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Letter to the Editor

# Mapping spatio-temporal distribution of monkeypox disease incidence: A global hotspot analysis

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*Dear Editor*

Monkeypox (mpox) is an emerging zoonotic and sexually transmitted infection caused by the monkeypox virus and historically endemic in western and central Africa [1]. However, a widespread outbreak occurred worldwide in May 2022, when the first case was confirmed in the United Kingdom in a man traveling from Nigeria [2]. The current outbreak is largely affecting specific sexual networks such as gay, bisexual, or MSM populations, but evidence of transmission beyond these groups, including women and children, suggests the potential for spread to more diverse populations and through different modes of transmission [3]. The outbreak quickly spread to other countries, including Portugal and the United States, with more than 87,000 cases and 130 deaths reported in more than 110 countries as of May 2023, including most places that had never previously reported mpox [4]. The United States had the highest number of cases, followed by Brazil and Spain [4]. In response to the global outbreak, the World Health Organization declared it a public health emergency of international concern (PHEIC) on July 23, 2022 [5].

GIS technology is crucial in analyzing the spatiotemporal patterns of infectious diseases, including mpox, which can help track the spread of the disease, identify high transmission areas, and plan interventions to control outbreaks [6]. The current study is the first to investigate the spatial distribution and clustering patterns of mpox incidence rate (cases and deaths per 100k population) worldwide between January 2022 and January 2023, using GIS tools such as Global and local Moran's I statistics and Getis-Ord Gi* statistic. The analyses were conducted using Arc GIS 10.5 software.

Fig. 1A shows the worldwide distribution of monkey pox cases and deaths from January 2022 to January 2023. The data depicts a low number of cases in January–April 2022, with a surge in May 2022, peaking at 31,485 cases in August 2022, and 21 deaths in November 2022. The number of cases decreased in September and continue to fluctuate in the following months, while deaths were stable from August 2022 to January 2023.

The study utilized the Getis-Ord Gi* statistic to detect hot and cold spots of mpox cases and deaths per 100,000 populations across various countries from January 2022 to January 2023. The findings suggest that mpox cases concentrated on Oceania and Asia continent, with hot spots of cases in New Zealand (99% confidence level) between July 2022 and January 2023, except for November 2022, and Australia, Indonesia, and Japan (95% confidence level) between July and September 2022. In contrast, the North America continents including USA, Canada, Mexico, and South American including Peru, Argentina, Bolivia, Colombia, and Brazil showed cold spots during different months with a 90%–99% confidence level. No clustering of hot or cold spots was observed during January to April, June, and December 2022, which may suggest a fluctuation in mpox cases across these months (Fig. 1B).

In terms of deaths, the hotspots were varied across countries but consistent with time. Hotspots were observed in the USA, Mexico, and Chile with a 99% and 95% confidence interval, and in New Zealand, Argentina, and Mexico with a 90% confidence interval. Hotspots were observed in every month between July 2022–January 2023, except October month. Cold spots were detected in several countries, including Russia, Germany, and some African and South Asian countries. No clustering of hot or cold spots was observed for deaths during May, and June 2022 (Fig. 1C).

The global spatial autocorrelation results showed that the spatial correlation of cases decreased in May–June and then increased July–September, indicating a changing spatial pattern of mpox cases over time. However, the spatial distribution of mpox deaths appeared to be random throughout the study periods (Fig. 1F). The identified clusters of mpox cases and deaths had lower Z-scores and higher p-values, indicating they were randomly distributed and not significant. Anselin local Moran's I findings suggest that the North American and Asian countries had a high-high (HH) clusters of cases (Fig. 1D), while HH clusters of deaths were identified in the North and South America only (Fig. 1E).

In conclusion, our findings reveal that despite low infection rates, Oceania and Asia continent showed hotspot for mpox cases, while American continent showed hotspot for deaths. Overall, while spatial analysis can provide important information on disease patterns and hotspots, other factors such as demographics, socio-economic status, and access to healthcare should also be considered in determining the overall risk of a disease in a given population.

