ORIGINAL ARTICLE

Assessment of Mpox Awareness and Preparedness among Healthcare Workers in a Tertiary Care Hospital in Islamabad, Pakistan

Amna Nisar[1*], Maria Shakoor Abbasi[1], Ramesh Kumar[2], Mor Khan Shar[1], Bilal Ahmed[1], Anum Tahir[1]

[1] School of Dentistry, SZABMU Islamabad [2] Health Services Academy Islamabad

[*]Corresponding author: Amna Nisar — amnakhan12398@gmail.com

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ABSTRACT

Background: The recent global re-emergence of monkeypox (Mpox), a zoonotic Orthopoxvirus, has heightened public health concerns, placing the healthcare workforce at the forefront of outbreak management. Assessing their preparedness and readiness, especially in tertiary care hospitals, is essential for effective early detection, prevention, and control of the disease.

Material & Methods: This cross-sectional study was conducted at Pakistan Institute of Medical Sciences (PIMS), Islamabad, to assess the awareness, preparedness, and readiness of healthcare workers, including both clinical and non-clinical staff, regarding monkeypox (Mpox) outbreaks. A structured, self-administered questionnaire was used to collect data from a stratified random sample of doctors, nurses, paramedics, and supporting staff. Data were analyzed using descriptive statistics, chi-square tests, ANOVA, and multivariate logistic regression to identify key factors influencing preparedness and readiness.

Results: Among 395 participants, moderate awareness (mean score 5.41/8) and preparedness (mean score 9.91/17) levels were found. Females, nurses, and paramedics exhibited significantly greater awareness and preparedness ($p < 0.001$). A positive correlation was observed between awareness and preparedness ($\rho = 0.305$, $p < 0.001$). Gender and profession emerged as significant predictors of both awareness and preparedness in logistic regression analysis ($p < 0.01$).

Conclusion: The study highlights significant gaps in Mpox awareness, preparedness, and readiness among healthcare workers, emphasizing the urgent need for targeted, profession-specific training programs to enhance both preparedness and readiness for effective outbreak response.

Keywords: *Awareness, Preparedness, Readiness, Mpox, Healthcare Workers*

Introduction

Monkeypox virus (MPXV) is a zoonotic virus belonging to the Orthopoxvirus genus in the Poxviridae family. It can be transmitted via both animal-to-human and human-to-human routes. Transmission occurs through direct contact with blood, bodily fluids, or cutaneous and mucosal lesions of infected animals, and inter-human transmission typically occurs via respiratory droplets or direct contact with infected skin or contaminated materials.[1] In addition, Healthcare Workers (HCWs) have been identified as a vulnerable group due to their exposure to infected patients and contaminated environments. Nosocomial transmission has been documented in previous outbreaks, highlighting the necessity for strict infection prevention and control (IPC) measures in healthcare settings.[2]

Symptoms of Monkeypox (Mpox) include fever, headache, muscle aches, lymphadenopathy, and a characteristic vesiculopustular rash. While its symptoms are similar to smallpox, Mpox generally exhibits a lower mortality rate, estimated between 1% and 10%.[3] Following the eradication of smallpox in 1980 and cessation of routine vaccination, global immunity to orthopoxviruses has declined, contributing to the resurgence of Mpox in non-endemic areas.[4] Since May 2022, the disease has been reported in countries that had not previously experienced documented transmission of mpox outside of Africa. In response to the rapidly escalating situation of Mpox worldwide, on the 23rd of July 2022, the WHO declared the escalating global outbreak of Mpox a Public Health Emergency of International Concern (PHEIC).[5]

While global outbreaks have received considerable attention, the Southeast Asian and specifically Pakistani context reveals a unique set of challenges. Southeast Asia, as a whole, remains at risk due to high population density, porous borders, and limited healthcare infrastructure in many areas. A total of 40 Mpox cases have been reported in the Southeast Asian region by 2023. Pakistan confirmed its first two Mpox cases in 2023, both linked to international travel.[6] By the end of 2024, over 220 suspected cases were tested, and eleven were confirmed. In response, the Ministry of National Health Services implemented various public health measures, including designated isolation facilities, airport screenings, and the establishment of Mpox testing centers. However, systemic challenges such as limited diagnostic capabilities, inadequate infection control infrastructure, and an overstretched healthcare system, still grappling with endemic diseases like malaria, dengue, hepatitis, and the aftermath of COVID-19, pose considerable hurdles.[7]

