JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

Assessment of knowledge, attitudes and behavior, perception, risk factors, practices, One Health, and interventions regarding Monkeypox in Pakistan

Kainat Bibi[1], Huma Khan[1], Muhammad Sohail Afzal[2], Abid Ali[3], Haroon Ahmed[1,4]

[1] Department of Biosciences, Faculty of Health Sciences, COMSATS University Islamabad (CUI), Park Road, Chak Shahzad, Islamabad, Pakistan
[2] Department of Life Sciences, School of Science, University of Management and Technology (UMT), Lahore, Pakistan
[3] Department of Zoology, Abdul Wali Khan University, Mardan, Khyber Pakhtunkhwa 23200, Pakistan
[4] Department of Public Health, Faculty of Health Sciences, Istanbul Aydin University, Türkiye

Abstract

Introduction: The monkeypox virus, a species of the *Orthopoxvirus* genus in the *Poxviridae* family, is the etiological agent of monkeypox, a rare but re-emerging zoonotic disease in non-endemic regions

Aim and Objectives: This study assessed the knowledge, attitudes, and awareness, as well as the risk factors related to monkeypox, among the general population of Pakistan. It also investigated preventive practices, healthcare-seeking behavior, and One Health awareness to inform evidence-based strategies for reducing monkeypox incidence in Pakistan.

Methodology: A cross-sectional study was conducted in Pakistan from June to December 2023 to evaluate knowledge, attitudes, perceptions, risk factors, practices, One Health, and interventions related to monkeypox. A standard, pre-validated questionnaire addressing critical questions about monkeypox was used, and 640 participants completed the study.

Results: Among 640 study participants, the majority were male (56.6%). Overall, 75.6% of participants had poor knowledge of monkeypox. A positive attitude was reported in 58.8% of participants, and 74.8% expressed willingness to adopt precautionary measures. The chi-square test results showed significant associations between socio-demographic characteristics and knowledge, including gender ($p < 0.033$), education ($p < 0.028$), occupation ($p < 0.038$), and smoking status ($p < 0.000$). For attitudes, significant associations were observed with gender ($p < 0.003$), income ($p < 0.003$), occupation ($p < 0.007$), and smoking status ($p < 0.000$).

Conclusions: Although most participants demonstrated insufficient knowledge and positive attitudes towards monkeypox. This underscores the need for a comprehensive public health education initiative aimed at preventing the emergence and transmission of monkeypox in Pakistan.

Key words: knowledge; attitudes; perception; risk factors; One Health; interventions; monkeypox virus; Pakistan.

J Infect Dev Ctries 2026; 20(7):1038-1048. doi:10.3855/jidc.20285

(Received 27 April 2024 – Accepted 17 December 2025)

Introduction

Monkeypox, caused by the monkeypox virus, is an infectious disease whose recent emergence in non-endemic regions has raised substantial global public health concerns. Despite its clinical resemblance to smallpox, it is associated with significantly lower mortality rates. The virus is endemic to Central and West Africa; however, outbreaks have additionally been attributed to the exotic pet trades and international travel. The World Health Organization declared a global health emergency in 2022 in response to its international dissemination via defined modes of interaction, primarily through close physical contact. Phylogenetically, the monkeypox virus is divided into two clades: Clade I, also known as the Congo Basin Clade (Central African), and Clade II, formerly referred to as the West African Clade [1]. Monkeypox, although clinically resembling smallpox, is generally associated with less severe illness in humans; yet, severe presentations can involve complications such as encephalitis and respiratory distress [2]. Evidence suggests that human infection primarily results from infected animal hosts, including rodents and other small mammals, as a key factor in viral maintenance [3]. The epidemiology of monkeypox is closely linked to its zoonotic cycle, involving dynamic interactions between humans, animals, and the environment.

Monkeypox viruses (MPVs) share structural and functional characteristics with other Orthopoxviruses (OPVs). Morphologically, this virion is ovoid or brick-shaped and is encased in an external lipoprotein envelope characterized by a corrugated geometric surface pattern [4]. The outer membrane encases and protects a compact core that harbors a linear double-stranded DNA (197kb) along with transcription factors and enzymes, thereby protecting against environmental and physicochemical stresses [5]. Monkeypox virus can invade the human host via intradermal, mucosal, nasopharyngeal, and oropharyngeal routes. After the initial replication phase at the entry site, the virus

disseminates to local lymph nodes and subsequently enters the circulatory system, leading to the onset of viremia [6]. Variola virus (VACV) and most other orthopoxviruses, including MPV, produce two distinct infectious forms: intracellular mature virions (IMV) and extracellular-enveloped virions (EEVs), both originating from infected host cells [7,8]. Extracellular enveloped virions (EEVs) penetrate host cells through direct membrane fusion, whereas IMVs employ the micropinocytosis pathway to initiate infection [9]. IMVs represent the predominant infectious form, enabling transmission between hosts. In contrast, EEVs facilitate viral spread within the same host following initial infection. EEVs are continuously released from infected cells and migrate locally through tissues via body fluids [10]. MPV exhibits broad tropism, as evidenced by its detection in various animal reservoirs such as dormice, prairie dogs, and giant pouched rats, as well as in infected host tissues. In 2022, a large-scale outbreak of monkeypox affected thousands worldwide. According to the WHO, multiple cases were reported in the United Kingdom in May 2022, linked to Clade II of MPV. This outbreak had an estimated case fatality rate of only 1% [11-13]. Following May 2022, a substantial number of monkeypox cases were confirmed in multiple non-endemic countries worldwide. This unusual outbreak prompted the WHO to identify monkeypox as an "evolving threat of public health concern" in June 2023 [14,15].

Animal-to-human transmission may occur through non-invasive contact, such as animal handling, cage cleaning, hunting, or processing their meat. Although infection can also be acquired through bites or scratches from infected animals, the risk is generally higher with non-invasive contact [16,17]. Monkeypox virus can be transmitted through respiratory secretions, direct physical contact, vertical transmission, percutaneous exposure, or indirect contact with contaminated objects. During the 2022 outbreak, the primary route of transmission was direct contact with lesions or sores on mucosal surfaces [18-22]. Clinical manifestations include fever, cough, sore throat, back pain, and fatigue. These symptoms usually appear before the rash, and the incubation period is generally 6-13 days but can span 21 days [23]. Within 1-2 weeks, the rash progresses from small macules (2-5 mm) to papules, vesicles, and then pustules. Severe cases can lead to bronchopneumonia, sepsis, encephalopathy, myocarditis, keratitis with blindness, proctitis, or rectal perforation.