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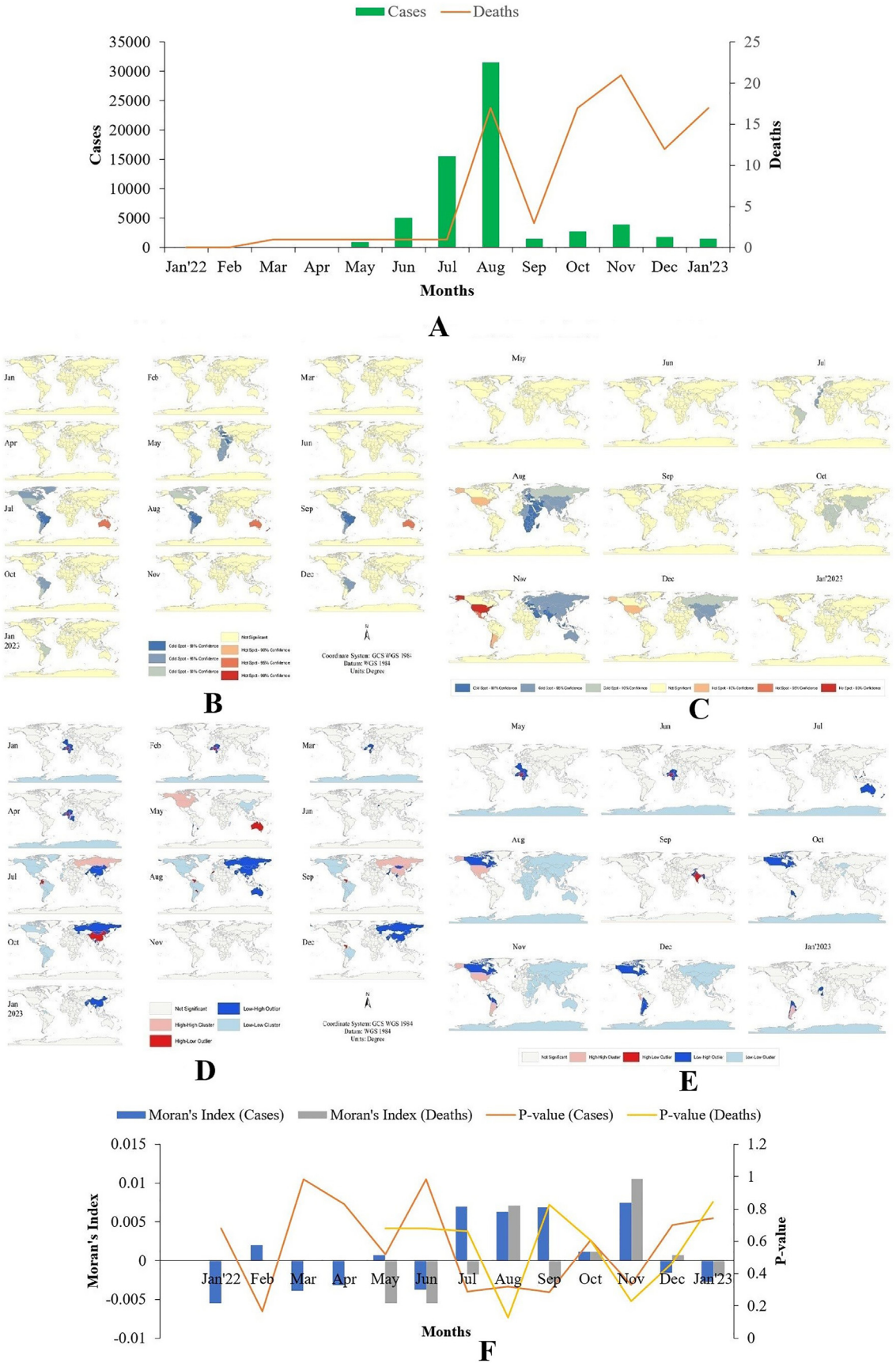



**Fig. 1.** Spatio-temporal distribution of mpox disease worldwide. **A.** Monthly (January 2022–January 2023) mpox cases and deaths distribution worldwide, **B.** Hotspot of monthly mpox cases per 100k population, **C.** Hotspot of monthly mpox deaths per 100k population. **D.** Moran's I statistics with corresponding p-value for mpox cases and deaths per 100k population. **E.** Cluster analysis of monthly mpox cases per 100k population, **F.** Cluster analysis of monthly mpox deaths per 100k population.

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## Declaration of competing interest

The authors declare no conflict of interest.

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Muhammad Mainuddin Patwary[a,b,*], Juvair Hossan[a,b], Sharif Mutasim Billah[a,b], Md Pervez Kabir[a,c], Alfonso J. Rodriguez-Morales[d,e]

[a] *Environment and Sustainability Research Initiative, Khulna, 9208, Bangladesh*

[b] *Environmental Science Discipline, Life Science School, Khulna University, Khulna, 9208, Bangladesh*

[c] *Department of Civil Engineering, University of Ottawa, Ottawa, Ontario, Canada*

[d] *Clinical Epidemiology and Biostatistics, Universidad Cientifica del Sur, Lima, Peru*

[e] *Gilbert and Rose-Marie Chagoury School of Medicine, Lebanese American University, Beirut, P.O. Box 36, Lebanon*

[*] Corresponding author. Environment and Sustainability Research Initiative, Khulna, 9208, Bangladesh.
*E-mail addresses:* raju.es111012@gmail.com (M.M. Patwary), juvairhossan181050@gmail.com (J. Hossan), shakib8376@gmail.com (S.M. Billah), pervezes10@gmail.com (M.P. Kabir), ajrodriguezmmd@gmail.com (A.J. Rodriguez-Morales).