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RESEARCH ARTICLE

Knowledge, attitudes, and practices toward monkeypox among university students in Khyber Pakhtunkhwa, Pakistan: A cross-sectional study from Gomal University

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ABSTRACT

Background and Aim: The re-emergence of monkeypox (mpox) as a global public health concern necessitates assessing awareness and preparedness, particularly among educated youth who can act as health knowledge multipliers. This study aimed to evaluate the knowledge, attitudes, and practices (KAP) regarding mpox among undergraduate and postgraduate students at Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan.

Materials and Methods: A cross-sectional study was conducted from December 2024 to March 2025 among 443 university students selected through a simple random sampling method. A structured, prevalidated questionnaire was used to assess knowledge (18 items), attitudes (8 items), and practices (10 items). Data were analyzed using descriptive statistics and Chi-square tests to identify associations between demographic factors and KAP domains, with a significance level set at $p < 0.05$.

Results: Most participaints were male (75.2%) and from urban areas (58.0%). Overall, 94.6% recognized mpox as a viral disease, while 77.7% identified it as a zoonotic disease. However, misconceptions persisted; only 55.8% acknowledged airborne transmission and 47.2% recognized possible reverse zoonosis. Concern about contracting mpox was expressed by 53.3% of students, and 61.6% were willing to receive vaccination. Knowledge levels were significantly associated with academic year ($p = 0.003$) and major ($p = 0.010$), with medical students demonstrating better knowledge (55.0%) compared to their non-medical peers (25.4%). Gender significantly influenced attitudes ($p < 0.001$) and practices ($p = 0.025$), with females showing lower positive attitudes and practice scores. Common preventive behaviors included handwashing (93.9%) and seeking medical attention (84.9%), while only 34.1% were vaccinated.

Conclusion: Although awareness about mpox was high among Gomal University students, notable gaps existed regarding the transmission and prevention of the disease. Gender, academic discipline, and study year had a significant influence on knowledge and attitudes. Integrating zoonotic disease education into university curricula, campus health promotion, and social media-based awareness programs could strengthen students' preventive practices and outbreak preparedness.

Keywords: knowledge, attitudes, and practices, monkeypox, Pakistan, public health, university students, vaccination, zoonosis.

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INTRODUCTION

Monkeypox (Mpox) is a zoonotic disease caused by the mpox virus, characterized by fever, rash, and swollen lymph nodes [1]. Following the global eradication of smallpox, mpox remains one of the four recognized human infections associated with this viral group. The mpox virus was first identified in monkeys in 1958, whereas the first confirmed human case was documented in 1970 in the Democratic Republic of the Congo [2]. Before 2021, mpox was largely confined to Central and West Africa, where transmission predominantly occurred through contact with infected wild animals. Human-to-human transmission was relatively uncommon and generally resulted in small, localized outbreaks that occasionally spread to other regions through travel or familial exposure [3]. However, in May 2022, mpox was reported simultaneously in several non-endemic countries, prompting the World Health Organization (WHO) to declare it a Public Health Emergency of International Concern in July 2022 [4]. The infection carries a mortality rate of up to 10% [5], underscoring the urgent need for effective surveillance and response strategies to control its spread.

Universities, being densely populated and interactive environments, are potential hotspots for the transmission of infectious diseases. The knowledge, attitudes, and behaviors of university students regarding such emerging infections play a vital role in influencing both their personal preventive actions and those of the surrounding community [6]. In a cross-sectional study involving 314 university students in Saudi Arabia, 72% of medical students reported being inadequately informed about mpox [7]. Similarly, Kumar *et al*. [8] reported that only 6.3% of Pakistani university students demonstrated sufficient understanding of mpox, and merely 20.5% expressed a positive attitude toward preventive measures. Their study also revealed significant associations between mpox-related knowledge and factors such as educational background, academic discipline, and geographical region. These results reflect an alarming lack of awareness among university populations, which could impede effective management and control of mpox outbreaks.

Pakistan, classified as a lower-middle-income country, faces significant challenges in allocating public health resources and developing infrastructure. In 2021, the government devoted only 1.2% of its gross domestic product to healthcare, well below the WHO's recommended 5% [9]. The national literacy rate remains below 40% [10], and <1–3rd of the population completes university-level education. Such limited literacy and health awareness contribute to a poor understanding of basic health rights and disease prevention. During pandemics, university students often serve as information multipliers within their communities, making their knowledge and attitudes critical for effective public health education initiatives.

Currently, Pakistan lacks in-country diagnostic facilities for mpox, forcing health authorities to send suspected samples abroad during emergencies. This dependency increases diagnostic delays and heightens the risk of disease spread. Enhancing public understanding of mpox symptoms and transmission routes is therefore essential for early case detection and isolation. Additionally, hospitals and public health centers should be equipped with designated isolation units to control potential outbreaks efficiently.