The preventive measures include hand hygiene after handling contaminated items or infected animals, avoiding close contact with infected persons and animals, thoroughly cooking meat, and home isolation when symptomatic. In terms of treatment, there is no authorized vaccine or medication for monkeypox. Several antivirals used for smallpox and other viral infections may be effective against monkeypox. Tecovirimat (ST-246; TPOXX), brincidofovir (Tembexa), and cidofovir, administered intravenously for cytomegalovirus retinitis in patients with AIDS, are among the available options. Intravenous vaccinia immunoglobulin (VIGIV), approved for smallpox complications, may also be used for monkeypox during epidemics.

The current study aimed to assess the knowledge, attitude, awareness, and behavior towards monkeypox among the general population of Pakistan, as well as the risk factors contributing to its transmission. Furthermore, we investigated the preventive practices, healthcare-seeking behavior, and One Health awareness regarding surveillance to inform evidence-based strategies for reducing monkeypox incidence in Pakistan.

Methodology

Study area

This cross-sectional study was conducted in Islamabad and Rawalpindi, Pakistan. Islamabad, the capital city (33.43°N, 73.04°E), is located at the base of Margalla Hills on the northern edge of the Pothohar Plateau, covering an area of 906.50 km^2 with a population of 1,267,000. Adjacent to it, Rawalpindi occupies the northernmost region of the Punjab province, with an area of 5,286 km^2 and a population of 2,430,000. Both cities have a subtropical humid climate, characterized by hot summers, cold winters, and monsoon season [24].

Study design and sampling procedure

A cross-sectional study was conducted by using face-to-face interviews and online mode. The Raosoft online sample size calculator was used for the calculation of the sample size with the assumptions of a 95% confidence level and a 5% margin of error. Participants over the age of 18 are included in the study, and participants over the age of 50 were excluded from this study. A total of 640 participants were identified and interviewed in the study areas based on the age-based inclusion and exclusion criteria.

The research instrument or questionnaire was designed by using past published literature [25-27]. The survey was generated using Google Forms, conducted in compliance with the STROBE (Strengthening the

Reporting of Observational Studies in Epidemiology) guidelines, and composed in English. The document included details on the background of the study, a statement ensuring confidentiality, and the option for voluntary participation. The survey was subdivided into seven sections: (1) socio-demographic variables (gender, age, education level, discipline, region of residence, and monthly family income) (2) knowledge-based questions (3) attitude and behavior-based questions (4) perception-based questions (5) One Health questions (6) practices and intervention-based questions (7) risk factors related to monkeypox.

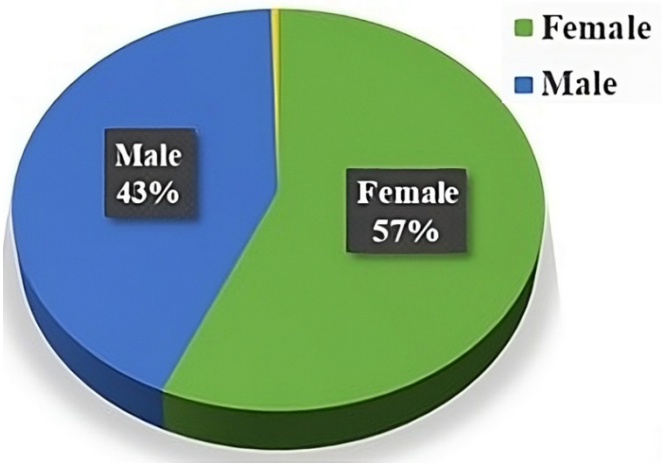
Measures

The questionnaire consists of 57 items across seven sections, assessing socio-demographic characteristics, knowledge, attitudes and behavior, perceptions, One Health, risk factors, practices, and interventions. The knowledge section has 14 closed-ended questions. Nine statements were used to evaluate respondents' attitudes and behavior. Three statements were used to assess respondents' impressions of the severity of monkeypox, their concerns about it, and its influence on daily activities. Five statements were used to assess the One Health response to monkeypox. Seven statements were used to assess participants' practices and interventions regarding monkeypox and their influence on daily lives. Five statements were used to assess participants' awareness regarding monkeypox risk factors. The scoring system awarded one point for each positive answer and zero points for each negative response.

Data collection

Data were collected from June to December 2023 to assess the level of knowledge and awareness among Pakistan's general population. The survey was filled out face-to-face and online.

Figure 1. Gender wise distribution of the participants.



Statistical analysis

The database was created in MS Excel, and basic frequencies were calculated using IBM SPSS. Descriptive statistics were used to analyze the data initially, and the variables were classified as independent and dependent. The independent variables included age, gender, ethnicity, education, occupation, residence, marital status, people in the household, smoking status, and monthly income. The dependent variables included knowledge, attitudes, and behavior, perception, practices, interventions, risk factors, and One Health concepts. In addition to descriptive statistics, Chi-square tests were used to examine levels of knowledge, attitudes, and practices regarding

Table 1. Socio-demographic characteristics.

Characteristics	Number (n)	Percentage (%)
Age (years)		
Up to 25	509	79.5
25-30	106	16.6
More than 30	25	3.9
Gender		
Male	275	42.9
Female	365	57.1
City		
Islamabad	407	63.6
Rawalpindi	233	36.4
Marital Status		
Single	559	87.3
Married	78	12.2
Other	3	0.5
Education Level		
Illiterate	1	0.2
Matric	6	0.9
Undergraduate	488	76.3
Graduate	130	20.3
Other	15	2.3
Occupation		
Student	584	91.3
Business	30	4.7
Job Person	26	4.1
Residence		
Urban	546	85.3
Rural	94	14.7
Income		
Up to 60,000	173	27.0
60,000-1,50,000	177	27.7
More than 1,50,000	40	6.3
None	250	39.1
People in Household		
1-3	117	18.3
4-6	364	56.9
Above 6	159	24.8
Ethnicity		
Sindhi	6	0.9
Punjabi	417	65.2
Pashto	122	19.1
Saraiki	27	4.2
Baloch	3	0.5
Other	65	10.1
Smoking Status		
Smoker	102	15.9
Non-smoker	538	84.1

monkeypox. Significance was defined as $p < 0.05$.

