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Understanding the unprecedented 2023 dengue outbreak in Bangladesh: a data-driven analysis

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ABSTRACT

Objectives: This study aims to elucidate the epidemiological characteristics, spatial distribution, and potential contributing factors associated with the 2022-2023 dengue outbreak in Bangladesh.

Methods: We retrospectively analyzed dengue fever cases reported by national health surveillance systems, focusing on incidence, geographical spread, and fatalities. Statistical methods were used to explore correlations between population density, healthcare capacity, and disease prevalence.

Results: Our study revealed that in 2023, dengue cases and deaths surged five-fold (from 62,382 to 320,835) and nearly six-fold (from 281 to 1699) compared with 2022. Major cities such as Dhaka and Chittagong emerged as epicenters with significantly higher caseloads and mortality rates. The analysis identified a strong positive correlation between population density and disease prevalence, suggesting urbanization as a contributing factor. In addition, a shift in the peak dengue season from August to September was observed. Furthermore, disparities in health care infrastructure were identified, with densely populated areas experiencing critical shortages of hospital beds, potentially impacting fatality rates.

Conclusions: This unprecedented dengue outbreak in Bangladesh highlights the need for a multifaceted approach. Prioritizing vector control, targeted public awareness in identified hotspots, addressing healthcare resource inequities, and further research on environmental and demographic determinants of transmission are crucial for mitigating future outbreaks in Bangladesh.

Introduction

The World Health Organization reported the highest global burden of dengue fever cases in 2023, with the disease impacting over 80 countries [1]. Dengue is a mosquito-borne viral illness primarily transmitted by infected *Aedes* mosquitoes [2]. The virus exists as four distinct serotypes (dengue virus [DENV]-1, 2, 3, and 4), with a potential fifth serotype (DENV-5) recently identified in Malaysia [2]. Nevertheless, phylogenetic analysis indicated that DENV-5 is genetically similar to the other four serotypes, suggesting a common ancestral origin [3]. Although a primary dengue infection can confer lifelong immunity to the specific serotype encountered, subsequent exposure to a different serotype can range from mild, self-limiting illness (e.g. fever) to life-threatening complications such as dengue hemorrhagic fever and dengue shock syndrome [4]. Dengue is now considered endemic in over 100 countries, with approximately 70% of the global disease burden concentrated in Asia [5].

This recent global resurgence of dengue fever is likely due to a complex interplay of factors. Rapid and unprecedented urbanization has created perfect breeding conditions for *Aedes* mosquitoes. In addition, the expanding human population increases interactions between humans and mosquitoes, facilitating the spread of dengue [6]. A systematic review combining studies from China, Brazil, India, and Pakistan found that human population densities exceeding 1000 inhabitants per square kilometer were linked to higher levels of arboviral diseases [7]. Moreover, climate change contributes significantly to the incidence and distribution of dengue. Warmer temperatures accelerate the DENV replication within mosquitoes, enabling quicker infection of new hosts. High humidity enhances the survival rate, feeding activity, and egg development of *Aedes* mosquitoes. Excessive precipitation creates shallow, stagnant water pools essential for mosquito reproduction [8]. The *El Niño* phenomenon, a natural form of climate change, further worsens the issue by raising temperatures, which stimulates egg hatching and accelerates larval growth, thus reducing the time to maturity [9]. Finally, inadequate healthcare systems in many dengue-endemic countries can delay diagnosis and treatment, potentially leading to severe complications and increased mortality rates [10].

Addressing these multifaceted challenges necessitates an initial phase of rigorous data analysis. This analysis is essential for identifying outbreak patterns, mapping high-risk areas, intervention planning, and

