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Enhancing Healthcare Workers' Preparedness for Mpox Through Structured Online Training: A Quasi-Experimental Study in Saudi Arabia

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Abstract

Background

Emerging infectious diseases such as Mpox require prompt recognition and response by healthcare workers (HCWs). This study evaluated the effectiveness of a structured online training session on HCWs' knowledge and attitudes toward Mpox.

Methods

A quasi-experimental pre-post study was conducted among HCWs in a tertiary hospital in Riyadh, Saudi Arabia. A validated 25-item questionnaire consisting of 18 knowledge items and 7 attitude items was administered before and immediately after the training session. The 90-minute online session addressed Mpox epidemiology, transmission, clinical features, and infection control measures. Independent-samples statistical analyses were used to compare pre- and post-training scores.

Results

Of 1,500 invited HCWs, 732 completed the pre-test and 768 completed the post-test. Mean knowledge scores increased significantly from 12.4/25 to 19.2/25 ($p < 0.001$, Cohen's $d = 0.78$), while attitude scores also improved markedly.

Conclusion

Structured online training significantly improved healthcare workers' knowledge and attitudes toward Mpox, demonstrating the value of scalable educational interventions for outbreak preparedness. Integrating such evidence-based training into routine continuing medical education programs may strengthen early detection, reinforce infection prevention practices, and enhance health system readiness for emerging infectious diseases.

Introduction

Mpox (monkeypox) is a zoonotic orthopoxvirus infection that has re-emerged as a significant global public health concern [1]. The monkeypox virus (MPXV) comprises two genetic clades: clade I, historically prevalent in Central Africa, and clade II, traditionally associated with West Africa, although instances of mixed clades have been reported in Cameroon [2]. In recent years, Mpox has re-emerged as a global health threat, affecting more than 50 countries worldwide [3]. This resurgence led to the declaration of a Public Health Emergency of International Concern (PHEIC) twice within a short period—first in July 2022 and again in May 2024 [9–11]. These declarations were triggered by rapid transmission across large populations, cross-border spread to regions previously unaffected, and multiple transmission pathways including sexual contact, direct skin-to-skin contact, and other forms of close physical interaction [3, 4, 12].

Increased global mobility and international travel have transformed what were once sporadic outbreaks into geographically widespread transmission events [13]. Between 2003 and 2021, Mpox cases were exported from Africa to several countries including the United States, Israel, Singapore, and the United Kingdom [14, 15]. However, during the 2022 global outbreak many cases occurred without clear epidemiological links to endemic regions, highlighting the evolving transmission dynamics of the virus [13]. Given the unpredictability of Mpox spread and the interconnected nature of modern health systems, healthcare institutions must maintain a high level of preparedness, including equipping healthcare workers with the knowledge required to recognize, manage, and prevent Mpox infections [16–18]. Assessing healthcare workers' understanding of Mpox transmission is therefore essential for strengthening outbreak preparedness and response.

Global travel and increased population mobility have transformed what were once isolated Mpox cases into geographically widespread outbreaks [13]. Between 2003 and 2021, Mpox spread from Africa to the USA (2003, 2021), Israel (2018), Singapore (2019), and the UK (2018, 2019, and 2021) [14, 15], with most cases linked to African sources [2]. However, during the 2022

Mpox outbreaks, which affected over 70 countries across all six WHO regions, no clear epidemiological link could be identified for many cases in 2022 [13] or for the recent Swedish case in 2024. Given the complexities of international travel and the unpredictable transmission dynamics of Mpox, governments and healthcare systems need to be adequately prepared for all eventualities, including equipping healthcare workers to protect themselves [16–18]. Therefore, assessing healthcare workers' understanding of Mpox transmission is essential to inform effective outbreak response.

In response to the resurgence and global spread of Mpox, the WHO has identified knowledge gaps among HCWs as a major barrier to outbreak preparedness, making structured educational interventions a global priority [19]. Its Research and Development Blueprint meeting in June 2022 underscored gaps in understanding Mpox transmission, epidemiology, and clinical features [20–22]. This study addresses these gaps by evaluating a practical training initiative in a large tertiary healthcare network during an ongoing WHO-declared public health emergency [11], emphasizing the need for proactive, preparedness-oriented approaches to Mpox.