Results

Socio-demographic characteristics

Among the 640 participants, 57.1% were female, and 42.9% were male (Figure 1). Most respondents (79.5%) were aged 25 years or younger, whereas only 3.9% were aged 30 years or older. Most participants (85.3%) lived in urban areas, and 76.3% held undergraduate qualifications in various disciplines. Students comprised 91.3% of the sample, while 39% reported being unemployed with no income. Additionally, 84.1% were self-identified as non-smokers (Table 1).

Knowledge of participants about monkeypox

A total of 75.6% of participants reported prior awareness of monkeypox, whereas 21.5% were unaware of the virus. More than half (56.7%) had first learned about monkeypox only a few months before the study was conducted. The internet, particularly social media, was the primary source of information for 53.4% of participants. Only 19.8% were familiar with monkeypox-diagnosed individuals in Pakistan, and 44.1% expressed a neutral opinion on the availability of vaccines. Regarding clinical knowledge, 43.9% could identify early symptoms, while 45.3% lacked awareness of potential transmission routes (Table 2).

Attitude and behavior of participants towards monkeypox

Regarding attitudes, 65.2% of surveyed participants acknowledged that monkeypox is a serious infectious disease, and 74.8% supported adopting preventive measures. A total of 68.3% expressed willingness to

Table 2. Knowledge of participants regarding the monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Have you ever heard about monkeypox?	Yes	484	75.6
	No	135	21.1
	Maybe	21	3.3
When was the first time, you heard about monkeypox?	Within several month ago	363	56.7
	Within several weeks ago	152	23.8
	No information received	125	19.5
Where have you received information regarding monkeypox?	Television	97	15.2
	Internet	342	53.4
	From other sources	89	13.9
	None	112	17.5
Do you know anyone who was/is diagnosed with monkeypox infection?	Yes	127	19.8
	No	482	75.3
	Maybe	31	4.8
Do you know that monkeypox is caused by a virus?	Yes	375	58.6
	No	198	30.9
	Maybe	67	10.5
Do you know that monkeypox is similar to smallpox?	Yes	255	39.8
	No	221	34.5
	Maybe	164	25.6
Is there any vaccine available for treating monkeypox infection?	Yes	171	26.7
	No	187	29.2
	Maybe	282	44.1
Do you know that vaccines that are used to treat smallpox can be used to treat monkeypox infection?	Yes	160	25.0
	No	224	35.0
	Maybe	256	40.0
Do you know about symptoms associated with monkeypox infection?	Yes	281	43.9
	No	250	39.1
	Maybe	109	17.0
Do you know that early symptoms of monkeypox infection includes rashes, fever, muscle ache, back ache, swollen lymph nodes, chills and exhaustion?	Yes	266	41.6
	No	244	38.1
	Maybe	130	20.3
Do you know that a rash appears on face, hands or feet in monkeypox infection?	Yes	316	49.4
	No	206	32.1
	Maybe	118	18.4
Do you know that rashes caused by monkeypox infection starts as red flat bumps which can be painful and develop into blisters fill with pus and crust over and fall off?	Yes	244	38.1
	No	255	39.8
	Maybe	141	22.1
Do you know that monkeypox infection can infect your mouth, face, hands, feet and genitals?	Yes	227	35.5
	No	286	44.7
	Maybe	127	19.8
Do you know about transmission routes of monkeypox virus?	Yes	215	33.6
	No	290	45.3
	Maybe	135	21.1

receive a monkeypox vaccination (Figure 2), and 70.3% stated they would accept a government-provided vaccine (Tables 3 and 4).

Perceptions of participants towards monkeypox

Overall, 58.8% of respondents reported favorable perceptions. Almost half (49.2%) expressed greater concern about monkeypox compared to previous pandemics. Furthermore, a majority (60.3%) acknowledged that if monkeypox were to become a pandemic similar to COVID-19, it could affect them socially and mentally (Table 5).

One Health concepts regarding monkeypox

Findings indicated that 42.8% of participants had a

Figure 2. Attitudes towards monkeypox vaccination of the participants.

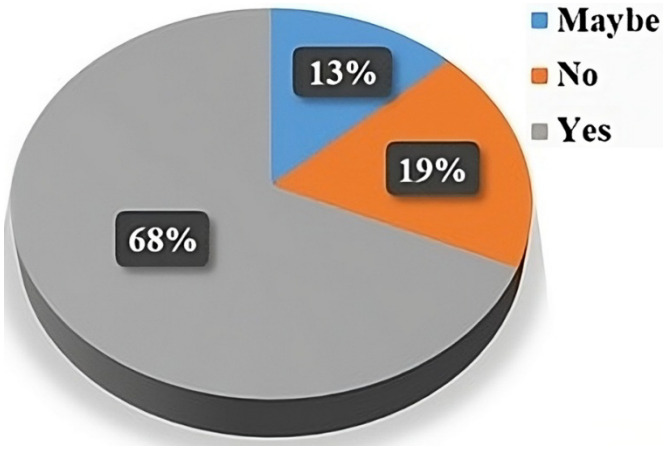


Table 3. Attitude of participants regarding monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Do you think that monkeypox infection is a serious infection?	Yes	417	65.2
	No	122	19.1
	Maybe	101	15.8
Do you think that it is necessary to take precautionary measures to avoid monkeypox?	Yes	479	74.8
	No	92	14.4
	Maybe	69	10.8
Do you think that if this becomes pandemic, will it affect your routine?	Yes	450	70.3
	No	105	16.4
	Maybe	85	13.3
Do you know that vaccination can prevent monkeypox infection?	Yes	395	61.7
	No	132	20.6
	Maybe	113	17.7
Would you like to be vaccinated against monkeypox infection?	Yes	437	68.3
	No	120	18.8
	Maybe	83	12.9
Would you like to be vaccinated against monkeypox infection if vaccine will be provided by government?	Yes	450	70.3
	No	118	18.4
	Maybe	72	11.3