As of mid-2025, Pakistan has reported at least 11 confirmed mpox cases since the first case emerged in April 2023, with one fatality recorded during this period [9, 10]. The index case was identified in Islamabad on April 21, 2023, in a 25-year-old who had returned from Saudi Arabia [10]. In August 2024, the Khyber Pakhtunkhwa (KPK Health Department confirmed three cases among travelers returning from the United Arab Emirates, followed by another case in Azad Kashmir; none were attributed to the more virulent clade Ib (a sub-lineage of Clade I, historically associated with the Central African/Congo Basin region). Experts have highlighted several major challenges to the national response, including limited diagnostic capacity, weak disease surveillance, and low public awareness. In early 2025, an additional case was detected at Peshawar airport in a traveler returning from Dubai, and another was confirmed in Karachi in March 2025 involving a 28-year-old man infected after his wife returned from abroad. To date, all mpox cases in Pakistan have been travel-associated or imported, with no evidence of sustained human-to-human transmission [11].

Despite the increasing global incidence of mpox and its recognition as a Public Health Emergency of International Concern, research on public awareness, perception, and preventive behaviors toward the disease in Pakistan remains extremely limited. Previous investigations by Kumar *et al.* [8] and World Health Organization [9] have primarily focused on online surveys or hospital-based populations in major urban centers such as Karachi, Lahore, and Islamabad. Consequently, there is a scarcity of empirical evidence from southern Khyber Pakhtunkhwa (KPK), a province characterized by porous borders, migrant movement, and a mixed urban-rural demographic that could significantly influence disease transmission dynamics. Furthermore, most earlier studies targeted healthcare workers or medical students, often neglecting non-medical university students who play an equally vital role in health communication and behavioral change within their social environments. The limited data on the knowledge, attitudes, and practices (KAP) of these groups pose a barrier to designing targeted awareness interventions. In addition, Pakistan's public health infrastructure remains underdeveloped, with low literacy rates, inadequate diagnostic facilities, and limited community-level disease surveillance [9, 10]. These systemic challenges, coupled with poor awareness of zoonotic transmission pathways and preventive practices, could delay early detection and containment efforts in the event of local mpox transmission. Within the broader One Health framework, university students represent a key bridge population that connects human health, animal health, and environmental interfaces. Therefore, understanding their awareness and preparedness toward mpox is critical for shaping future zoonotic disease prevention and communication strategies at both institutional and provincial levels.

This study was designed to assess the KAP regarding mpox among undergraduate and postgraduate students at Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Gomal University was purposefully selected because it is one of the largest public-sector higher-education institutions in southern KPK, enrolling students from both urban and rural districts, thereby providing a diverse socioeconomic and educational sample. The university also hosts multiple faculties, including veterinary sciences, medical and allied health sciences, pharmacy, and non-health disciplines, allowing comparative evaluation of mpox-related awareness across different academic backgrounds. Given that KPK has reported several imported mpox cases since 2023 and shares socioeconomic and travel characteristics with areas of potential outbreak risk, this region represents an ideal sentinel location for studying mpox awareness among young adults. The specific objectives of this study were:

1. To assess the level of knowledge about mpox transmission, prevention, and symptoms among university students
2. To evaluate students' attitudes toward mpox-related health risks, vaccination, and disease stigma
3. To identify common preventive practices and behaviors related to infection control
4. To determine the demographic and academic factors (such as gender, major, and year of study) that influence KAP scores.

The findings of this study are expected to generate baseline data that can guide university-level health education programs, inform provincial disease preparedness policies, and support the integration of One Health-based zoonotic awareness modules in higher education curricula.

MATERIALS AND METHODS

Ethical approval and Informed consent

The study protocol was reviewed and approved by the Ethical Review Board of Gomal University, Dera Ismail Khan (Approval Letter No: 2156/FVAS/GU.07.10.2024). All participants were informed of the study objectives and procedures, and written informed consent was obtained prior to their participation.

Study period and location

This cross-sectional study was conducted between December 2024 and March 2025, encompassing a 4-month period for data collection and analysis. The study was conducted among undergraduate and postgraduate students of Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa (KPK), Pakistan. The cross-sectional design facilitated data collection at a single point in time, providing a representative overview of the students' current KAP levels regarding mpox.

Questionnaire development and validation

The KAP questionnaire used in this study was adapted from previously published surveys on emerging infectious diseases, including WHO guidelines and relevant peer-reviewed literature. The tool was customized to suit the local context of Gomal University students. Content validity was ensured through expert review by epidemiologists and infectious disease specialists, while face validity was established through a pilot test involving 20 students (excluded from the final analysis) to assess clarity, cultural appropriateness, and comprehension. The final questionnaire comprised:

- 18 knowledge items addressing etiology, transmission, symptoms, prevention, and control of mpox
- 8 attitude items evaluating perceived risk, trust in health authorities, and willingness to receive vaccination
- 10 practice items assessing hygiene behaviors, preventive measures, and health-seeking actions. Demographic information collected included age, gender, academic year, field of study, origin (urban/rural), occupation, and main sources of mpox-related information.

Study population and eligibility criteria

The study population consisted of undergraduate and postgraduate students enrolled in various academic departments of Gomal University. Eligibility criteria included:

1. Age ≥16 years
2. Active enrollment in an undergraduate or postgraduate program at Gomal University
3. Willingness to provide informed consent. Students who were absent during data collection, declined participation, or failed to complete the questionnaire were excluded from the study.

Sample size determination and sampling technique

The sample size was determined using Cochran's formula for single proportions, assuming a 50% population proportion, a 95% confidence level, and a 5% margin of error.

$$n_0 = \frac{Z^2 \times p \times (1-p)}{e^2}$$

Where:

- n_0 = required sample size
- Z = Z-score for 95% confidence (1.96)
- p = expected prevalence (0.5)
- e = margin of error (0.05).