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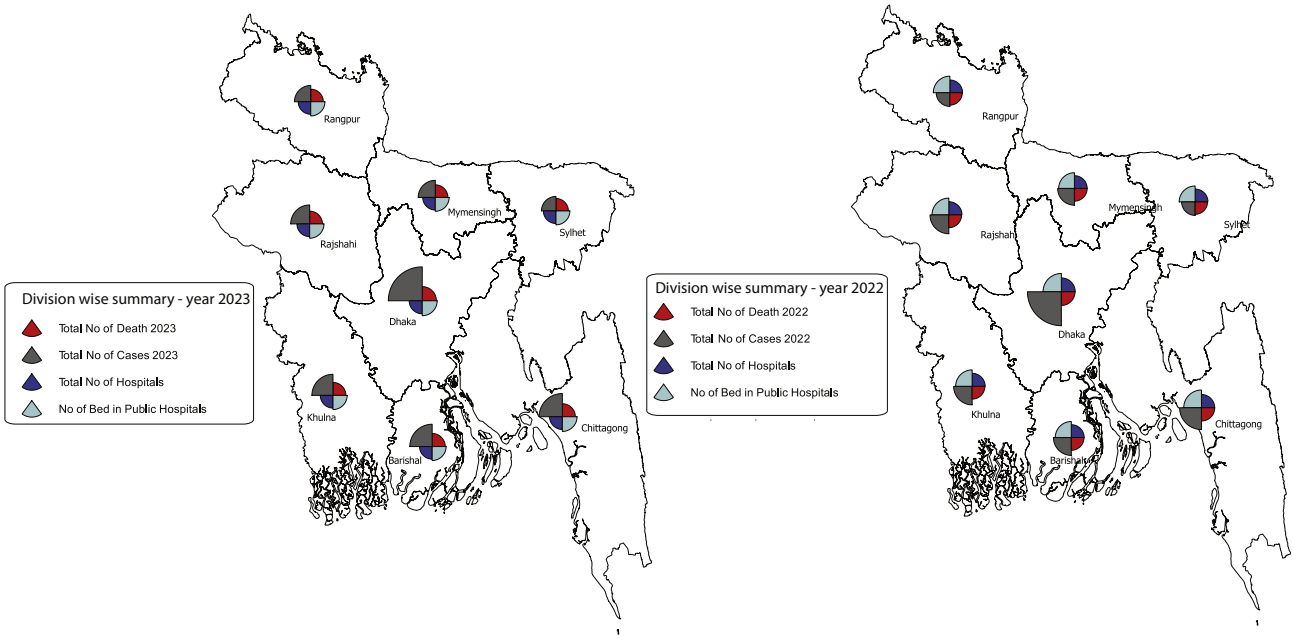

Figure 1. Dengue outbreak in Bangladesh (2022-2023). This map visualizes the 2022-2023 dengue outbreak across eight administrative divisions of Bangladesh. It displays the number of dengue cases, deaths, hospitals (public and private), and public hospital beds for each division during this period, allowing for the identification of areas with higher caseloads, fatalities, and potential health care resource limitations.

optimizing resource allocation [11]. Furthermore, a comprehensive approach is essential that integrates improved vector control strategies, urban planning initiatives, robust healthcare infrastructure development, and targeted public health measures. These combined efforts are crucial for effectively managing and mitigating the impact of dengue.

A vast number of studies on dengue have been conducted in Bangladesh focusing on its transmission, risk factors, morbidity, and mortality [12–15]. However, there is a gap in understanding the primary elements affecting viral transmission, revealing the peak month of dengue case surges and identifying areas with a high risk of outbreaks in Bangladesh. Previously, the majority of dengue studies have used generalized estimations [12–15], which are useful for understanding the transmission but often poorly predict the specific outbreak locations. Some studies suggest that the changes in the future dengue burden will be driven primarily by population growth in endemic areas rather than environmental changes [13].

The objective of this work is to investigate the possible association between population density and the incidence of dengue fever in Bangladesh. A fundamental component of this research involves the use of data from 2022 to 2023 to elucidate the geographical dispersion of the outbreak. This examination pinpoints regions with a higher density of cases, with the goal of comprehending the spatial distribution trends and pinpointing potential hotspots. Furthermore, the study performs administrative divisional comparisons to identify statistically notable differences in case numbers and associated fatalities. Finally, an evaluation of hospital bed capacity relative to the national population is also conducted.