Table 4. Behavior regarding monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
If you have symptoms related to monkeypox, will you seek medical assistance?	Yes	489	76.4
	No	82	12.8
	Maybe	69	10.8
If you have symptoms related to monkeypox, will you isolate yourself from others until your lesions fall off?	Yes	496	77.5
	No	86	13.4
	Maybe	58	9.1
If you have symptoms related to monkeypox, will you stay at home and take rest?	Yes	509	79.5
	No	74	11.6
	Maybe	57	8.9

Table 5. Perception of the participants regarding monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Do you think that monkeypox is a serious threat?	Yes	376	58.8
	No	134	20.9
	Maybe	130	20.3
Are you concerned about monkeypox more than any other pandemic?	Yes	315	49.2
	No	181	28.3
	Maybe	144	22.5
Do you think that if monkeypox infection becomes pandemic like that of COVID-19, will it affect you socially and mentally?	Yes	386	60.3
	No	138	21.6
	Maybe	116	18.1

good understanding of monkeypox transmission, particularly via close contact with infected animals. Most participants (76.4%) expressed their intention to avoid such contact, and most respondents supported recommended practices, including maintaining cleanliness. Furthermore, 81.4% reported willingness to ensure thorough cooking of meat-based dishes to reduce the risk of infection (Table 6).

Practices and interventions regarding monkeypox

Practice assessment showed that 81.2% of participants had a positive attitude toward adopting preventive measures against monkeypox. A significant majority (83.8%) acknowledged the need to avoid contact with contaminated materials, and many (81.6%) supported key measures such as proper handwashing and wearing masks around infected animals and people. Moreover, 82.3% of participants reported awareness of community programs in Pakistan focused on monkeypox prevention and control (Table 7).

Risk factors of monkeypox

Risk factor assessment showed that 38.7% of participants lacked adequate knowledge of specific monkeypox risk factors. This included unawareness of increased susceptibility among pregnant women, children, and immunocompromised individuals (38.7%), and only 24.5% recognized that males may be more susceptible than females. Furthermore, 43.3% were unaware of the high prevalence among individuals engaged in homosexual relationships. Overall, the data highlighted that awareness of general risk factors and transmission modes was insufficient among most participants (Table 8).

Table 6. One health knowledge regarding monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Do you know that monkeypox virus can be transmitted from infected wild animals and primates?	Yes	210	32.8
	No	265	41.4
	Maybe	165	25.8
Do you know that monkeypox virus can transmit through close contact with an infected animal?	Yes	274	42.8
	No	204	31.9
	Maybe	162	25.3
Do you know that monkeypox virus can be transmitted by scratches and biting of an infected animal?	Yes	225	31.2
	No	224	35.0
	Maybe	191	29.8
Do you avoid contact from an infected animal?	Yes	489	76.4
	No	101	15.8
	Maybe	50	7.8
Do you thoroughly cook food that contains animal meat?	Yes	521	81.4
	No	75	11.7
	Maybe	44	6.9
Do you seek medical assistance whenever infected animal bites or scratches you?	Yes	531	82.9
	No	60	9.4
	Maybe	49	7.7

Table 7. Practices and interventions of participants regarding monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Do you think that precautionary measures will help you to remain safe from infection?	Yes	520	81.2
	No	61	9.5
	Maybe	59	9.2
Do you avoid contact with materials that is contaminated with virus?	Yes	536	83.8
	No	70	10.9
	Maybe	34	5.3
Do you wash your hands properly with soap and water?	Yes	537	83.9
	No	65	10.2
	Maybe	38	5.9
Do you avoid contact with people who suffer from any type of viral infection?	Yes	505	78.9
	No	87	13.6
	Maybe	48	7.5
Do you prefer to wear mask when around infected people or animals?	Yes	522	81.6
	No	68	10.6
	Maybe	50	7.8
Do you clean or disinfect touched surfaces?	Yes	166	25.9
	No	336	52.5
	Maybe	138	21.6
Are there any programs in your community aimed at preventing and controlling monkeypox infection?	Yes	527	82.3
	No	83	12.9

Table 8. Risk factors of monkeypox virus.

Variables	Categories	Number (n)	Percentage (%)
Do you know that pregnant women, children and immunocompromised persons are at high risk of developing monkeypox?	Yes	236	36.9
	No	248	38.7
	Maybe	156	24.4
Do you know that monkeypox virus can transmit through sexual contact with an infected person?	Yes	289	45.1
	No	211	32.9
	Maybe	140	21.9
Do you know that men are affected with monkeypox more than women?	Yes	163	24.5
	No	314	49.1
	Maybe	163	24.5
Do you know that monkeypox virus transmits by making close contact with lesions, body fluids, respiratory droplets, contaminated clothes of an infected person?	Yes	236	36.9
	No	272	42.5
	Maybe	132	20.6
Do you know that monkeypox virus can transmit through close contact with infected person?	Yes	287	44.8
	No	189	29.5
	Maybe	164	25.6
Do you know that Monkeypox is highly prevalent among those individuals who have physical relationship with same gender?	Yes	203	31.7
	No	277	43.3
	Maybe	160	25.0

Association between socio-demographics with knowledge and attitudes regarding monkeypox

The analysis examined relationships between socio-demographic characteristics and respondents' knowledge, attitudes, and behaviors regarding monkeypox. Statistically significant associations were found for gender ($p < 0.033$), education level ($p < 0.028$), occupation ($p < 0.038$), and smoking status ($p < 0.000$). These results suggest that these factors may influence awareness and perceptions of monkeypox. In contrast, no significant associations were observed for age $p > 0.856$), residential location ($p > 0.679$), city of residence ($p > 0.639$), marital status ($p > 0.227$), household size ($p > 0.822$), or ethnicity ($p > 0.616$) (Figure 3; Table 9).

Attitude analysis revealed significant associations with gender ($p < 0.003$), ethnicity ($p < 0.012$), occupation ($p < 0.038$), income ($p < 0.003$), and smoking status ($p < 0.000$). No significant associations were identified for age ($p > 0.197$), residence ($p > 0.481$), city ($p > 0.200$), educational level ($p > 0.231$), marital status ($p > 0.432$), or number of household members ($p > 0.590$) (Figure 4; Table 9).

Discussion

By November 27, 2022, reported monkeypox cases worldwide had risen to nearly 81,000 [28]. Despite the increase, awareness of the disease remains limited, especially among students in non-health disciplines and illiterate individuals [29]. The current study revealed that while many respondents demonstrated positive knowledge, attitudes, and practices regarding monkeypox, a significant proportion still exhibited poor knowledge and inadequate practices.