The minimum required sample size was 384 participants, and an additional 20% was added to account for potential non-response, yielding a target of 460 students. After excluding incomplete questionnaires, 443 valid responses were included in the final analysis, providing adequate statistical power for subgroup comparisons.

A multi-stage sampling technique was employed:

1. Stratified sampling to classify students by educational level
2. Proportionate sampling to determine participant numbers from each stratum
3. Simple random sampling to select individual participants, ensuring representativeness and minimizing selection bias.

This robust sampling framework, incorporating a balanced mix of undergraduate and postgraduate students, enhanced the validity and generalizability of the findings.

Data collection procedure

Data collection began after formal approval from the Faculty of Veterinary and Animal Sciences, Gomal University. Trained research assistants were instructed on ethical conduct, data collection procedures, and questionnaire administration. Participants were approached in classrooms, where they were briefed about the study objectives and confidentiality. After obtaining consent, questionnaires were administered in a controlled classroom environment to minimize external influence and ensure independent responses. Completed questionnaires were immediately reviewed for accuracy and completeness. Missing or unclear responses were clarified on-site with the participants when possible. The overall data collection phase lasted 2 months, enabling coverage across multiple faculties.

Before full-scale data collection, a pilot test involving 20 students was performed to evaluate clarity, timing, and logistical feasibility. The test confirmed an average completion time of 15–20 min and led to minor wording adjustments for better clarity. The pilot validation process strengthened the reliability and internal consistency of the final instrument.

Scoring criteria

Responses in the knowledge and practice domains were scored as 1 for correct or positive answers and 0 for incorrect or negative ones.

The attitude section used a 4-point Likert scale:

- Strongly disagree = 0
- Disagree = 1
- Neutral = 2
- Agree = 3.

Higher scores indicated more favorable attitudes toward mpox prevention and control. Each domain's total score was converted into a percentage, with scores ≥70% classified as "good" knowledge, positive attitudes, or good practices, and scores <70% as "poor."

This 70% threshold aligns with previous KAP studies in infectious disease epidemiology, where it is recognized as an acceptable cut-off for sufficient awareness and compliance with preventive measures.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences, Version 25 (IBM Corp., USA). Descriptive statistics, including frequencies and percentages, were used to summarize the data. Associations between sociodemographic factors and KAP levels were examined using Pearson's Chi-square (χ^2) test of independence. A $p < 0.05$ was considered statistically significant.

RESULTS

Demographic characteristics of participants

Table 1 presents the demographic profile of the 443 university students who completed the questionnaire. The sample consisted predominantly of male students (75.2%) and was predominantly from urban areas (58.0%). More than half of the participants (54%) were between 16 and 20 years of age. Regarding academic level, 99.1% were enrolled in undergraduate programs, with 40.2% in their 3rd year, 25.1% in their 2nd year, and 13.1% in their 1st year. A large majority (84.9%) were medical majors, while 15.1% pursued non-medical disciplines. Most participants (97.3%) were unemployed, reflecting the student status of the study population.

Knowledge about Mpox

Table 2 summarizes participants' knowledge regarding mpox. Almost all participaints (94.6%) correctly identified mpox as a viral disease. More than half (55.8%) recognized airborne transmission as a possible route of infection, while a large proportion (76–80%) identified contaminated objects and close contact with infected individuals as important sources of transmission (Figure 1).

A majority (57.1%) understood that food is not a transmission risk, and 47.2% knew that mpox can be transmitted from humans to animals, while 77.7% correctly classified it as a zoonotic disease. Knowledge of disease incubation (5–21 days) and the need for patient isolation was reported by 72%–78% of participants. However, 77.9% were unaware that bites from infected monkeys can also transmit the disease.

Table 1: Basic characteristics of the study participants (n = 443).

Variable	Category	Frequency	Percentage
Age in years	16–20 years	236	53.3
	21–40 years	207	46.7
Gender	Male	333	75.2
	Female	110	24.8
Year of study	1st year	60	13.5
	2nd year	111	25.1
	3rd year	178	40.2
	4th Year	39	8.8
	5th year	55	12.4
Field of study	Undergraduate	439	99.1
	Postgraduate	4	0.9
Majors	Medicine	376	84.9
	Others	67	15.1
Origin	Urban	257	58.0
	Rural	186	42.0
Occupation	Employed	12	2.7
	Unemployed	431	97.3

Regarding clinical symptoms, 76.5% recognized skin rash as a key manifestation of mpox. In terms of preventive knowledge, 81%–84% believed that vaccination and good hygiene reduce infection risk, while 66%–76% were aware of vaccine availability and the need to avoid contact with wild animals to prevent spread.

Attitudes toward Mpox

Participants' attitudes and perceptions are presented in Table 3. Over half (53.3%) expressed concern about contracting mpox, while only 12.0% disagreed and 8.6% strongly disagreed. A substantial proportion (64.3%) felt a need to learn more about the disease, indicating an overall interest in health awareness.