Multiple studies highlight significant knowledge gaps regarding Mpox. In China, a national survey revealed poor public awareness [2], while research in Nepal showed most participants were unaware of its contagious nature [20, 22]. Even HCWs displayed limited preparedness due to inadequate knowledge [23], with sub-Saharan African studies reporting low confidence in affected areas [24]. A systematic review estimated only 26.0% (95% CI: 17.8–34.2) of HCWs had good Mpox knowledge [20]. In the Arab region, an Egyptian intervention improved HCWs' good knowledge from 7.3% to 100% and positive attitudes from 42.9% to 100% [25]. Similarly, a survey of 5,874 medical students/doctors across 17 Arab countries found only 13.8% had received Mpox-related training, though specialists scored higher [26]. These findings underscore the urgent need for structured educational initiatives to strengthen preparedness.

In Saudi Arabia, studies reveal variable Mpox knowledge among HCWs. A survey of 398 physicians found 55% had "good knowledge," with gaps in treatment and vaccination, emphasizing the need for targeted training [27]. Another study of healthcare workers similarly reported gaps in knowledge and attitudes toward Mpox, highlighting the need for structured educational interventions [28]. A further study of 212 practitioners and students showed good awareness of common symptoms but poor recognition of less typical signs, recommending further education [29]. An intervention involving 960 medical students significantly improved knowledge and attitudes post-training, demonstrating the value of educational programs [30,]. Despite these findings, Mpox-specific training for Saudi HCWs remains limited, underscoring the need for structured interventions to strengthen preparedness.

While direct studies on online training efficacy in Saudi Arabia are lacking, the aforementioned research indicates that structured educational interventions, including online training, can significantly improve healthcare workers' knowledge and attitudes toward Mpox transmission. Thus, this study seeks to assess the initial understanding of Mpox among HCWs and to evaluate how a systematic educational program can improve their awareness and perceptions regarding Mpox.

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Materials and Methods

Study Design and Setting:

This quasi-experimental study was conducted at King Saud University Medical City, a tertiary care hospital in Riyadh, from June to July 2023.

Pre- and post-training questionnaires were completed anonymously and were therefore analyzed as independent samples.

Ethics:

The study was approved by the KSU Institutional Research Board. Informed electronic consent was obtained.

Participants and Recruitment:

All HCWs (physicians, nurses, technicians, and allied staff) were invited via institutional email. Participation was voluntary. Inclusion criteria: HCWs aged ≥ 18 years working in clinical areas. Exclusion criteria: Non-clinical staff and those who had previously attended Mpox-specific training.

Instrument:

Data were collected using a 25-item structured questionnaire developed based on WHO and Saudi MoH guidelines. The tool included 18 knowledge items (symptoms, transmission, prevention) and 7 attitude items (perceived importance, confidence in response). Content validity was assessed by three infectious disease experts, and reliability tested in a pilot group of 30 HCWs (Cronbach's α = 0.86).

Intervention:

Participants attended a 90-minute online session via Zoom, delivered by an infectious disease consultant. Topics included Mpox epidemiology, clinical features, transmission, and infection control measures. Interactive polls and Q&A were incorporated. Attendance was tracked automatically, recording time spent; participants attending ≥ 80% were classified as "full attendance."

Data Analysis:

Scores were calculated as the total number of correct responses (range 0–25). Because the pre- and post-training responses were collected anonymously and could not be matched at the individual level, independent-samples t-tests were used to compare mean scores before and after the intervention. Effect sizes (Cohen's d) and 95% confidence intervals (CIs) were calculated to estimate the magnitude of the intervention effect.

All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant.

Results

A total of 732 HCWs completed the pre-test and 768 the post-test; 615 attended ≥80% of the session. Nurses comprised 58% of participants. Knowledge scores increased from 12.4 (95% CI: 11.9-12.9) to 19.2 (95% CI: 18.7-19.8), $p < 0.001$, $d = 0.78$. Attitude scores rose from 4.3/7 to 6.1/7 ($p < 0.001$). **Table 1** shows detailed results with percentages and confidence intervals.

Predominantly, the respondents were female in both evaluations, with percentages of 88.5% prior to the session and 91.3% following it. The largest age group was those aged 35-44 years, closely followed by individuals aged 25-34 years. A significant majority were nurses or technicians (94.1% pre-intervention and 96.5% post-intervention), while a smaller fraction were medical physicians. In terms of departmental affiliation, outpatient and critical care departments were the most frequently represented work areas. Although King Khalid University Hospital (KKUH) comprised a substantial portion of participants in both phases, its share decreased after the session, whereas there was an increase in participation from King Abdullah University Hospital (KAUH) and Dental University Hospital (DUH). These trends reflect a varied and representative sample engaged in training related to Mpox