In this study, a large proportion of participants were female, with students representing both health and non-health disciplines. Analysis revealed substantial variation in monkeypox knowledge levels. Notably, 34.4% of respondents had poor knowledge, indicating a gap in awareness about the disease, its transmission, prevention, and treatment. Although 39.8% recognized monkeypox as similar to smallpox, only 25% were

Figure 3. Association between socio-demographic characteristics and knowledge.

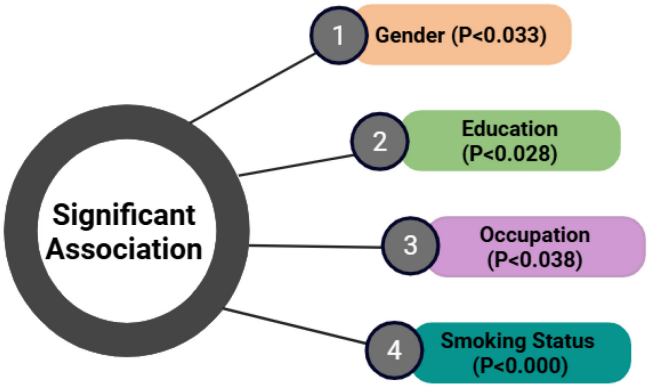


Figure 4. Association between socio-demographic characteristics and attitudes.

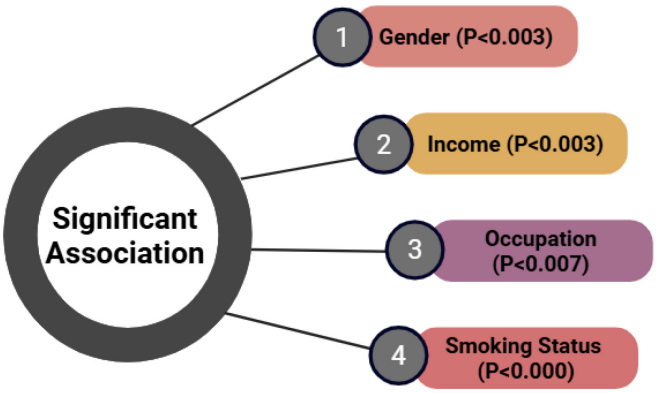


Table 9. Association between socio-demographics with knowledge and attitude regarding monkeypox.

Characteristics	Percentage (%)	Knowledge			*p*	Attitude			*p*
		Poor	Average	Good		Negative	Neutral	Positive	
Gender									
Female	57.1	136	122	104	0.033	154	97	111	0.003
Male	42.9	84	96	95		83	93	99	
Age (years)									
Up to 25	79.5	174	172	163		195	144	170	
25-30	16.6	36	39	31	0.902	32	34	40	0.605
More than 30	3.9	10	7	7		10	12	3	
Residence									
Urban	85.3	188	189	169	0.679	199	167	180	0.481
Rural	14.7	32	29	33		38	23	33	
City Name									
Islamabad	63.6	145	134	125	0.639	157	122	125	0.200
Rawalpindi	36.4	75	82	76		79	66	88	
Education									
Illiterate	0.20	0	1	0		0	0	1	
Matric	0.94	1	0	5		0	2	4	
Undergraduate	76.3	161	177	150	0.028	182	140	166	0.231
Graduate	20.3	50	39	41		52	41	37	
Other	2.34	8	1	6		3	7	5	
Marital Status									
Single	87.3	190	197	172		210	161	188	
Married	12.2	30	19	29	0.227	27	28	23	0.432
Other	0.50	0	2	1		0	1	2	
People in Household									
1-3	18.3	39	36	42		43	32	42	
4-6	56.9	128	126	110	0.822	137	103	124	0.590
Above 6	24.8	53	56	50		57	55	47	
Ethnicity									
Sindhi	0.94	3	2	1		4	1	1	
Punjabi	65.2	144	144	129		142	114	161	
Pashto	19.1	38	37	47	0.616	48	47	27	0.012
Saraiki	4.22	12	10	5		13	7	7	
Baloch	0.50	0	2	1		0	1	2	
Other	10.1	23	23	19		30	20	15	
Occupation									
Student	91.3	204	200	178		220	162	200	
Business	4.68	5	8	17	0.038	6	17	7	0.007
Job	4.06	11	8	7		11	10	5	
Income									
Up to 60,000	27.0	58	60	55		53	48	72	
60,000-1,50,000	27.7	55	66	56	0.134	61	49	67	0.003
More than 1,50,000	6.25	10	10	20		11	16	13	
None	39.1	97	82	71		112	77	61	
Smoking Status									
Smoker	15.9	19	32	51	0.000	21	32	49	0.000
Non-smoker	84.1	201	186	151		216	158	164	

aware that smallpox vaccination can be effective against it. These findings are consistent with earlier investigations [30,31], which similarly identify parallels among orthopoxviruses in terms of pathogenesis, transmission, prevention, control, and treatment. Earlier research [32,33] has indicated that smallpox vaccination is considered effective in preventing and controlling MPXV. In line with earlier research [34], our study found that female participants (57%) demonstrated significantly better understanding of MPXV. Most of the respondents possessed undergraduate-level qualifications and relied primarily on the internet for information. These findings are consistent with prior work showing a positive correlation between higher education level and stronger disease knowledge [35,36].

Education plays a key role in shaping health behaviors and managing epidemics by increasing awareness of health-related conditions. Greater access to media, the internet, and newspapers facilitates rapid information dissemination and supports intellectual development. In our findings, attitudes towards monkeypox were largely neutral, though 33.3% expressed positive views, indicating an optimistic outlook. However, 37% exhibited negative attitudes and behaviors, indicating areas where targeted public health interventions are needed. Interestingly, lower-income participants demonstrated more optimism, which contradicts prior research associating higher socioeconomic status with more positive attitudes

[37,38]. The study found that females exhibited better health practices than males, aligning with prior research showing women are more likely to adopt preventive measures [39], possibly due to women's stronger risk perception and greater concern for personal health.