While some general knowledge about emerging infectious diseases may exist, Mpox remains under-recognized due to its low historical prevalence in the

region.[8] HCWs, especially in tertiary hospitals such as Pakistan Institute of Medical Sciences (PIMS) Islamabad, are pivotal in the early detection, management, and containment of infectious diseases. Their knowledge, attitudes, and practices (KAP) along with preparedness and readiness, directly influence the success of public health interventions and outbreak containment.[9] The COVID-19 pandemic served as a stark reminder of the consequences of inadequate HCW preparedness, ranging from delayed diagnoses to preventable occupational infections and system overloads. Mpox presents unique challenges, including (1) Clinical resemblance to diseases such as smallpox and measles that may delay identification. (2) Risk of stigma, especially in vulnerable communities, can hinder case disclosure. (3) Need for specialized Infection prevention and control (IPC) protocols (WHO, 2024).

Several global KAP studies on Mpox preparedness have been conducted across diverse healthcare settings, such as in Saudi Arabia, Italy, Ethiopia, and multi-country analyses of Arab nations.[9-11] While these studies contribute valuable insights into general awareness levels, vaccine acceptability, and prevention practices among HCWs, they also reveal significant shortcomings, including, limited geographic generalizability and inconsistent measurement tools.

To date, no major peer-reviewed studies have been published assessing Mpox-related preparedness and readiness among HCWs in Pakistan, especially in high-burden tertiary care facilities. This is a significant gap, given Pakistan's vulnerability to emerging zoonotic and viral outbreaks due to, cross-border population movement, limited disease surveillance systems and overburdened tertiary care infrastructure. It is important to identify gaps and inform targeted interventions such as training programs, resource allocation, and policy development. This study will contribute valuable knowledge to Pakistan's public health efforts and add to the global understanding of Mpox preparedness in tertiary care settings within resource-limited contexts. The objectives of our study are (1) To determine the awareness of Mpox outbreak among the clinical and non-clinical staff in the PIMS, Islamabad. (2) To assess the preparedness and readiness of healthcare workers for managing monkeypox (Mpox) in PIMS, Islamabad.

Methodology

A cross-sectional study was conducted at the PIMS, Islamabad, over a period of three months from August 2025-November 2025. Ethical approval was obtained from the Ethical Review Board, with Approval No: No. SOD/ERB/2025/62. Informed written and verbal consent was obtained from all participating healthcare workers. Participants were informed about the study objectives, procedures, voluntary participation, and their right to withdraw at any stage without penalty. Confidentiality and anonymity were strictly maintained, and the study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

The sample size was calculated using the OpenEpi calculator based on the single population proportion formula, assuming a 95% confidence level, a margin of error of 5%, and an expected proportion of adequate Mpox preparedness of 50%. This conservative estimate was selected due to the absence of prior published data on Mpox preparedness among healthcare workers in Pakistan and to ensure maximum sample size estimation. Based on these assumptions, the minimum required sample size was calculated to be 395 participants.

HCWs (doctors, nurses, paramedics), non-clinical supporting staff, and currently employed personnel at PIMS who voluntarily consented to participate were included in the study. HCWs from the infectious diseases department, those on leave or absent during the data collection period, and individuals who declined participation were excluded.

A stratified random sampling technique was employed. After determining the total sample size, the study population was stratified into four professional categories: doctors, nurses, paramedics, and supporting staff. Participants were randomly selected from each stratum in proportion to their representation in the hospital workforce to ensure adequate and unbiased representation of all professional groups. Accordingly, the final sample consisted of 78 doctors, 97 nurses, 42 paramedics, and 178 supporting staff.

Data was collected using a structured questionnaire. It was administered in a paper-based survey, depending on feasibility and participant preference. The questionnaire was divided into three sections. Section I was used to collect demographic data such as age, gender, education, discipline in which the respondent was currently working. Section II was used to collect information regarding the awareness, preparedness and readiness for MPOX outbreak. Awareness regarding monkeypox was evaluated using 8 questions. Correct responses were scored as 1 and incorrect responses were scored as 0. The total scores for the awareness were calculated for each item by adding the items' scores (possible range of 0–8 marks). The frequency of each response selected and the percentages were used to calculate the results (MPX A-score). Additionally, the mean score was calculated. Hospital staff was categorized as good if their general knowledge scores fall between 80 and 100% (7–8), moderate if they fall between 60 and 79% (5–6), and poor if they fall below 60% (4 or less) using a modified Bloom's criteria cut-off point. Similarly, the mean preparedness score was calculated. Based on a modified Bloom's criteria cut-off point, hospital staff were categorized as having good preparedness if their scores ranged between 13 and 17, moderate preparedness for scores between 7 and 12, and poor preparedness for scores below 7.