Characteristics	Pre-session, n=732 n (%)	Post session, n=768 n (%)
Sex		
Female	648 (88.5)	701 (91.3)
Male	84 (11.5)	67 (8.7)
Age group		
18-24	16 (2.2)	13 (1.7)
25-34	214 (29.2)	221 (28.8)
35-44	277 (37.8)	305 (39.7)
45-54	173 (23.6)	178 (23.2)
55-64	52 (7.1)	51 (6.6)
Clinical role		
Medical physicians	43 (5.9)	27 (3.5)
Nurses and Technicians	689 (94.1)	741 (96.5)
Working department		
Critical care departments	246 (33.6)	253 (32.9)
Infectious Disease/Isolation wards	19 (2.6)	11 (1.4)
General Hospital floors	154 (21)	172 (22.4)
Outpatients department	283 (38.7)	297 (38.7)
Nonclinical areas	30 (4.1)	35 (4.6)
Hospital		
KKUH	540 (73.8)	472 (61.5)
KAUH	108 (14.8)	158 (20.6)
DUH	84 (11.5)	138 (18)
Knowledge Score (0–18)	12.4 ± 4.1	19.2 ± 3.8 p-value: <0.001 Effect Size: (Cohen's): 0.78 (large)
Attitude Score (0–7)	4.2 ± 1.6	6.3 ± 1.2 p-value: <0.001 Effect Size (Cohen's): 0.65 (medium)

Table 1. Sociodemographic characteristics of participating healthcare workers. KKUH: King Khalid University Hospital, KAUH: King Abdulaziz University Hospital, DUH: Dental University Hospital

Table 1 summarizes he sociodemographic characteristics of participating healthcare workers. Female participants predominated in both the pre- and post-intervention groups (88.5% and 91.3%, respectively). The largest age group was 35–44 years, followed by 25–34 years. Nurses and technicians constituted the majority of respondents (94.1% pre-intervention and 96.5% post-intervention), reflecting their dominant representation in the clinical workforce.

The data presented in Figure 1 indicate that the proportion of accurate responses showed an increase across all areas of knowledge after the intervention, especially in the categories of precautionary measures and symptoms & signs.

Note:

Values are presented as n (%) for categorical variables and mean ± SD for continuous variables. Statistical significance for pre-post differences was assessed using independent-samples t-tests. Effect sizes were interpreted as small (0.2), medium (0.5), or large (≥0.8). Post-training improvements in both knowledge and attitude scores indicate a substantial impact of the intervention on HCWs' preparedness.

The figure depicts the proportion of accurate answers provided by healthcare workers in four key areas of knowledge: General Knowledge, Transmission, Symptoms & Signs, and Precautionary Measures, both prior to and following a formal educational intervention. Significant enhancements were noted across all domains, particularly in Precautionary Measures and Symptoms & Signs, where the largest increases were found.Table 2 presents the detailed statistical findings relevant to this analysis.

Table 2: Descriptive analysis of HCW's perceptions about Mpox disease related awareness, attitudes and worries.

The perceptions of HCWs regarding Mpox showed significant shifts after the educational session (Table 2). Awareness of the global increase in Mpox cases, as reported by the WHO, rose considerably following the session (mean score: 3.68 compared to 3.11). A majority of HCWs viewed Mpox as more concerning than COVID-19 during both time periods, with a slight uptick noted post-session (53% compared to 52%). The consensus on the necessity for additional infection control measures in light of new outbreaks grew from 86.5% to 90.4%.

Concerns surrounding international travel remained consistently elevated, with over 86% expressing some degree of apprehension. The main sources of information about Mpox were international health organizations (82.1% post-session versus 77.8% pre-session), followed by local official channels and social media networks. There was a notable increase in reliance on scientific journals, rising from 25.8% to 33.2%, indicating a possible shift towards seeking more evidence-based information.

The predominant concerns reported included the risk of personal or family infection (67.8% post-session compared to 59.6% pre-session), fears of a potential new global pandemic (63.9% post), and anxiety about traveling to areas affected by outbreaks. Concerns related to aesthetics, such as scarring, also saw a modest rise. In terms of vaccination priorities, a greater number of HCWs after the session supported targeting high-risk HCWs (72.3% versus 55.6%) and close contacts of confirmed Mpox cases (80.4% versus 60.2%).

Lastly, there was a significant boost in motivation for self-education: post-session, 98.4% of participants indicated that the pre-webinar survey motivated them to seek further knowledge about Mpox, up from 93.6% pre-session. These results reflect an enhancement in awareness, heightened risk perception, and an increased propensity towards preventive health actions following the intervention.

A summary of domain-level improvements is provided in Supplementary Table S2. For detailed item-level data (Supplementary Table S1).