In this study, analysis revealed that 30.8% of respondents had poor perception regarding monkeypox, indicating a substantial gap in understanding. These findings are consistent with recent data from Pakistan [40], where 68.3% of participants reported negative perceptions towards the monkeypox virus, aligning with the U.S.–based public perception study [41]. Importantly, knowledge must be applied in daily life and can be leveraged to encourage positive attitudes through active awareness initiatives.

The One Health analysis revealed that 35.6% of respondents demonstrated poor understanding, indicating gaps in awareness of monkeypox transmission and related preventive measures. Previous research [42] has emphasized the agricultural sector's importance in controlling zoonotic diseases such as monkeypox, which originated from wildlife, and highlighted food security concerns in rural African regions.

Practice-related data indicated that 62% of participants were categorized as having poor practices. Most respondents (82.3%) were unaware of any monkeypox awareness programs in Pakistan, highlighting the need for targeted educational initiatives. While 81.6% expressed positive attitudes towards wearing masks, consistent with the previous research among general practitioners showing strong preventive behavior [43,44]. Most participants agreed on the importance of isolating infected individuals and implementing preventive measures and quarantine to control MPXV transmission, likely influenced by the COVID-19 pandemic experience [45]. Risk factor analysis revealed varying levels of awareness, particularly regarding transmission. In response to questions on monkeypox risk factors, 42.3% of participants provided inadequate answers. Only 31.7% of participants showed awareness of virus transmission risk among men who are involved in sexual activity with other men (MSM) [46,47]. Supporting this, a pooled meta-analysis found sexual contact to be a factor in over 91% of reported cases [48], and a UK-based cohort study documented 54 laboratory-confirmed cases at a single facility involving MSM [49].

The findings of this study are consistent with prior research reporting insufficient knowledge among Italian physicians; healthcare workers in Jordan and Kuwait; the public in Saudi Arabia, Lebanon, and Iraq; and medical students from various countries [50–52]. As MPXV is endemic to tropical rainforest regions, it remains unfamiliar to most Pakistanis due to the country's temperate climate and lack of prior exposure [53,54]. Public health education for travelers to endemic regions is crucial to enable the adoption of appropriate prevention and treatment measures – similar to MPXV control in DRV and COVID-19 management in China [55,56]. To prevent the introduction of such diseases into non-endemic regions, awareness campaigns should target professional travelers, business sectors, and tourists visiting high-risk regions.

Conclusions

This study identified generally poor knowledge of monkeypox with notable gaps in awareness of its transmission, prevention, and treatment. Attitudes toward the disease were largely neutral, although a majority (68.3%) indicated willingness to receive vaccination. Knowledge and attitude levels were significantly associated with gender, education, occupation, and income. These findings underscore the need for educational initiatives on monkeypox and its prevention. Effective public awareness will require coordinated efforts among international organizations, national and local health authorities, community groups, health care professionals, and media outlets. Our findings provide valuable insights for scientists, policymakers, researchers, and the public and also highlight the importance of timely vaccination to reduce monkeypox risk.

Ethical statement

Ethical approval was obtained from the Ethics Review Board of the Department of Biosciences at COMSATS University Islamabad.

Authors contributions

KB and HK performed data collection, documentation, and analysis, and MSA and AA assisted with data collection and the methodology section. HA supervised the study. HK and HA critically review and revise the manuscript. All authors read and approved the final manuscript.

Corresponding author

Dr. Haroon Ahmed, Professor.
Infectious Diseases Division
Department of Biosciences
COMSATS University Islamabad (CUI), Islamabad, Pakistan
Tel: +923455162128; +92-51-90496099
Email: haroonahmad12@yahoo.com;
haroonahmed@comsats.edu.pk

Conflict of interest

No conflict of interest is declared.