It also assessed readiness and preparedness for a potential monkeypox outbreak, including the perceived level of preparedness, existence of specific protocols, training received, frequency of drills, availability of personal protective equipment (PPE), awareness of public health guidelines, and confidence in adapting to new recommendations.

To assess the internal consistency of the adapted structured questionnaire, Cronbach's alpha was calculated. The overall Cronbach's alpha coefficient for the 25 items included in the scale was 0.788, indicating good reliability and satisfactory internal consistency among the items.

Descriptive statistics were used to summarize participants' socio-demographic characteristics and their responses on knowledge, and preparedness related to

Mpox. Frequencies and percentages were calculated for categorical variables (e.g., gender, designation, department). Means and standard deviations were calculated for continuous variables (e.g., age, awareness and preparedness.

Inferential analyses were performed to determine associations and differences among variables. Chi-square test was used to assess associations between categorical variables. Gender vs level of Knowledge, Profession vs level of preparedness, Discipline vs level of Knowledge and Discipline vs level of preparedness. ANOVA was used to compare mean preparedness/readiness scores across different groups (Profession: doctors vs. nurses vs. allied staff). Spearman correlation was used to examine the relationship between awareness and preparedness scores.

Multivariable logistic regression was conducted to identify predictors of high preparedness and readiness, adjusting for confounding variables such as age, gender, experience, and profession.

A p-value < 0.05 were considered statistically significant.

Results:

A total of 395 participants were included in the study ages ranged from 18 to 60, with a mean age of 33.01 years (SD = 10.23), indicating a relatively young and early to mid-career workforce. Other demographics are shown in table 1.

Table 1. Socio-demographic Characteristics of Participants (N = 395)

Variables	Category	Frequency (%) N = 395
Age	18-29	189 (47.8)
	30-39	103 (26.1)
	40-49	66 (16.7)
	50-60	37 (9.4)
Gender	Male	181 (45.8)
	Female	214 (54.2)
Education	Intermediate	162 (41.0)
	Graduate	163 (41.3)
	Postgraduate	63 (15.9)
	Post fellowship	7 (1.8)
Profession	Doctors	78 (19.7)
	Nurses	97 (24.6)
	Paramedics	42 (10.6)
	Supporting staff	178 (45.1)
Discipline	Emergency	71 (18.0)
	Outpatient department	160 (40.5)
	Intensive care Unit	104 (26.3)
	Admin block	60 (15.2)

The mean awareness score among the participants was 5.41 (SD = 2.18) out of a maximum possible score of 8, indicating a moderate level of awareness regarding Mpox. The preparedness and readiness score ranged from 0 to 17, with a mean score of 9.91 (SD = 3.73), suggesting a moderate level of self-reported preparedness and readiness to manage or respond to potential Mpox outbreaks.

Among the 395 respondents, awareness regarding Mpox was distributed as follows:

30.1% (n = 119) of participants had a poor level of awareness, 32.4% (n = 128) demonstrated a moderate level of awareness, and 37.5% (n = 148) exhibited a good level of awareness. This indicates that while a considerable proportion had good awareness, a significant segment of the workforce (over 60%) still had low to moderate awareness, highlighting the need for targeted educational interventions.

In terms of preparedness and readiness:

20.0% (n = 79) of participants fell into the poor preparedness category, 58.0% (n = 229) demonstrated a moderate level of preparedness, and 22.0% (n = 87) were found to have good preparedness levels. These findings suggest that although more than half of the respondents have a moderate level of preparedness, only a small fraction are well-prepared, and one-fifth are poorly prepared. This underlines the necessity of structured preparedness programs and readiness training in the healthcare setting.

Inferential analyses were conducted to examine associations and differences between demographic/professional variables and levels of awareness and preparedness using Chi-square tests. An overview of the association between different variables is shown in Table 2 and 3.

A Chi-square test showed a significant association between gender and level of awareness, $p < .001$. A higher percentage of females (44.9%) had good awareness compared to males (28.7%). It also revealed a significant association between discipline and awareness level, $p = .002$. Emergency and Admin Block staff had higher percentages of good awareness (46.5% and 43.3%, respectively), compared to ICU and OPD. Statistically significant association between profession and awareness level, $p < .001$. Nurses and paramedics exhibited the highest proportions of good awareness (64.9% and 54.8%, respectively), followed by doctors (38.5%). In contrast, supporting staff demonstrated the lowest level of awareness, with over half (53.4%) categorized under poor awareness.