Table 3: Multivariate Linear Regression Analysis of the Health Care Workers Knowledge about Mpox disease score before the workshop. Dependent variable: Mpox overall knowledge score before the workshop. Model r-squared=0.10, f (9, 722) =8.82, p value<0.001.

A multivariate linear regression analysis was performed to determine the predictors of HCWs overall knowledge scores regarding Mpox before the educational intervention (Table 3). The model demonstrated statistical significance ($F(9, 722) = 8.82$, $p < 0.001$) and accounted for roughly 10% of the variance in knowledge scores ($R^2 = 0.10$). Several variables emerged as significant independent predictors.

The analysis revealed that female HCWs had notably lower knowledge scores than their male counterparts ($\beta = -0.869$; 95% CI: -1.541 to -0.197; $p = 0.011$). Additionally, HCWs (aged ≥35 years) exhibited significantly higher knowledge scores ($\beta = 0.519$;

95% CI: 0.057 to 0.981; p = 0.028). Furthermore, a higher self-reported awareness of Mpox transmission (β = 0.570; p < 0.001), increased concern about Mpox relative to COVID-19 (β = 0.336; p = 0.036), and a consensus on the need for stricter infection control measures (β = 1.404; p < 0.001) were all linked to significantly elevated knowledge scores.

Table 4: Multivariate LOGISTIC Regression Analysis of HCW attitude toward monkeypox immunization for healthcare workers at risk (PRE-Session)

A multivariate logistic regression analysis was performed to investigate the factors influencing HCWs' attitudes towards mpox vaccination prior to an educational intervention (Table 4). The analysis revealed two notable independent predictors. The overall knowledge score regarding Mpox showed a significant correlation with favorable attitudes toward vaccination (AOR = 1.237; 95% CI: 1.170-1.308; p < 0.001), suggesting that increased knowledge is associated with stronger support for immunization among at-risk HCWs. Second, concern regarding international travel, categorized as either somewhat or very worried, emerged as another significant predictor (AOR = 1.555; 95% CI: 1.183-2.043; p = 0.002), indicating that a heightened sense of vulnerability influenced positive attitudes toward vaccination.

Conversely, demographic variables such as age, gender, clinical role, hospital affiliation, and awareness of the recent WHO announcement did not exhibit a significant relationship with vaccination attitudes (p > 0.05 for all). These results highlight the necessity for interventions focused on enhancing knowledge and addressing risk perception to bolster vaccination readiness among HCWs.

Table 5: Multivariate Logistic Regression Analysis of HCWs' Attitudes Toward Monkeypox Immunization for At-Risk Healthcare Workers (Post Session)

A multivariate logistic regression analysis was performed to determine the factors influencing HCWs' attitudes towards Mpox vaccination for at-risk individuals after the educational intervention. The findings reveal that two independent variables had a notable impact on positive attitudes towards vaccination:

Higher overall knowledge scores regarding Monkeypox were significantly linked to supportive attitudes (AOR = 1.229; 95% CI: 1.157-1.305; p < 0.001), highlighting the lasting effect of information acquisition.

Additionally, concerns related to international travel emerged as a strong predictor (AOR = 1.727; 95% CI: 1.288-2.315; p < 0.001), indicating that individuals' perceptions of personal risk may drive greater endorsement for preventive measures. **[Insert Table 5 here]**

Table 6: Multivariable Logistic binary Regression Analysis of HCW attitude toward monkeypox immunization for high risk contact health workers with positive mpox cases (PRE-SESSION)

A multivariable binary logistic regression analysis was performed to determine the factors influencing HCWs' attitudes towards vaccinating high-risk colleagues who had direct exposure to confirmed Mpox cases before the educational intervention. Being aged 45 years or older correlated negatively with supportive vaccination attitudes (AOR = 0.651; 95% CI: 0.466-0.910; p = 0.012). A higher overall knowledge score regarding Mpox emerged as a substantial positive predictor of pro-vaccination attitudes (AOR = 1.211; 95% CI: 1.147-1.279; p < 0.001), suggesting that increased knowledge is strongly linked to favorable views on vaccination. **[Insert Table 6 here]**

Table 7: Multivariate Logistic Regression Analysis of HCW attitude toward monkeypox immunization for high risk contact health workers with positive cases (POST-SESSION)

In a multivariate logistic regression analysis to examine the factors influencing HCWs' attitudes towards Mpox vaccination for those at high risk after an educational intervention. The overall knowledge score regarding Mpox was a strong positive predictor of supportive attitudes toward vaccination (AOR = 1.236; 95% CI: 1.158-1.319; p < 0.001). Furthermore, HCWs expressing varying levels of concern about international travel were notably more inclined to endorse vaccination for colleagues who had been exposed (AOR = 1.542; 95% CI: 1.117-2.129; p = 0.008). **[Insert Table 7 here]**