Trust in official health communication was relatively high, with 60.7% agreeing that they trusted health authorities. More than 61.6% expressed willingness to be vaccinated, demonstrating positive preventive intent. However, 39.1% of participaints reported concerns about social stigma or discrimination, while 32.7% remained neutral. Regarding perceptions of mpox severity, 39.1% believed that it could evolve into a pandemic similar to COVID-19, and 39.3% thought that it might have a significant impact on global population health. Additionally, half of the participaints (50.3%) expressed concern about mpox spreading to their city. Overall, the results indicate moderate to high concern, trust in authorities, and general readiness to engage in preventive behaviors.

Preventive practices against Mpox

Table 4 highlights participants' self-reported preventive practices. The majority (93.9%) reported frequent handwashing, while 55.8% regularly used hand sanitizers. A total of 67.5% avoided touching their face with unwashed hands, and 56.4% adhered to social distancing.

Mask-wearing in public was reported by 58.2%, though 41.8% did not follow this practice. Only 34.1% of students had been vaccinated against mpox, but 72.9% expressed a willingness to be vaccinated if the vaccine

Table 2: Study participant's response to the knowledge question (n = 443).

Question	Correct n (%)	Incorrect n (%)
Is mpox a viral illness? (Answer yes)	419 (94.6)	24 (5.4)
Is mpox transmitted through airborne droplets? (Answer yes)	247 (55.8)	196 (44.2)
Transmission of monkeypox through contaminated surfaces or objects (Answer yes)	339 (76.5)	104 (23.5)
Transmission of monkeypox through close contact with an infected person (Answer yes)	356 (80.4)	87 (19.6)
Is mpox transmitted through food? (Answer yes)	190 (42.9)	253 (57.1)
Can monkeypox be transmitted from humans to animals? (Answer yes)	209 (47.2)	234 (52.8)
Can monkeypox be transmitted from animals to humans? (Answer yes)	344 (77.7)	99 (22.3)
Is mpox transmitted from humans to humans? (Answer yes)	344 (77.7)	99 (22.3)
Can kids get monkeypox? (Answer yes)	333 (75.2)	110 (24.8)
The incubation period of mpox is around 5–21 days. (Answer yes)	346 (78.1)	97 (21.9)
Does mpox infection require isolation? (Answer yes)	323 (72.9)	120 (27.1)
The rash is a symptom of mpox	339 (76.5)	104 (23.5)
Vaccination is the most effective way to prevent mpox.	372 (84.0)	71 (16.0)
Practicing good hygiene can help reduce the risk of infection. (Answer yes)	363 (81.9)	80 (18.1)
Is the monkeypox vaccine developed? (Answer yes)	295 (66.6)	148 (33.4)
Swollen lymph nodes distinguish mpox from chickenpox.	298 (67.3)	145 (32.7)
Avoiding contact with wild animals is an important way to prevent the further spread of mpox.	340 (76.7)	103 (23.3)

Table 3: Study participant's response to the attitude question (n = 443).

Question	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
I am concerned about contracting mpox.	236 (53.3)	116 (26.2)	53 (12.0)	38 (8.6)
I should know more about mpox.	285 (64.3)	91 (20.5)	49 (11.1)	18 (4.1)
Do you trust the monkeypox information provided by health authorities?	269 (60.7)	107 (24.2)	47 (10.6)	20 (4.5)
If an mpox vaccine is available, I will choose to get it.	273 (61.6)	97 (21.9)	45 (10.2)	28 (6.3)
Are you concerned about monkeypox stigma or discrimination?	173 (39.1)	145 (32.7)	100 (22.6)	25 (5.6)
Mpox will become a new pandemic disease like COVID-19.	173 (39.1)	103 (23.3)	114 (25.7)	53 (12.0)
Mpox may become a disease that reduces the global population.	174 (39.3)	94 (21.2)	106 (23.9)	69 (15.6)
The spread of the mpox virus to my city is worrying.	223 (50.3)	91 (20.5)	84 (19.0)	45 (10.2)