References

1. World Health Organization (2023) Monkeypox fact sheet. Available: https://www.who.int/news-room/fact-sheets/detail/monkeypox. Accessed: 10 August 2024.
2. Khodakevich L, Jezek Z, Kinzanzka K (1986) Isolation of monkeypox virus from wild squirrel infected in nature. Lancet 1: 98-99. doi: 10.1016/S0140-6736(86)90748-8.
3. Nakazawa Y, Emerson GL, Carroll DS, Zhao H, Li Y, Reynolds MG, Damon IK (2013) Phylogenetic and ecologic perspectives of a monkeypox outbreak, southern Sudan, 2005. Emerg Infect Dis 19: 237-245. doi: 10.3201/eid1902.121220.
4. Zaucha GM, Jahrling PB, Geisbert TW, Swearengen JR, Hensley L (2001) The pathology of experimental aerosolized monkeypox virus infection in cynomolgus monkeys (*Macaca fascicularis*). Lab Invest 81: 1581-1600. doi: 10.1038/labinvest.3780373.
5. Cho CT, Wenner HA (1973) Monkeypox virus. Bacteriol Rev 37: 1-18. doi: 10.1128/br.37.1.1-18.1973.
6. Zhu F, Li L, Che D (2022) Monkeypox virus under COVID-19: caution for sexual transmission–correspondence. Int J Surg 104: 106768. doi: 10.1016/j.ijsu.2022.106768.
7. Alakunle E, Moens U, Nchinda G, Okeke MI (2020) Monkeypox virus in Nigeria: infection biology, epidemiology, and evolution. Viruses 12: 1257. doi: 10.3390/v12111257.
8. Schmidt FI, Bleck CKE, Mercer J (2012) Poxvirus host cell entry. Curr Opin Virol 2: 20-27. doi: 10.1016/j.coviro.2011.11.007.
9. Schmelz M, Sodeik B, Ericsson M, Wolffe EJ, Shida H, Hiller G, Griffiths G (1994) Assembly of vaccinia virus: the second wrapping cisterna is derived from the trans Golgi network. J Virol 68: 130-147. doi: 10.1128/JVI.68.1.130-147.1994.
10. Smith GL, Murphy BJ, Law M (2003) Vaccinia virus motility. Annu Rev Microbiol 57: 323-342. doi: 10.1146/annurev.micro.57.030502.091037.
11. Out A, Ebenso B, Walley J, Barceló JM, Ochu CL (2022) Global human monkeypox outbreak: atypical presentation demanding urgent public health action. Lancet Microbe 3: e554-e555. doi: 10.1016/S2666-5247(22)00167-3.
12. Sklenovská N, Van Ranst M (2018) Emergence of monkeypox as the most important orthopoxvirus infection in humans. Front Public Health 6: 383729. doi: 10.3389/fpubh.2018.00241.
13. Likos AM, Sammons SA, Olson VA, Frace AM, Li Y, Olsen-Rasmussen M, Damon IK (2005) A tale of two clades: monkeypox viruses. J Gen Virol 86: 2661-2672. doi: 10.1099/vir.0.81215-0.
14. Nuzzo JB, Borio LL, Gostin LO (2022) The WHO declaration of monkeypox as a global public health emergency. JAMA 328: 615-617. doi: 10.1001/jama.2022.12513.
15. Wenham C, Eccleston-Turner M (2022) Monkeypox as a PHEIC: implications for global health governance. Lancet 400: 2169-2171. doi: 10.1016/S0140-6736(22)02222-9.
16. Reynolds MG, Davidson WB, Curns AT, Conover CS, Huhn G, Davis JP, Damon IK (2007) Spectrum of infection and risk factors for human monkeypox, United States, 2003. Emerg Infect Dis 13: 1332-1339. doi: 10.3201/eid1309.070175.
17. Reynolds MG, Yorita KL, Kuehnert MJ, Davidson WB, Huhn GD, Holman RC, Damon IK (2006) Clinical manifestations of human monkeypox influenced by route of infection. J Infect Dis 194: 773-780. doi: 10.1086/505880.
18. Thornhill JP, Barkati S, Walmsley S, Rockstroh J, Antinori A, Harrison LB, Orkin CM (2022) Monkeypox virus infection in humans across 16 countries—April–June 2022. N Engl J Med 387: 679-691. doi: 10.1056/NEJMoa2207323.
19. Patel A, Bilinska J, Tam JC, Fontoura DDS, Mason CY, Daunt A, Nori A (2022) Clinical features and novel presentations of human monkeypox in a central London centre during the 2022 outbreak: descriptive case series. BMJ 378: e072410. doi: 10.1136/bmj-2022-072410.
20. Tarín-Vicente EJ, Alemany A, Agud-Dios M, Ubals M, Suñer C, Antón A, Mitjà O (2022) Clinical presentation and virological assessment of confirmed human monkeypox virus cases in Spain: a prospective observational cohort study. Lancet 400: 661-669. doi: 10.1016/S0140-6736(22)01436-2.
21. Català A, Clavo-Escribano P, Riera-Monroig J, Martín-Ezquerra G, Fernandez-Gonzalez P, Revelles-Peñas L, Fuertes I (2022) Monkeypox outbreak in Spain: clinical and epidemiological findings in a prospective cross-sectional study of 185 cases. Br J Dermatol 187: 765-772. doi: 10.1111/bjd.21790.
22. Centers for Disease Control and Prevention (2022) Monkeypox: how it spreads. Updated 2022 Jul 29. Available: https://www.cdc.gov/poxvirus/monkeypox/if-sick/transmission.html. Accessed: 10 August 2024.
23. Pembi E, Omoleke S, Paul H, Augustine T, Cuevas LE (2022) Monkeypox outbreak in a correctional center in north eastern Nigeria. J Infect 85: 702-769. doi: 10.1016/j.jinf.2022.09.010.
24. Macrotrends LLC (n.d.) Pakistan population 1960-2025. Available: https://www.macrotrends.net/countries/PAK/pakistan/population. Accessed: 10 August 2024.
25. Riad A, Drobov A, Rozmarinová J, Drapáčová P, Klugarová J, Dušek L, Klugar M (2022) Monkeypox knowledge and vaccine hesitancy of Czech healthcare workers: a health belief model (HBM)-based study. Vaccines 10: 2022. doi: 10.3390/vaccines10122022.
26. Sallam M, Al-Mahzoum K, Dardas LA, Al-Tammemi AAB, Al-Majali L, Al-Naimat H, Harapan H (2022) Knowledge of human monkeypox and its relation to conspiracy beliefs among students in Jordanian health schools: filling the knowledge gap on emerging zoonotic viruses. Medicina 58: 924. doi: 10.3390/medicina58070924.
27. Harapan H, Setiawan AM, Yufika A, Anwar S, Wahyuni S, Asrizal FW, Mudatsir M (2020) Knowledge of human monkeypox viral infection among general practitioners: a cross-sectional study in Indonesia. Pathog Glob Health 114: 68-75. doi: 10.1080/20477724.2020.1744790.
28. Kaler J, Hussain A, Flores G, Kheiri S, Desrosiers D (2022) Monkeypox: a comprehensive review of transmission, pathogenesis, and manifestation. Cureus 14: e26531. doi: 10.7759/cureus.26531.
29. Khan S, Akbar SMF, Yahiro T, Al Mahtab M, Kimitsuki K, Nishizono A (2022) Unprecedented rise of monkeypox in Europe and America: are Asian countries ready for a new outbreak during the ongoing COVID-19 pandemic? J Glob Health 12: 03066. doi: 10.7189/jogh.12.03066.
30. Dolin R, Bennett JE, Mandell GL (2005) Mandell, Douglas, and Bennett's principles and practice of infectious diseases, 6th ed. Elsevier Churchill Livingstone, Philadelphia, pp 1727-3662.
31. Bunge EM, Hoet B, Chen L, Lienert F, Weidenthaler H, Baer LR, Steffen R (2022) The changing epidemiology of human monkeypox—a potential threat? A systematic review. PLoS