Data sources and methods

Bangladesh comprises eight administrative divisions: Dhaka, Barisal, Chittagong, Rajshahi, Rangpur, Khulna, Mymensingh, and Sylhet [16] (Figure 1). Dhaka leads the nation in population, with an estimated 45.6 million residents. In contrast, Barisal has the fewest residents, at around 9.33 million. Chittagong follows Dhaka in population, with approximately 34.18 million. The remaining divisions range in population from 11.42 million in Sylhet to 20.79 million in Rajshahi [17].

The epidemiologic data were obtained from the Ministry of Health and Family Welfare, Bangladesh from January 2022 to December 2023, which consists of information on dengue patients belonging to eight divisions of Bangladesh [18]. Data before 2022 were excluded from this study because of the limited information publicly available from earlier years due to the COVID-19 pandemic. For example, only 1 month's worth of dengue cases and death data are available for 2021 [18]. Similarly, month-by-month dengue data for 2020 are also missing [18]. This suggests that most health resources, including laboratory testing, hospitals, and epidemiological monitoring, were focused on COVID-19, leading to delays in diagnosing other diseases such as dengue [19]. Division-wise number of dengue cases and deaths is given in Table 1.

To encompass the full scope of the outbreak, data were gathered from all eight divisions. The data set includes not only confirmed dengue infection cases diagnosed through established tests such as reverse transcription-polymerase chain reaction (RT-PCR) and non-structural protein 1 rapid tests but also fatalities and hospitalizations recorded across both public and private healthcare facilities. Daily data for each division were collected and subsequently aggregated and organized on a monthly basis, enabling the tracking of the temporal dynamics of the outbreak. To outline outbreak hotspot areas, we utilized monthly-based percentile box plots and location-based circle charts (to display percentage distribution). For the statistical display of the results, we used the ARC Map 10.7, and OriginPro 2024 programs.

Results

The year 2023 witnessed an unprecedented surge in dengue fever incidence across all administrative divisions in Bangladesh. Compared with 2022, which recorded 62,382 cases and 281 deaths, the number of cases in 2023 skyrocketed to 3,21,179, with fatalities reaching 1705 (Figure 2). Notably, previously unaffected divisions such as Sylhet and Rangpur reported no deaths in 2022 but experienced a concerning rise in fatalities during the 2023 outbreak. Although Sylhet continued to have a relatively lower case burden than other divisions in 2023 (1435 cases), it represented a significant increase from the 125 cases reported in 2022 (Figure 2 [a, b]).