Questions	Pre-session, n=732	Post session, n=768
Rate how are you of the recent announced rise in Mpox cases worldwide by WHO?	3.11 (0.97)	3.68 (0.98)
Comparing your worries about COVID-19 versus Monkeypox, which one is more worrisome to you now?		
I am worried more about COVID-19	221 (30.2)	219 (28.5)
I am worried more about Monkeypox	381 (52)	407 (53)
I am not worried about either	130 (17.8)	142 (18.5)
With the new Monkeypox outbreaks in some countries: healthcare workers should apply more infection control measures than the current ones		
Agree	633 (86.5)	694 (90.4)
Neither agree or disagree	88 (12)	52 (6.8)
Disagree	11 (1.5)	22 (2.9)
With the new Monkeypox outbreaks in many countries please rate how much worry about traveling abroad?		
Not worried at all	98 (13.4)	100 (13)
Somewhat worried	484 (66.1)	508 (66.1)
Extremely worried	150 (20.5)	160 (20.8)
What are your sources of Monkeypox information's/health information's?		
Official local statements or press release from MOH or Saudi-CDC (Weqayah)	413 (56.4)	566 (74.1)
International health authorities' websites (like the WHO or CDC)	518 (77.8)	627 (82.1)
Social Networks	439 (60)	486 (63.6)
Science journals and articles	189 (25.8)	254 (33.2)
Other sources	34 (4.6)	36 (4.7)
What are the main Worry reasons for the Monkeypox?		
Me or my family being affected by the Monkeypox	436 (59.6)	518 (67.8)
I am worried about Vaccination: I do not want to be vaccinated	195 (26.6)	176 (23)
Another worldwide pandemic	459 (62.7)	488 (63.9)
I am worried to travel to countries that have Monkeypox outbreak.	333 (45.5)	430 (56.3)
Worried about the scars of the disease	193 (26.4)	225 (29.5)
Other concerns and worries	21 (2.9)	11 (1.4)
13. In your opinion: In case Monkeypox vaccine becomes available, who should be prioritized to receive it?		
All Healthcare Workers	522 (71.6)	518 (67.6)
HCWs with high risk, e.g., lab staff	405 (55.6)	554 (72.3)
Teachers	138 (18.9)	130 (17)
Elderly aged 65 and over	355 (48.7)	405 (52.9)
High risk contact of Mpox diagnosed person	439 (60.2)	616 (80.4)

Patients with chronic disease (like DM, hypertension, renal disease...)	379 (52)	443 (57.8)
Children	230 (31.6)	312 (40.7)
Other people	42 (5.8)	16 (2.1)
Did this pre-webinar survey encourage you to read more on Mpox?		
No	47 (6.4)	12 (1.6)
Yes	685 (93.6)	756 (98.4)

Table 2: Descriptive analysis of HCW's perceptions about Mpox disease related awareness, attitudes and worries.

Parameter	Unstandardized Coefficients	95.0% CI for Beta coefficient		
		Lower Bound	Upper Bound	p value
(Constant)	18.395	17.014	19.775	<.001
What is your gender?	-0.869	-1.541	-0.197	0.011
Age>=35 years	0.519	0.057	0.981	0.028
Self-rated awareness of monkeypox spread	0.570	0.348	0.791	<.001
Worry from Mpox compared to COVID: somewhat to extremely more worried from Mpox	0.336	0.023	0.650	0.036
Attitude toward healthcare workers need to apply more infection control measures than the current ones	1.404	0.863	1.954	<.001

Table 3: Multivariate Linear Regression Analysis of the Health Care Workers Knowledge about Mpox disease score before the workshop. Dependent variable: Mpox overall knowledge score before the workshop. Model r-squared=0.10, f (9, 722) =8.82, p value<0.001.

	Multivariate AOR	95% C.I.for AOR		
		Lower	Upper	p value
Age	0.873	0.741	1.029	0.105
Sex:Female	1.270	0.765	2.110	0.356
Clinical role	0.847	0.423	1.694	0.638
How aware are you of the recent increase in Monkeypox cases worldwide as anounced by the WHO this month?	0.998	0.847	1.176	0.983
Working hospital	1.056	0.942	1.184	0.352
Monkeypox Disease overall knowledge score	1.237	1.170	1.308	<0.001
Worry from travel abroad: Worried (somewhat or very)	1.555	1.183	2.043	0.002
Constant	0.011			<0.001

Table 4: Multivariate LOGISTIC Regression Analysis of HCW attitude toward monkeypox immunization for healthcare workers at risk (PRE-Session)