Negl Trop Dis 16: e0010141. doi: 10.1371/journal.pntd.0010141.
32. Edghill-Smith Y, Golding H, Manischewitz J, King LR, Scott D, Bray M, Franchini G (2005) Smallpox vaccine–induced antibodies are necessary and sufficient for protection against monkeypox virus. Nat Med 11: 740-747. doi: 10.1038/nm1261.
33. Earl PL, Americo JL, Wyatt LS, Eller LA, Whitbeck JC, Cohen GH, Moss B (2004) Immunogenicity of a highly attenuated MVA smallpox vaccine and protection against monkeypox. Nature 428: 182-185. doi: 10.1038/nature02331.
34. Nath SD, Islam AK, Majumder K, Rimti FH, Das J, Tabassum MN, Hawlader MDH (2025) Assessment of knowledge on human Mpox virus among general population in Bangladesh. Discov Public Health 22: 256. doi: 10.1186/s12982-025-00381-2.
35. Li ZH, Zhang XR, Zhong WF, Song WQ, Wang ZH, Chen Q, Mao C (2020) Knowledge, attitudes, and practices related to coronavirus disease 2019 during the outbreak among workers in China: a large cross-sectional study. PLoS Negl Trop Dis 14: e0008584. doi: 10.1371/journal.pntd.0008584.
36. Raghupathi V, Raghupathi W (2020) The influence of education on health: an empirical assessment of OECD countries for the period 1995–2015. Arch Public Health 78: 20. doi: 10.1186/s13690-020-00402-5.
37. McArthur L, Pena M, Holbert D (2001) Effects of socioeconomic status on the obesity knowledge of adolescents from six Latin American cities. Int J Obes Relat Metab Disord 25: 1262-1268. doi: 10.1038/sj.ijo.0801674.
38. Marmot M (2002) The influence of income on health: views of an epidemiologist. Health Aff 21: 31-46. doi: 10.1377/hlthaff.21.2.31.
39. Deeks A, Lombard C, Michelmore J, Teede H (2009) The effects of gender and age on health-related behaviors. BMC Public Health 9: 213. doi: 10.1186/1471-2458-9-213.
40. Jamil H, Idrees M, Idrees K, Tariq W, Sayyeda Q, Asghar MS, Sah R (2023) Socio-demographic determinants of monkeypox virus preventive behavior: a cross-sectional study in Pakistan. PLoS One 18: e0279952. doi: 10.1371/journal.pone.0279952.
41. Winters M, Malik AA, Omer SB (2022) Attitudes towards monkeypox vaccination and predictors of vaccination intentions among the US general public. PLoS One 17: e0278622. doi: 10.1371/journal.pone.0278622.
42. Reynolds MG, Doty JB, McCollum AM, Olson VA, Nakazawa Y (2019) Monkeypox re-emergence in Africa: a call to expand the concept and practice of One Health. Expert Rev Anti Infect Ther 17: 129-139. doi: 10.1080/14787210.2019.1567330.
43. Riccò M, Ferraro P, Camisa V, Satta E, Zaniboni A, Ranzieri S, Marchesi F (2022) When a neglected tropical disease goes global: knowledge, attitudes and practices of Italian physicians towards monkeypox, preliminary results. Trop Med Infect Dis 7: 135. doi: 10.3390/tropicalmed7070135.
44. Salim NA, Septadina IS, Permata M, Hudari H (2022) Knowledge, attitude, and perception of anticipating 2022 global human monkeypox infection among internal medicine residents at Palembang, Indonesia: an online survey. Jurnal Kedokteran dan Kesehatan 9: 253-262. doi: 10.36706/jkk.v9i3.18961. [Article in Indonesian]
45. Hemati S, Farhadkhani M, Sanami S, Mohammadi-Moghadam F (2022) A review on insights and lessons from COVID-19 to the prevent of monkeypox pandemic. Travel Med Infect Dis 50: 102441. doi: 10.1016/j.tmaid.2022.102441.
46. Bragazzi NL, Kong JD, Mahroum N, Tsigalou C, Khamisy-Farah R, Converti M, Wu J (2023) Epidemiological trends and clinical features of the ongoing monkeypox epidemic: a preliminary pooled data analysis and literature review. J Med Virol 95: e27931. doi: 10.1002/jmv.27931.
47. Seang S, Burrel S, Todesco E, Leducq V, Monsel G, Le Pluart D, Palich R (2022) Evidence of human-to-dog transmission of monkeypox virus. Lancet 400: 658-659. doi: 10.1016/S0140-6736(22)01487-8.
48. Sah R, Abdelaal A, Reda A, Katamesh BE, Manirambona E, Abdelmonem H, Rodriguez-Morales AJ (2022) Monkeypox and its possible sexual transmission: where are we now with its evidence? Pathogens 11: 924. doi: 10.3390/pathogens11080924.
49. Girometti N, Byrne R, Bracchi M, Heskin J, McOwan A, Tittle V, Gohil J (2022) Demographic characteristics and clinical features of confirmed human monkeypox virus cases in individuals attending a sexual health center in London, United Kingdom. Lancet Infect Dis 22: 1292-1298. doi: 10.1016/S1473-3099(22)00411-X.
50. Sallam M, Eid H, Awamleh N, Al-Tammemi AAB, Barakat M, Athamneh RY, Mahafzah A (2022) Conspiratorial attitude of the general public in Jordan towards emerging virus infections: a cross-sectional study amid the 2022 monkeypox outbreak. Trop Med Infect Dis 7: 411. doi: 10.3390/tropicalmed7120411.
51. Ahmed SK, Abdulqadir SO, Omar RM, Abdullah AJ, Rahman HA, Hussein SH, Abdulla AQ (2023) Knowledge, attitude and worry in the Kurdistan region of Iraq during the mpox (monkeypox) outbreak in 2022: an online cross-sectional study. Vaccines 11: 610. doi: 10.3390/vaccines11030610.
52. Alsanafi M, Al-Mahzoum K, Sallam M (2022) Monkeypox knowledge and confidence in diagnosis and management with evaluation of emerging virus infection conspiracies among health professionals in Kuwait. Pathogens 11: 994. doi: 10.3390/pathogens11090994.
53. Damon IK (2011) Status of human monkeypox: clinical disease, epidemiology and research. Vaccine 29: D54-D59. doi: 10.1016/j.vaccine.2011.04.014.
54. Durski KN (2018) Emergence of monkeypox—west and central Africa, 1970–2017. MMWR Morb Mortal Wkly Rep 67: 306-310. doi: 10.15585/mmwr.mm6710a5.
55. Nolen LD, Osadebe L, Katomba J, Likofata J, Mukadi D, Monroe B, Reynolds MG (2016) Extended human-to-human transmission during a monkeypox outbreak in the Democratic Republic of the Congo. Emerg Infect Dis 22: 1014-1021. doi: 10.3201/eid2206.150579.
56. Hadi AG, Kadhom M, Hairunisa N, Yousif E, Mohammed SA (2020) A review on COVID-19: origin, spread, symptoms, treatment, and prevention. Biointerface Res Appl Chem 10: 7234-7242. doi: 10.33263/BRIAC106.72347242.