallpox Vaccination Status (ref = unvaccinated)	-0.408	0.329	1.531	0.216	0.665	.0349–1.269
Pre-2022 Knowledge (ref = no prior knowledge)	0.581	0.407	2.044	0.153	1.789	0.806–3.969

*model Nagelkerke R^2 = .214.
†relationship significant at $p < .05$

practitioners, our findings indicate that knowledge gaps exist across heterogenous specialties. Since a potential patient may present before any of a number of medical practitioners, continuing medical education across all specialties of medicine may be desirable, Our findings suggest specific areas of clinician continuing education that may be useful in preparing clinicians to respond to monkeypox. Specifically, it may be useful for clinical practice to educate clinicians that there are effective drugs against monkeypox available and that individuals who have received a smallpox vaccine before may need a booster. Clinicians are also largely unaware that monkeypox often involves systemic complications and that children are as at high a risk of these complications as are adults. It may also be important for clinicians to be aware that monkeypox may be transmitted through respiratory droplets, direct contagion from touching lesions, exposure to bodily fluids, and on surfaces. And, perhaps most significant, the gaps in correctly diagnosing probable cases of monkeypox should be addressed. Although monkeypox remains relatively rare in the United States, assisting clinicians in differentiating probable monkeypox cases and other diseases characterized by skin lesions may be necessary.

Overall, participants in this study reported lower intentions to adopt practices that assist in limiting the spread of monkeypox than are desirable. A little over half of clinicians indicated that they did not intend to receive a vaccination against monkeypox, and over 40 % indicated that they did not intend to deliver such a vaccine. These findings contrast sharply with a study of Indonesian physicians, where more than 90 % of general practitioners indicated they would be willing to accept a vaccine to prevent monkeypox [30]. Ohio, USA practitioners' intentions were not associated with knowledge or attitudes related to the ability to control monkeypox infection. Significantly, they were not associated with either vaccine hesitancy, as nearly all of our participants had been vaccinated against COVID-19 and seasonal influenza. Rather, the only significant predictor of intentions to give or receive vaccinations against monkeypox was the perception of the risk of monkeypox. Clinicians who did not see monkeypox as a severe public health threat in the United States, fear that it might become a worldwide pandemic, or worry that monkeypox would add extra burdens to the healthcare system were less likely to intend to receive or deliver a vaccine. These attitudes present clear opportunities for messaging to clinician population. They are actionable areas where the perceived threat of monkeypox can be raised and discussed to potentially motivate clinicians into different actions. Therefore, educational efforts should be accompanied by even stronger efforts to contextualize this education in a threat environment to encourage clinicians to adopt actions to help prevent the spread of monkeypox.

Limitations

Although this study is the first, to our knowledge, to examine KAPs related to monkeypox in a US clinician population, and although it conforms with the limited previous research on other practitioners in other countries, there are some limitations. First, our study is limited to the state of Ohio. The finding of this study may not represent KAPs across the US, as there have been more cases of monkeypox in coastal states like New York and California. Although Ohio is often considered a bellwether state for the US, future research may find that different patterns of disease spread in different states may lead to different KAPs. Also, in our sample, clinicians of color were underrepresented. This may be because the university health system accessed is in a predominantly white area with white clinicians. Because there is evidence that communities of color in the US [31], and minoritized communities around the world [32], are disproportionately impacted by monkeypox, future studies should attempt to engage these minoritized communities.

In addition, the monkeypox outbreak is rapidly evolving. Our study intentionally ceased collecting data when the first US death from monkeypox was reported. Events like this may raise the perceived threat of monkeypox, and may drive clinicians to learn more about the disease. Alternatively, because our collective knowledge of monkeypox is growing, some of the points of what we regard as required knowledge may change. For example, this study used an estimated case fatality rate range based on the African experience of monkeypox of anywhere between 3 % and 11 % [7,25], when the current case fatality rate in the Americas is less than 0.05 % [32,33]. Moreover, as knowledge of actual risk changes, it may influence the risk perceived by practitioners It is essential to continue to monitor knowledge levels, attitudes, and practices to see how they grow and change along with the changes in the spread of this disease.

Conclusions

In summary, our findings indicate that clinicians in Ohio have poor levels of knowledge related to monkeypox and are insufficiently likely to practice vaccination behaviors to prevent the further spread of monkeypox. The greatest area for improvement is regarding the perceived threat of monkeypox, which suggests that continuing clinical education and outreach should not only focus on promoting better knowledge and prevention practices, but should also illustrate the threat that this emergent zoonotic disease poses for public health.

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Compliance with ethical standards

The study protocol was approved by the Institutional Review Board at Ohio University (22-E-211) as an exempt study with a waiver of signed informed consent.

Competing interests

The authors declare that they have no conflict of interests.

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