Table 2. Association Between Demographic/Professional Characteristics and Awareness Levels (n = 395)

		Awareness Level			Total	Degrees of Freedom (df)	P value
		poor	Mod	Good			
Gender	Male	74	55	52	181	2	0.000
	Female	45	73	96	214		
Discipline	Emergency	15	23	33	71	6	0.002
	OPD	62	38	60	160		
	ICU	27	48	29	104		
	Admin	15	19	26	60		

		Awareness Level			Total	Degrees of Freedom (df)	P value
		poor	Mod	Good			
Profession	Doctors	11	37	30	78	6	0.000
	Nurses	6	28	63	97		
	Paramedics	7	12	23	42		
	Supporting staff	95	51	32	178		
Total		**119**	**128**	**148**	**395**		

There was a statistically significant association between profession and level of preparedness, $p < .001$. Nurses and paramedics showed higher proportions of good preparedness (42.3% and 35.7%, respectively), while doctors and supporting staff had lower rates (11.5% and 11.0%, respectively).

A significant relationship was observed between discipline and preparedness level, $p < .001$. Staff from Outpatient Departments showed a higher percentage of moderate preparedness (66.3%), while Emergency and Admin Block staff had higher levels of good preparedness (33.8% and 31.7%, respectively)

Table 3. Association Between Demographic/Professional Characteristics and Preparedness Levels (n = 395)

		Preparedness Level			Total	Degrees of Freedom (df)	P value
		poor	Mod	Good			
Profession	Doctor	28	41	9	78	6	0.000
	Nurses	16	40	41	97		
	Paramedics	4	23	15	42		
	Supporting staff	31	125	22	178		
Discipline	Emergency	12	35	24	71	6	0.000
	OPD	38	106	16	160		
	ICU	18	58	28	104		
	Admin	11	30	19	60		
Total		**79**	**229**	**87**	**395**		

The ANOVA revealed a statistically significant difference in preparedness scores between at least two professional groups, $F(3, 391) = 13.34$, $p < .001$

The Tukey HSD multiple comparisons test was conducted following a significant one-way ANOVA to identify specific group differences in preparedness scores among healthcare professions. The results revealed the following statistically significant differences:

- Doctors reported significantly higher preparedness scores compared to:
  - Nurses (Mean Difference = -3.089, $p < .001$)
  - Paramedics (Mean Difference = -3.031, $p < .001$)
  - Supporting staff (Mean Difference = -1.383, $p = .048$)
- Nurses had significantly higher preparedness scores than:
  - Supporting staff (Mean Difference = 1.706, $p = .003$)

Other comparisons between groups (e.g., Paramedics vs. Nurses) was not statistically significant ($p > .05$), indicating no meaningful differences in their preparedness scores as depicted in table 4.

Table 4. Tukey HSD Post Hoc Test for Multiple Comparisons of Preparedness Scores Across Professions

(I) Profession	(J) Profession	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Doctor	Nurses	-3.089*	.543	.000	-4.49	-1.69
	Paramedics	-3.031*	.683	.000	-4.79	-1.27
	Supporting staff	-1.337*	.485	.031	-2.59	-.09
Nurses	Doctor	3.089*	.543	.000	1.69	4.49
	Paramedics	.058	.660	1.000	-1.64	1.76
	Supporting staff	1.752*	.451	.001	.59	2.91
Paramedics	Doctor	3.031*	.683	.000	1.27	4.79
	Nurses	-.058	.660	1.000	-1.76	1.64
	Supporting staff	1.694*	.613	.030	.11	3.27
Supporting staff	Doctor	1.337*	.485	.031	.09	2.59
	Nurses	-1.752*	.451	.001	-2.91	-.59
	Paramedics	-1.694*	.613	.030	-3.27	-.11

**. The mean difference is significant at the 0.05 level.*

The Shapiro-Wilk and Kolmogorov-Smirnov tests indicated that both awareness and preparedness scores were not normally distributed ($p < 0.001$). Therefore, Spearman's rank-order correlation was used to examine the relationship between awareness and preparedness.

The analysis revealed a statistically significant, positive correlation between awareness and preparedness scores: Spearman's $\rho = 0.305$, $p < 0.001$ (two-tailed).

This suggests that higher awareness levels were moderately associated with higher levels of preparedness among the participants.