	Multivariate **AOR**	**95% C.I.for AOR**		
		Lower	**Upper**	**p value**
What is your gender?	1.242	0.666	2.317	0.496
Age	0.866	0.722	1.039	0.123
Clinical role	0.938	0.360	2.447	0.896
At what Hospital area do you work usually most of the time?	1.068	0.943	1.209	0.303
How aware are you of the recent increase in Monkeypox cases worldwide as announced by the WHO this month?	1.083	0.912	1.285	0.363
Monkeypox Disease overall knowledge score	1.229	1.157	1.305	<0.001
Worry from Traveling abroad: somewhat to very worried	1.727	1.288	2.315	<0.001
Constant	0.009			<0.001.

Table 5: Multivariate Logistic Regression Analysis of HCWs' Attitudes Toward Monkeypox Immunization for At-Risk Healthcare Workers (Post Session)

	multivariate **AOR**	**95% C.I.for AOR**		
		Lower	**Upper**	**p value**
Age>=45 years	0.651	0.466	0.91	0.012
What is your gender?	1.036	0.626	1.713	0.891
Clinical role	0.985	0.497	1.952	0.965
At what Hospital area do you work usually most of the time?	1.017	0.907	1.14	0.777
Monkeypox Disease overall knowledge score	1.211	1.147	1.279	<.001
Worried from travel abroad: somewhat to extremely worried	1.281	0.978	1.678	0.072
Constant	0.028			<.001

Table 6: Multivariable Logistic binary Regression Analysis of HCW attitude toward monkeypox immunization for high risk contact health workers with positive mpox cases (PRE-SESSION)

	Multivariate_AOR	95% C.I.for AOR		
		Lower	Upper	p value
Sex= female	1.203	0.603	2.401	0.601
Age	0.856	0.701	1.045	0.126
Clinical role	1.912	0.762	4.799	0.168
At what Hospital area do you work usually most of the time?	0.986	0.857	1.134	0.841
How aware are you of the recent increase in Monkeypox cases worldwide as announced by the WHO this month?	1.016	0.84	1.229	0.867
Monkeypox Disease overall knowledge score	1.236	1.158	1.319	<.001
Worried from travel abroad: somewhat to extremely worried	1.542	1.117	2.129	0.008
Constant	0.013			<.001

Table 7: Multivariate Logistic Regression Analysis of HCW attitude toward monkeypox immunization for high risk contact health workers with positive cases (POST-SESSION)

Discussion

This study evaluated the impact of a structured online educational intervention on healthcare workers' knowledge and attitudes toward Mpox during an evolving global outbreak. While several cross-sectional studies have documented significant knowledge gaps regarding Mpox among healthcare professionals [15, 26–28], interventional studies assessing structured educational strategies in real-world healthcare settings remain relatively limited [25, 29]. By implementing and evaluating a targeted training intervention in a large tertiary healthcare system in Saudi Arabia, this study provides empirical evidence demonstrating how structured educational programs can rapidly enhance outbreak preparedness among frontline healthcare workers.

Our findings demonstrate substantial improvements in healthcare workers' knowledge of Mpox following the educational intervention. The most pronounced gains were observed in understanding key transmission routes, including sexual transmission and human-to-human skin contact. These improvements address knowledge gaps previously identified in systematic reviews, where pooled estimates indicated that only approximately 26% of healthcare workers possessed adequate Mpox knowledge [15, 37]. Similar deficiencies have been reported in healthcare settings in Ethiopia and other regions, highlighting the global need for targeted training initiatives to strengthen healthcare workforce preparedness [38–40].

The intervention also significantly improved recognition of clinical manifestations, particularly lymphadenopathy, which increased dramatically after the training session. This finding is important because lymphadenopathy is a distinguishing feature that helps differentiate Mpox from other febrile rash illnesses [31]. Previous studies in Saudi Arabia have similarly reported limited awareness of atypical or less commonly recognized Mpox symptoms among healthcare practitioners [27, 40]. The marked improvement observed in this study suggests that structured educational interventions can effectively address such diagnostic knowledge gaps.

In contrast, recognition of classical symptoms such as fever and rash was already high at baseline and showed only modest improvement following the intervention. This pattern is consistent with previous studies indicating that widely recognized symptoms are generally better understood by healthcare workers even before targeted educational programs are implemented [41–44].