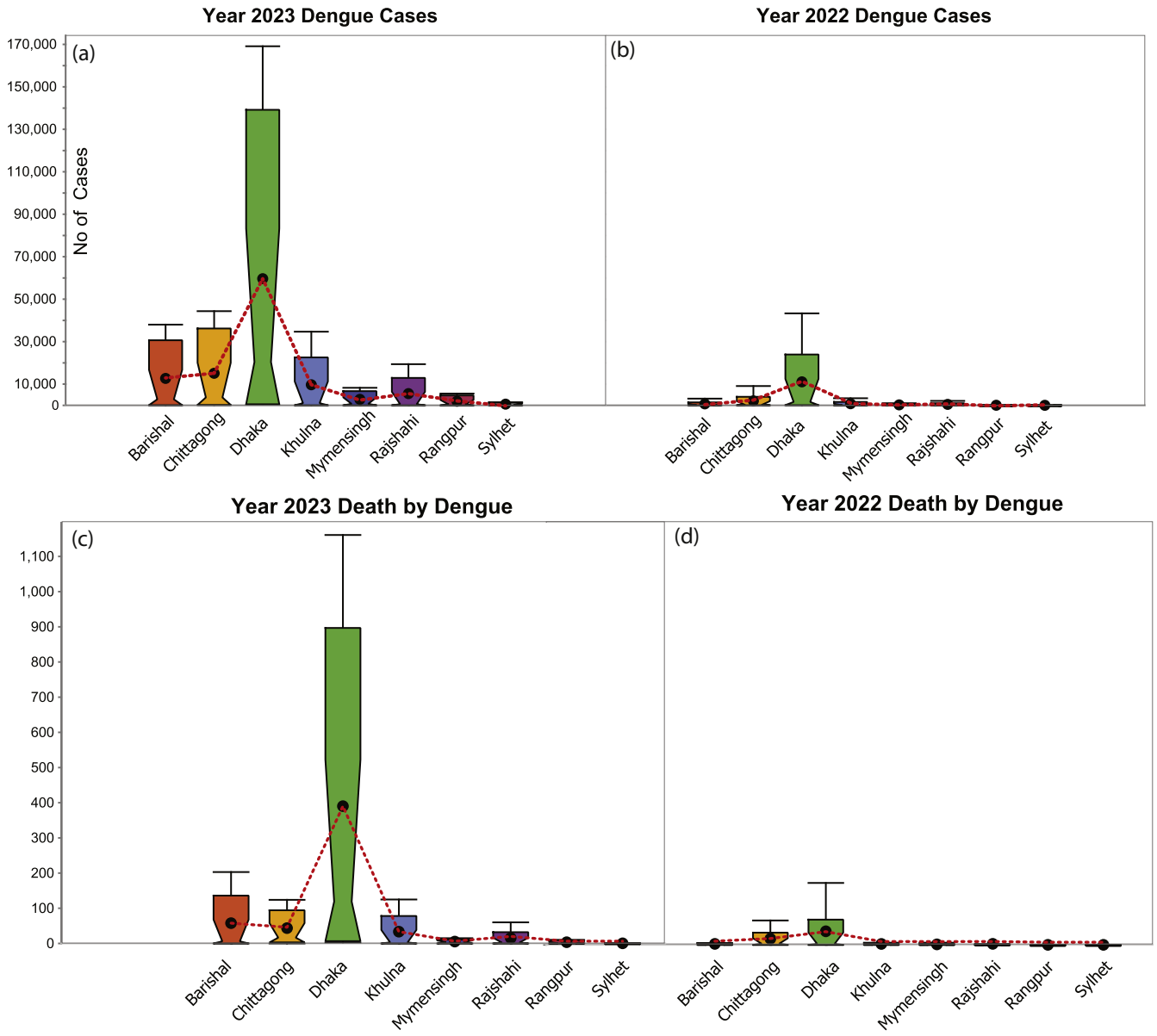

Figure 2. Division-wise dengue cases and deaths (2022-2023). This figure utilizes box-and-whisker plots to compare the distribution of reported dengue cases (a & b) and deaths (c & d) across divisions of Bangladesh for 2022 and 2023. The red dashed line represents the average for each year. The interquartile range depicts the middle 50% of data points, with the box ends showing the first and third quartiles. The whiskers extend to data points within 1.5 times the interquartile range from the box. This visualization allows for quick identification of divisions with higher or lower incidences and mortalities, along with the degree of variation within each division.

Analyzing monthly trends, a shift in peak seasonality was observed. In 2022, the highest caseloads occurred in October (21,932 cases), followed by November (19,334 cases) and September (9911 cases). In contrast, 2023 saw a peak in September (79,598 cases), followed by October (67,769 cases), with November exhibiting a decline (40,716 cases). Both years demonstrated a decrease in cases toward the year's end (Figure 3 [a, b]).

Spatial distribution of dengue cases

Bangladesh witnessed a dramatic increase (~500%) in confirmed dengue fever cases in 2023 compared with the previous year (Figure 1). This surge was accompanied by a significant rise in fatalities (1699 deaths in 2023 compared with 281 in 2022). The geographic distribution of the outbreak revealed a pattern of unevenness, where a positive relationship in some divisions was observed with lower numbers of cases and deaths in 2022, followed by a significant increase in 2023. Dhaka, as the epicenter, continued to have the highest caseload, with a concerning upward trend in 2023. Chittagong, Barisal, and Khulna also saw substantial increases, indicating the infection's spread beyond the established hotspot. In contrast, Sylhet, Rajshahi, and Rangpur experienced a comparatively milder impact, with the lowest case numbers (Figure 2 [a, b]), highlighting the unevenness of the outbreak's impact across different regions.