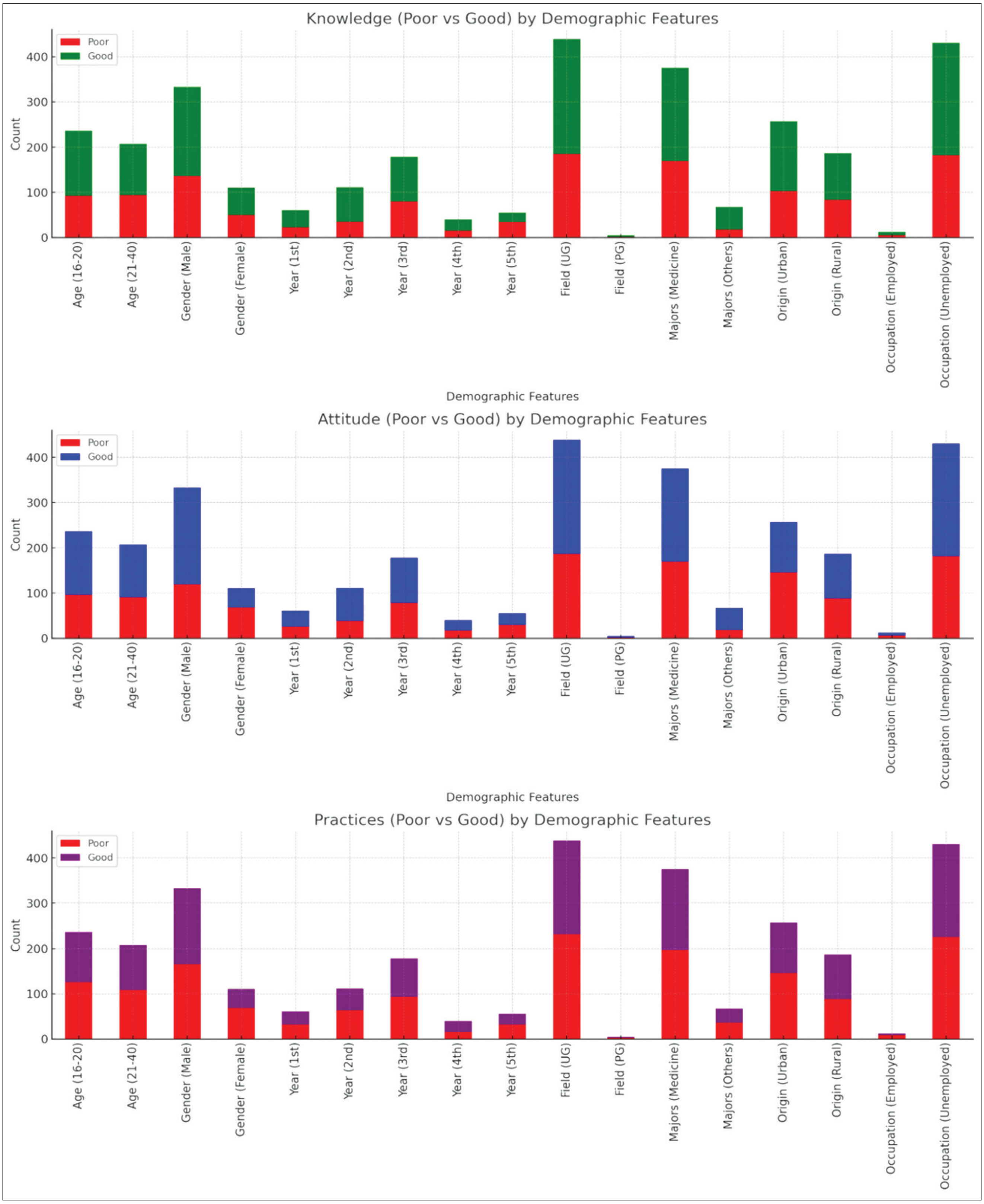

Figure 1: Distribution of good versus poor knowledge, attitudes, and practices by demographic characteristics.

were available. In terms of health-seeking behavior, 84.9% stated that they would seek medical attention if they experienced symptoms similar to mpox. A total of 60.9% felt capable of recognizing mpox symptoms, and 78.6% reported having reliable sources of mpox-related information. These findings generally indicate positive preventive behaviors, although gaps remain in consistently practicing protective measures, such as mask use and sanitizer application.

Table 4: Study participant's response to the question regarding practices provided by you, with the percentages merged into the relevant frequency columns.

Question	Yes (%)	No (%)
Do you wash your hands frequently throughout the day?	416 (93.9)	27 (6.1)
Do you regularly use hand sanitizer?	247 (55.8)	196 (44.2)
Do you avoid touching your face with unwashed hands?	299 (67.5)	144 (32.5)
Do you maintain social distancing measures?	250 (56.4)	193 (43.6)
Do you wear a mask in public places?	258 (58.2)	185 (41.8)
Have you been vaccinated against monkeypox?	151 (34.1)	292 (65.9)
If offered the vaccine, would you be willing to get vaccinated?	323 (72.9)	120 (27.1)
If you experience symptoms similar to those of monkeypox, would you seek medical attention?	376 (84.9)	67 (15.1)
Can you recognize the symptoms of monkeypox?	270 (60.9)	173 (39.1)
What are your primary sources of monkeypox information?	348 (78.6)	95 (21.4)

Table 5: Association of knowledge, attitude, and practices with demographic features of study participaints.

Demographic features	Category	Knowledge (poor % vs. good %)	p-value	Chi-square	OR (95% CI)	Attitude (poor % vs. good %)	p-value
Age in years	16–20 years	92 (39.0) versus 144 (56.7)	0.252	1.31	0.76 (0.47–1.22)	96 (40.7) versus 140 (59.3)	0.485
	21–40 years	94 (45.4) versus 113 (54.6)			(Reference)	91 (44.0) versus 116 (56.0)	
Gender	Male	136 (40.8) versus 197 (59.2)	0.480	0.50	0.83 (0.50–1.38)	119 (35.0) versus 214 (65.0)	<0.001
	Female	50 (45.5) versus 60 (54.5)			(Reference)	68 (61.8) versus 42 (38.2)	
Year of study	1st year	22 (36.7) versus 38 (63.3)	0.003	14.1	(Reference)	25 (41.7) versus 35 (58.3)	0.230
	2nd year	35 (31.5) versus 76 (68.5)			1.27 (0.62–2.59)	38 (34.2) versus 73 (65.8)	
	3rd year	80 (44.9) versus 98 (55.1)			0.69 (0.37–1.29)	78 (43.8) versus 100 (56.2)	
	4th year	15 (38.5) versus 24 (61.5)			0.93 (0.39–2.23)	17 (43.6) versus 22 (56.4)	
	5th year	34 (61.8) versus 21 (38.2)			0.36 (0.16–0.80)	29 (52.7) versus 26 (47.3)	
Field of study	Undergraduate	185 (42.1) versus 254 (57.9)	0.684	0.17	2.18 (0.22–21.6)	186 (42.4) versus 253 (57.6)	0.484
	Postgraduate	1 (25.0) versus 3 (75.0)			(Reference)	1 (25.0) versus 3 (75.0)	
Majors	Medicine	169 (45.0) versus 207 (55.0)	0.010	6.63	2.41 (1.33–4.38)	169 (44.9) versus 207 (55.1)	0.006
	Others	17 (25.4) versus 50 (74.6)			(Reference)	18 (26.9) versus 49 (73.1)	
Origin	Urban	103 (40.1) versus 154 (59.9)	0.550	0.36	0.84 (0.58–1.22)	145 (56.5) versus 112 (43.5)	0.058