An important finding of this study relates to changes in attitudes toward preventive strategies, particularly vaccination. Post-intervention responses demonstrated increased support for vaccinating high-risk contacts and healthcare workers with occupational exposure. Multivariate analysis further revealed that higher knowledge scores were significantly associated with more favorable attitudes toward vaccination. This relationship between knowledge acquisition and preventive attitudes has

been consistently reported in previous studies and highlights the importance of educational interventions in influencing healthcare workers' perceptions and behaviors regarding emerging infectious disease control [27, 46, 47].

The study also identified notable shifts in information-seeking behavior among healthcare workers. Following the intervention, participants reported increased reliance on official sources of information, including national health authorities and international organizations such as the World Health Organization. This shift toward more authoritative sources is particularly important during emerging infectious disease outbreaks, where misinformation can compromise response efforts and healthcare workers must rely on accurate and timely guidance [26].

Another notable finding is the relationship between perceived risk and preventive attitudes. Participants expressing higher levels of concern regarding international travel were significantly more likely to support vaccination and other preventive measures. This association suggests that perceived vulnerability may act as a motivating factor for knowledge acquisition and preventive behaviors, a phenomenon that has been observed in previous studies examining healthcare workers' responses to emerging infectious diseases [13, 47–48, 50].

Demographic patterns observed in the study also provide useful insights. The predominance of nurses and technicians among participants reflects the composition of the healthcare workforce in many tertiary hospitals and highlights the importance of including these professional groups in outbreak preparedness initiatives. Nurses and allied healthcare staff often play central roles in infection prevention, patient triage, and early detection of emerging infectious diseases, making their preparedness particularly critical for effective outbreak response [32–36].

This study demonstrates that a structured, interactive online session can significantly improve healthcare workers' knowledge and attitudes regarding Mpox. These results are consistent with previous epidemiological and clinical reviews describing the evolving transmission patterns, clinical features, and global public health implications of Mpox [49–51]. Collectively, the findings support the effectiveness of structured educational interventions in improving healthcare workers' preparedness for emerging infectious diseases such as Mpox, a priority emphasized in recent global research agendas and preparedness frameworks [54–58]. The use of an online training format enabled broad participation across departments and professional categories while maintaining interactive learning components. These characteristics highlight the feasibility of implementing scalable educational interventions within large healthcare systems [38, 42, 45, 59–62].

Strengths

This study has several strengths. It included a large sample of healthcare workers across multiple professional groups within a major tertiary healthcare system. The intervention was implemented during a period of heightened global concern regarding Mpox, providing a realistic context for evaluating training effectiveness. Additionally, the use of validated survey instruments and multivariate statistical analysis enhances the reliability and robustness of the findings.

Limitations

Several limitations should be considered when interpreting the results. First, the pre- and post-intervention samples were not matched at the individual level, which may introduce selection bias and limits the ability to attribute improvements exclusively to the intervention. Second, the study measured knowledge and attitudes immediately after the training session; therefore, long-term retention of knowledge and translation into clinical practice were not assessed. Finally, although the study included a large sample from a tertiary healthcare network, the findings may not be fully generalizable to smaller healthcare facilities or other geographic regions.

Implications for Practice and Future Research

Despite these limitations, the results highlight the potential value of structured educational interventions for strengthening healthcare workforce preparedness. Integrating such training into routine continuing medical education programs and institutional preparedness strategies could enhance early recognition of emerging infections, improve adherence to infection prevention measures, and support more effective outbreak responses.

Future research should consider longitudinal or matched study designs to evaluate sustained knowledge retention and behavioral outcomes following training interventions. Multicenter studies would also improve generalizability and help identify context-specific factors influencing healthcare workers' preparedness. In addition, further investigation into the psychological and motivational factors influencing professional learning may help optimize educational strategies for emerging infectious disease preparedness.

Conclusion

This study demonstrates that structured, interactive online education can significantly improve healthcare workers' knowledge and attitudes regarding Mpox, highlighting the important role of targeted educational interventions in strengthening outbreak preparedness. The substantial improvements observed following a brief training session indicate that well-designed educational programs can rapidly address knowledge gaps among frontline healthcare professionals and enhance their readiness to recognize, manage, and prevent emerging infectious diseases.

These findings underscore the importance of integrating evidence-based training initiatives into continuing medical education (CME) programs and institutional preparedness frameworks. By reinforcing awareness of transmission routes, clinical recognition, and infection prevention practices, such interventions can support earlier case detection, reduce the risk of healthcare-associated transmission, and improve the overall effectiveness of public health responses during infectious disease outbreaks.

Given the increasing frequency of emerging and re-emerging infectious threats in an interconnected world, including recent epidemiological reports from multiple regions [61,62], scalable educational strategies such as online training programs represent a practical and cost-effective approach for strengthening healthcare workforce preparedness. Incorporating similar models into routine healthcare training and emergency preparedness planning may enhance health system resilience and contribute to more effective responses to future infectious disease challenges.