Moreover, to visually explore the relationship between awareness and preparedness levels among healthcare workers, a scatter plot was constructed. This plot helps illustrate any observable trends or associations between the two variables. (figure 1)

It shows that as awareness scores increase, preparedness scores also tend to increase, indicating a positive association.

Participants with low awareness scores (0–2) have mostly lower preparedness.

Participants with higher awareness scores (6–8) show a wider range of preparedness scores, including higher values, suggesting that greater awareness might contribute to better preparedness.

Some participants with the same awareness scores have very different preparedness scores, implying that awareness is a significant but not the only factor affecting preparedness.

There appears to be a positive relationship between awareness and preparedness, but the variation suggests other predictors may also play a role. This visual supports including awareness as a predictor in regression analyses related to preparedness.

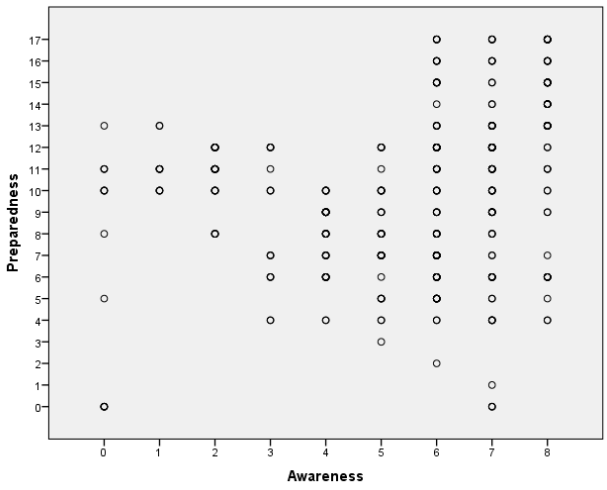

Figure 1. Scatter plot of Knowledge vs. Preparedness Scores

Multivariate logistic regression showed the model was statistically significant (Omnibus test: $\chi^2(4) = 40.35$, $p < 0.001$), with gender and profession emerging as significant predictors of high awareness, while education and discipline showed no significant effects (Table 5).

Table 5. Logistic Regression Predicting High Awareness

Predictor Variable	Odds Ratio (OR)	95% CI for OR	p-value
Gender	2.051	1.315 – 3.198	0.002
Education	0.900	0.652 – 1.243	0.523
Profession	0.601	0.487 – 0.743	0.000
Discipline	0.994	0.780 – 1.266	0.960

The regression model for preparedness was also significant, $\chi^2(4) = 20.28$, $p < 0.001$ with gender, education, and profession identified as significant predictors of high preparedness, whereas discipline was not significant (Table 6).

Table 6. Logistic Regression Predicting High Preparedness and Readiness

Variable	OR (Exp(B))	95% CI for OR	p-value
Gender	2.198	1.306 - 3.699	0.003
Education	0.651	0.441 - 0.961	0.031
Profession	0.691	0.540 - 0.885	0.003
Discipline	1.220	0.927 - 1.605	0.156

Discussion:

This study assessed Mpox-related awareness and preparedness among healthcare workers in a tertiary care hospital in Islamabad. The workforce was predominantly young (mean age 33 years), a trend consistent with findings from Ethiopia, Saudi Arabia, and other LMICs.[12-14] Additionally, similar age distributions had been noted in recent regional studies.[15,16] Female participants slightly outnumbered males, reflecting the increasing feminization of the healthcare workforce reported in regional research.[13,14] Most participants held intermediate or graduate qualifications, similar to educational distributions reported in previous studies.[12,16] Unlike previous studies that focused mainly on clinical staff, our study included a large proportion of non-clinical supporting staff, offering a more comprehensive assessment of institutional readiness.[9,16] Departmental representation varied, with most working in OPD, followed by ICU and Emergency, a distribution comparable to findings in other healthcare settings.[12,18]

Overall Mpox awareness was moderate, with just 37.5% demonstrating good knowledge. This aligns with other international studies, which reported similar knowledge gaps.[19,20] Additional evidence from Kuwait, Jordan, and Saudi Arabia further confirms intermediate awareness levels and persistent gaps in understanding Mpox epidemiology and clinical features.[21,17,10] Some studies also reported the presence of misinformation and conspiracy beliefs.[20] Compared with general populations which consistently showed low awareness, our findings reaffirm the important educational role of healthcare workers.[22,23]