(*Contd*...)

Table 5: *(Continued)*.

Demographic features	Category	Knowledge (poor % vs. good %)	p-value	Chi-square	OR (95% CI)	Attitude (poor % vs. good %)	p-value
	Rural	83 (44.6) versus 103 (55.4)			(Reference)	88 (47.3) versus 98 (52.7)	
Occupation	Employed	4 (33.3) versus 8 (66.7)	0.750	0.10	1.48 (0.42–5.21)	6 (50.0) is 6 (50.0)	0.760
	Unemployed	182 (42.3) versus 249 (57.7)			(Reference)	182 (42.3) versus 249 (57.7)	

Demographic features	Category	Chi-square	OR (95% CI)	Practices (poor % vs. good %)	p-value	Chi-square	OR (95% CI)
Age in years	16–20 years	0.49	0.87 (0.58–1.30)	125 (53.0) versus 111 (47.0)	0.868	0.03	1.03 (0.72–1.48)
	21–40 years		(Ref)	108 (52.2) versus 99 (47.8)			(Ref)
Gender	Male	25.3	0.30 (0.19–0.48)	165 (49.5) versus 168 (50.5)	0.025	5.02	0.60 (0.38–0.94)
	Female		(Ref)	68 (61.8) versus 42 (38.2)			(Ref)
Year of study	1st year	4.38	(Ref)	31 (51.7) is 29 (48.3)	0.375	4.19	(Ref)
	2nd year		0.73 (0.36–1.48)	63 (56.8) versus 48 (43.2)			0.81 (0.41–1.62)
	3rd year		0.92 (0.48–1.76)	93 (52.2) versus 85 (47.8)			0.98 (0.51–1.89)
	4th year		0.92 (0.38–2.23)	15 (38.5) versus 24 (61.5)			1.72 (0.72–4.12)
	5th year		0.60 (0.27–1.35)	31 (56.4) versus 24 (43.6)			0.83 (0.37–1.86)
Field of study	Undergraduate	0.49	2.21 (0.22–22.2)	231 (52.7) versus 208 (47.3)	0.917	0.01	1.08 (0.15–7.79)
	Postgraduate		(Ref)	2 (50.0) is 2 (50.0)			(Ref)
Majors	Medicine	7.56	2.23 (1.25–3.98)	197 (52.3) versus 179 (47.7)	0.840	0.04	0.94 (0.55–1.62)
	Others		(Ref)	36 (53.7) versus 31 (46.3)			(Ref)
Origin	Urban	3.61	1.45 (1.00–2.10)	145 (56.5) versus 112 (43.5)	0.058	3.61	1.45 (1.00–2.10)
	Rural		(Ref)	88 (47.3) versus 98 (52.7)			(Ref)
Occupation	Employed	0.09	0.82 (0.24–2.84)	8 (66.7) is 4 (33.3)	0.322	0.98	0.47 (0.13–1.70)
	Unemployed		(Ref)	225 (52.2) versus 206 (47.8)			(Ref)

OR = Odds radio, CI = Confidence interval.

Association between demographic factors and KAP levels

Table 5 presents the relationship between demographic variables and participants' KAP regarding mpox.

Knowledge

Knowledge levels did not significantly differ by age (χ^2 = 1.31, p = 0.252, odds ratio [OR] = 0.76, 95% confidence interval [CI]: 0.47–1.22) or gender (χ^2 = 0.50, p = 0.480, OR = 0.83, 95% CI: 0.50–1.38). However, significant associations were observed for year of study (χ^2 = 14.1, p = 0.003) and major (χ^2 = 6.63, p = 0.010). Second-year students exhibited the highest knowledge level (68.5% good knowledge), while 5^{th}-year students had the lowest (38.2%). Medical students were 2.41 times more likely (95% CI: 1.33–4.38) to demonstrate good knowledge than non-medical students. No significant relationships were found between knowledge and field of study, origin, or occupation (Figure 1).