Declarations

Ethics approval and consent to participate:

The study was conducted in accordance with the Declaration of Helsinki, and was approved by the Institutional Review Board of King Saud University College of Medicine. Ref. No. 24/1654/IRB of October 17th, 2024

Although informed consent was obtained from each participant, no identifiable patient information was used or published. No human tissue was used for the study.

Availability of data and materials: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no conflicts of interest related to this study.

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Authors' contributions:

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All the authors have read and agreed to the published version of the manuscript.

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Figures

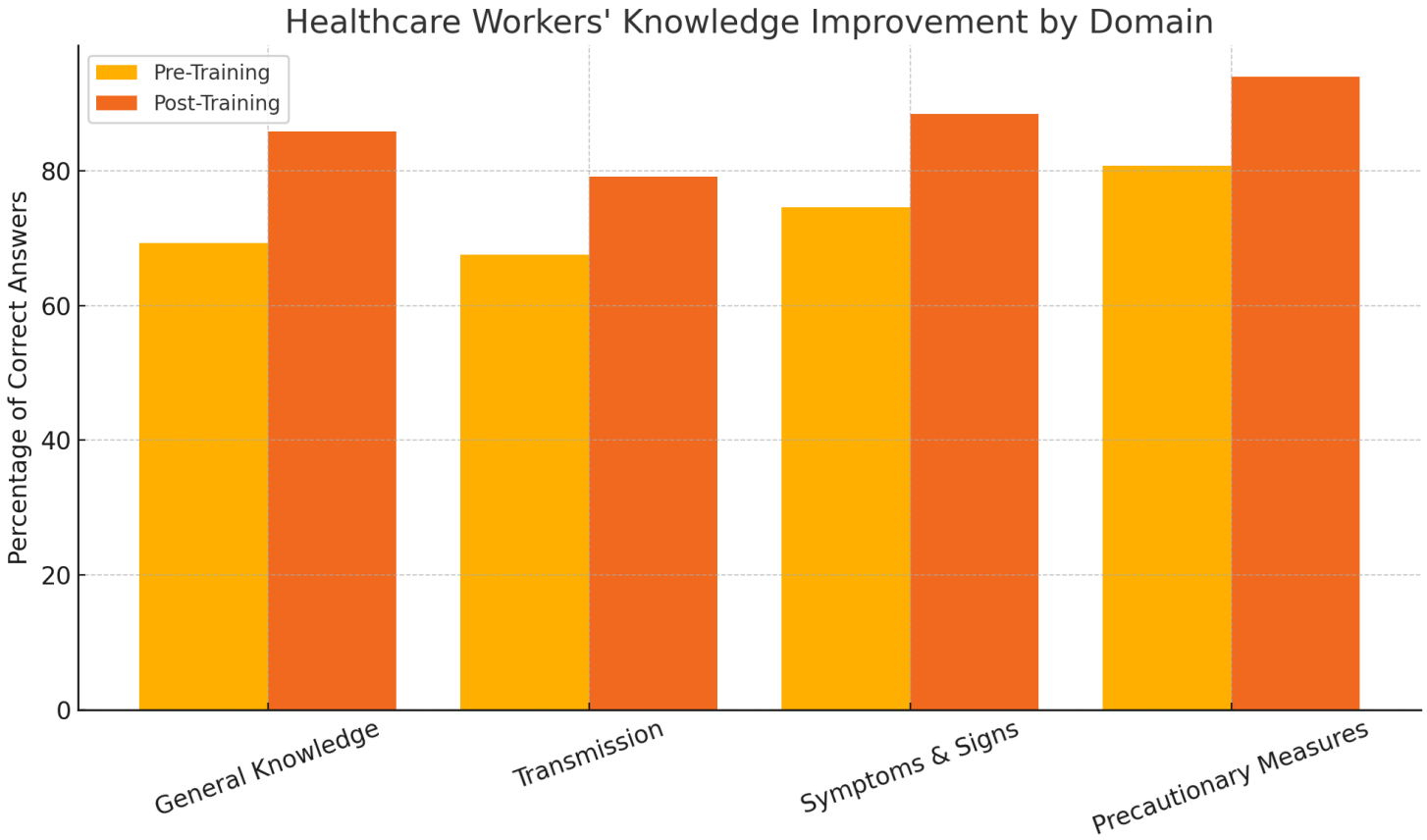


Figure 1

Improvement in Healthcare Workers' Knowledge by Domain – Percentage of Correct Responses.

Supplementary Files

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