Preparedness levels were relatively low, with only 22% demonstrating good readiness. This trend is consistent with observations from Kuwait and Saudi Arabia.[21,10] Multi-country research has further highlighted limited confidence in diagnosing Mpox and insufficient exposure to outbreak preparedness training.[20] Even in settings with higher reported readiness, such as Jordan, substantial gaps remain in formal training, simulation exercises, and telehealth preparedness.[24]

Significant demographic and professional differences were observed. Female participants showed higher

awareness than males ($p < .001$), aligning with previous international studies.[10,25] However, contrasting results have been reported from studies conducted in Nigeria and Egypt, highlighting regional variability in knowledge patterns.[15,16] Another study, from Pakistan, also found contrasting results, with 79.58% of male participants demonstrating good awareness compared to females. This discrepancy may be explained by differences in sample composition and gender distribution. In the Pakistani study, males constituted approximately 79% of the sample, whereas in the present study the male-to-female ratio was nearly balanced, reducing gender overrepresentation bias.[26] Moreover, variations in professional roles, access to training opportunities, and institutional responsibilities may further account for these differing findings. These observations underscore the importance of considering contextual and workforce composition factors when interpreting gender-based differences in infectious disease awareness.

Nurses and paramedics demonstrated significantly higher levels of Mpox awareness and preparedness compared to doctors and supporting staff in the present study. Yet other research has reported stronger physician knowledge.[25,9] The finding in our is consistent with observations reported by Khan et al.[27], who found that paramedical staff exhibited the highest KAP scores, followed by nurses, while doctors ranked lowest. The similarity between these findings suggests that frontline healthcare workers, particularly nurses and paramedics, may benefit from more frequent exposure to infection prevention and control protocols, routine patient screening, and structured institutional training programs. In contrast, physicians may receive less frequent hands-on training specific to outbreak preparedness, focusing instead on diagnostic and therapeutic decision-making. These findings emphasize the need for profession-specific training strategies, ensuring that all cadres of healthcare workers, including doctors and supporting staff, are adequately prepared to respond to emerging infectious disease threats.

Awareness also varied significantly across departments, with Emergency and Administrative staff scoring higher than OPD and ICU workers, suggesting that workplace exposure and information flow influence preparedness. A positive correlation between awareness and preparedness ($\rho = 0.305$, $p < 0.001$) is consistent with earlier findings as well.[28,29]

Multivariate analysis identified gender and profession as significant predictors of high awareness, whereas education level and department were not significant predictors. These findings partially align with studies from Arabic countries and Nigeria.[30,31] However, they differ from Ethiopian research, where educational status was a strong predictor.[9] Such variations highlight the influence of institutional training systems, professional exposure, and regional contexts.

A key strength of this study is its comprehensive sampling approach. Stratified sampling enabled representation across doctors, nurses, paramedics, and non-clinical staff, enhancing internal generalizability. The pilot-tested questionnaire improved contextual validity, and data collection conducted by the researcher minimized interviewer bias. The use of validated scoring criteria (modified Bloom's cut-offs) and statistical analyses including Chi-square, ANOVA, and multivariate logistic regression strengthened methodological rigor.

However, the study has limitations. Being a single-center cross-sectional study, the findings may not be generalizable to other healthcare settings in Pakistan. Self-reported responses may introduce recall or social desirability bias. Although pilot-tested, the questionnaire might not fully capture nuanced preparedness behaviors. The cross-sectional design also limits causal interpretation and does not reflect changes in knowledge or preparedness over time.

Overall, the findings underscore the need for structured, role-specific Mpox training, regular simulation exercises, and strengthened communication strategies. Enhancing both awareness and preparedness particularly among early-career and non-clinical staff is essential for improving institutional resilience and outbreak response capacity in LMIC contexts.

Conclusions

This study found moderate Mpox awareness but limited preparedness among healthcare workers at PIMS, affecting both clinical and non-clinical staff. Despite adequate general infection prevention knowledge, the lack of Mpox-specific training reduced confidence in outbreak response. Strengthening institutional policies through targeted training, simulation exercises, clear standard operating procedures, improved coordination, resource availability, and continuous public health education is essential to enhance preparedness and resilience against Mpox and other zoonotic threats.

Ethical Approval

Shaheed Zulfiqar Ali Bhutto Medical University
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Conflict of Interest

There is no conflict of interest to declare.

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There are no sponsors for this research; it is self-sponsored.

Authors' Contributions

AN: Conception & design, data collection, data analysis, manuscript writing
MSA: Conception & design, data analysis, manuscript writing
RK: Conception & design, data analysis
MKS: data collection, data analysis
BA: Data analysis and review
AT: Contributed data and analysis tools.

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