Attitudes

Gender was a significant determinant of attitudes (χ^2 = 25.3, p < 0.001), with males exhibiting lower odds of a positive attitude (OR = 0.30, 95% CI: 0.19–0.48) compared to females. Academic major also influenced attitudes (χ^2 = 7.56, p = 0.006), as medical students were more likely to exhibit positive attitudes (OR = 2.23, 95% CI: 1.25–3.98). Although the year of study did not reach statistical significance (χ^2 = 4.38, p = 0.230), a trend toward more positive attitudes in earlier study years was noted. Urban origin showed borderline significance (χ^2 = 3.61, p = 0.058, OR = 1.45, 95% CI: 1.00–2.10), indicating a possible tendency for urban participants to exhibit better attitudes (Figure 1).

Practices

A significant association was identified between gender and preventive practices (χ^2 = 5.02, p = 0.025), with males being less likely to report good practices (OR = 0.60, 95% CI: 0.38–0.94) than females. Other variables, including age, academic year, major, origin, and occupation, were not significantly associated with practices.

Overall, the strongest predictors were gender (for attitudes and practices) and academic major (for knowledge and attitudes). Effect sizes indicated meaningful differences (OR = 0.30 for gender and OR = 2.41 for major), while other demographic variables showed weaker associations with ORs close to 1. CI for non-significant associations crossed the null value, suggesting limited or inconsistent effects.

Additional observations

Interaction effects, such as the potential overlap between gender, academic discipline, and residence origin, were not examined in this analysis. Further subgroup analysis may reveal nuanced trends, such as whether gender-related differences in attitudes are more pronounced among non-medical students or whether urban residence confers additional advantages in specific study years (Figure 1).

DISCUSSION

Overview of the study findings

This study evaluated the KAP regarding mpox among 443 students at Gomal University, Dera Ismail Khan. The results revealed considerable variation in awareness and behavioral responses. Students with higher levels of knowledge tended to demonstrate more favorable attitudes and stronger engagement in preventive practices. This association underscores the crucial role of knowledge in shaping proactive health behaviors [12]. The study population was predominantly male (75.2%) and urban (58.0%), reflecting the demographic pattern observed in higher education across Pakistan and other developing nations [13, 14]. The age distribution showed that more than half of the participaints (54%) were aged between 16 and 20 years, representing a young and impressionable population whose health awareness is influenced by educational exposure and social environment [15, 16].

Comparison with previous studies

The findings of this study are consistent with, yet more encouraging than, previous KAP surveys conducted in Pakistan and abroad. A national university-based survey in Pakistan reported that only 6.3% of students possessed good knowledge about mpox, and 67.7% expressed willingness to be vaccinated [17]. In contrast, the current study identified substantially higher knowledge levels, particularly among medical students (55.0% with good knowledge), and stronger vaccine willingness (72.9%). This improvement may be attributed to enhanced media coverage during the global outbreak (2022–2023) and increasing public health awareness campaigns on university campuses. Parallel trends have been reported internationally. In Iran, university students and staff demonstrated poor knowledge (84.3%) and low positive attitudes (7.9%), with educational background and academic discipline emerging as key predictors of KAP [18]. Likewise, a study from Egypt among healthcare workers and medical students found moderate knowledge (55.3%) and favorable attitudes (44.5%), values comparable but slightly lower than those in the present study, possibly due to differences in perceived local risk and exposure to outbreaks [19].

Knowledge gaps and misconceptions

Despite high recognition of mpox as a viral and zoonotic disease (94.6% and 77.7%, respectively), critical misconceptions persist. Only 55.8% of participaints identified airborne transmission as a possible route, and a considerable proportion (77.9%) were unaware that animal bites can transmit the virus. Such findings suggest a limited understanding of zoonotic pathways, reflecting global public health trends in which disease ecology is often misunderstood, despite increased media reporting [20, 21]. The observed gaps underscore the need for structured health education that emphasizes the One Health perspective, highlighting the interconnections among humans, animals, and the environment. These insights also reinforce that awareness alone may not be sufficient unless accompanied by a contextual understanding of zoonotic transmission and preventive actions.

Attitudes toward mpox and preventive behaviors

A moderate level of concern was evident among participants, with 53.3% expressing apprehension about contracting mpox. This pattern aligns with behavioral models where perceived susceptibility drives health-protective actions [22, 23]. Encouragingly, 61.6% of participaints indicated willingness to be vaccinated, and 60.7% trusted the reliability of official health information sources, suggesting growing public receptivity toward preventive interventions [11]. However, preventive practices revealed selective adherence. While 93.9% practiced frequent handwashing, only 55.8% regularly used hand sanitizers and 58.2% wore masks in public. This over-reliance on basic hygiene, coupled with lower compliance in other protective behaviors, indicates partial adoption of preventive strategies, a trend also observed in previous student-based infectious disease studies by Shaikh and Hatcher [24], Boulos *et al*. [25], and Lim *et al*. [26].

Determinants of knowledge, attitude, and practice

Statistical analysis identified significant associations between academic major, study year, and gender with KAP levels. Medical students exhibited superior knowledge (55.0%) and more positive attitudes (55.1%) compared with their non-medical counterparts (25.4% and 26.9%, respectively), confirming the influence of academic specialization on health literacy [27]. Interestingly, 1st-year students demonstrated higher knowledge levels than senior students, possibly reflecting stronger engagement with general education courses or heightened interest among newer entrants [28, 29]. Conversely, this may also indicate a decline in attention to general health topics in later academic years. The strong willingness for vaccination (72.9%) and the moderate rate of previous immunization (34.1%) underscore the potential impact of targeted awareness programs that leverage students' trust in academic and institutional health sources [30].

Gender differences and sociocultural context

Gender emerged as a major determinant influencing attitudes and practices. Female students reported higher proportions of poor attitudes and practices, highlighting persistent gender disparities in health participation [31, 32]. Several sociocultural and structural barriers underpin these findings. In Pakistan and similar South Asian contexts, female students often experience restricted mobility and reduced autonomy in healthcare decisions, which limits their engagement in preventive activities and access to health services [33–35]. Additionally, digital access inequality exacerbates this gap. According to Pakistan's 2022 Digital Gender Gap Report, internet usage among women is 38% compared to 65% among men, which constrains female students' exposure to health information and online awareness campaigns [36]. Social norms surrounding modesty and limited health communication further inhibit open discussions on preventive behaviors, even among informed female students [37]. Addressing these disparities requires gender-sensitive educational programs and inclusive communication strategies.

Urban-rural variations

Although urban-rural differences in practice scores were not statistically significant, the observed trends merit attention. Urban-origin students had greater access to health facilities, digital information, and preventive supplies, which contributed to marginally better KAP performance [24, 38]. Rural-origin students, however, may face infrastructural challenges, including fewer health personnel, limited public health outreach, and restricted access to hygiene materials [39]. These structural inequities underline the need for location-specific interventions that extend beyond awareness, particularly in rural districts of Khyber Pakhtunkhwa, where the risk of delayed response to zoonotic diseases remains high due to inadequate surveillance and education networks.

Public health implications and recommendations

This study provides critical insights into university students' understanding and behavioral responses toward mpox. The findings highlight both strengths, such as high general awareness and positive vaccination intent, and gaps in nuanced understanding of zoonotic transmission and consistent preventive practices. These results have practical implications for designing future health education programs within the university sector. From a policy standpoint, university administrations and provincial health authorities should collaborate to implement campus-based awareness campaigns, peer-led ambassador programs, and digital health literacy workshops that are inclusive of both medical and non-medical students. Moreover, integrating One Health-based modules into university curricula can enhance students' comprehension of zoonotic and emerging infectious diseases. At the provincial level, the Khyber Pakhtunkhwa Health Department could extend mobile health units to university campuses, introduce student-focused vaccination drives, and coordinate with telecommunication networks to deliver targeted health messages to rural and female populations [40]. Future research should explore the longitudinal effects of health education programs on behavior change, as well as provide qualitative insights into the psychosocial barriers that influence students' preventive behaviors. Strengthening such evidence will be pivotal for developing comprehensive mpox preparedness strategies in educational settings.

CONCLUSION

This study provides an in-depth assessment of KAP regarding mpox among 443 students at Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Overall, the findings revealed high awareness of mpox as a viral and zoonotic disease (94.6% and 77.7%, respectively) but also identified critical knowledge gaps, particularly regarding zoonotic transmission through animal bites and the role of contaminated materials. Participants demonstrated moderate-to-positive attitudes, with 53.3% expressing concern about infection and 61.6% showing willingness to be vaccinated. Preventive practices were encouraging, especially hand hygiene (93.9%), but inconsistent adherence was observed for mask-wearing (58.2%) and the use of sanitizer (55.8%). Statistical analyses showed that academic major, year of study, and gender significantly influenced KAP levels: medical students and early-year undergraduates had better knowledge and attitudes, while female students reported comparatively lower practice scores.

From a public health perspective, these results highlight the need for targeted, context-specific health education. Universities should integrate One Health-oriented modules emphasizing zoonotic disease prevention, transmission ecology, and vaccination literacy. Practical interventions could include campus-based awareness programs, peer-led health ambassador networks, and digital health campaigns tailored for both medical and non-medical students, with a particular focus on bridging gender and urban–rural disparities in access to reliable health information.

A key strength of this study lies in its large and diverse sample, as well as the rigorous validation of its data collection instruments, which ensures representativeness and reliability. However, its limitations include its cross-sectional design, reliance on self-reported responses, and focus on a single university, which may limit its generalizability. Additionally, the study did not assess behavioral change over time or explore qualitative perceptions that may influence preventive behavior.

Future research should adopt longitudinal and multicentric designs to track shifts in awareness and practices following targeted health education programs. Exploring qualitative insights can deepen our understanding of sociocultural and psychological barriers that affect vaccine acceptance and behavioral compliance.

In conclusion, the study underscores that university students, as future professionals and community influencers, represent a strategic target group for promoting mpox awareness and preventive health behaviors. Strengthening their understanding through sustained education and intersectoral collaboration will not only enhance local disease preparedness but also contribute to global One Health goals aimed at mitigating zoonotic threats and emerging infectious diseases.

AUTHORS' CONTRIBUTIONS

SR, SU, MHE, MKS, DA, BB, SU, and AK: Conceptualized the study, methodology, investigation, analyzed and interpreted data, and drafted, reviewed, and edited the manuscript. SR, MHE, MIUM, WUR, and MIA: Methodology, investigation, analyzed and interpreted data, and reviewed and edited the manuscript. SR, MHE, and WUR: Methodology, formal analysis, and reviewed and edited the manuscript. All authors have read and approved the final version of the manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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