Division-level pattern of dengue cases and deaths

A marked geographic variation in dengue incidence was observed across administrative divisions of Bangladesh during 2022 and 2023. Dhaka emerged as the clear epicenter, with a substantial increase in cases from 43,325 in 2022 to 1,69,139 in 2023 (Figures 1, 2 [a, b]). A notable surge was also evident in Chittagong, where cases rose from

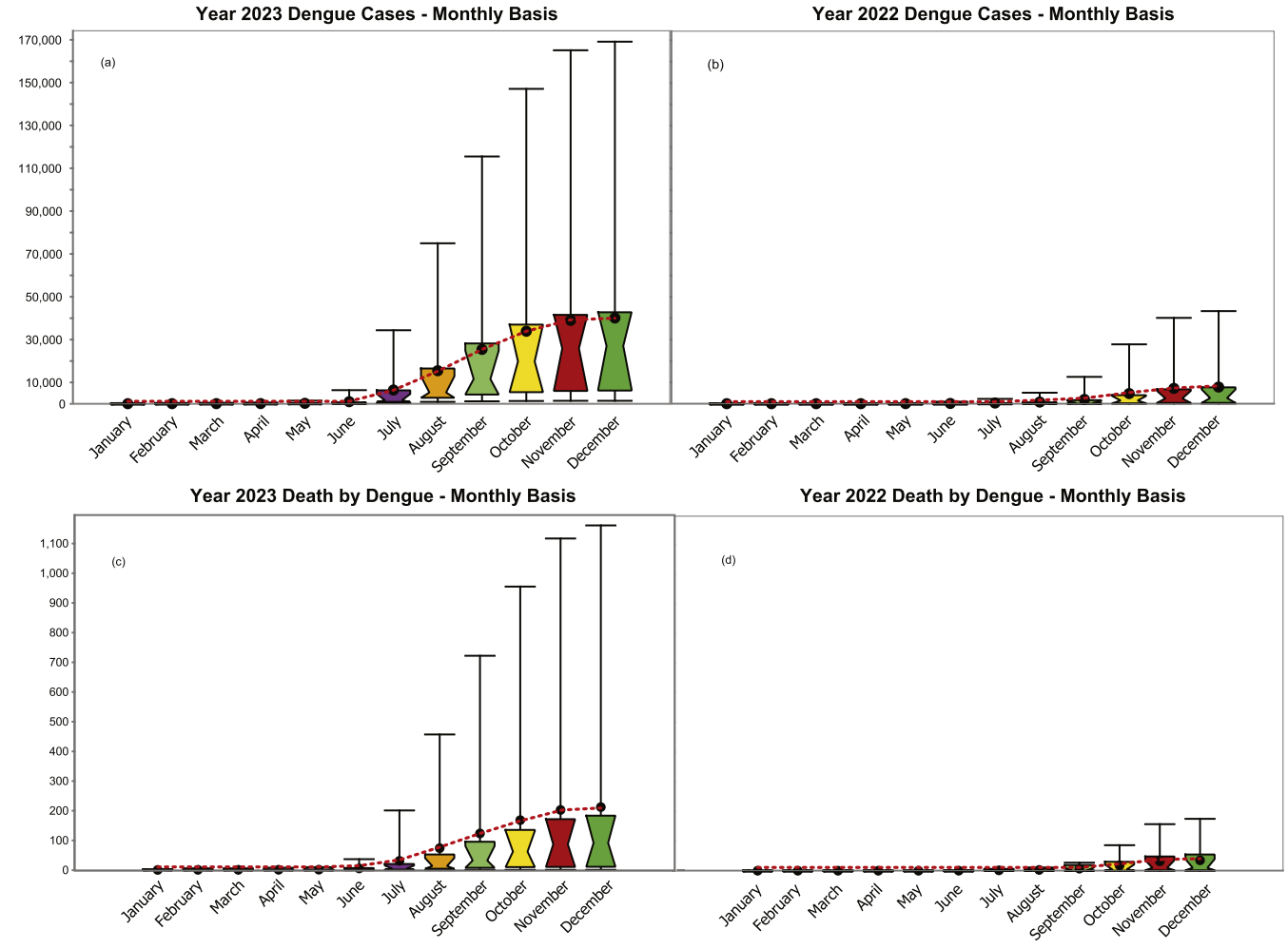

Figure 3. Monthly dengue cases and deaths (2022-2023). This figure presents box-and-whisker plots illustrating the monthly distribution of reported dengue cases (a & b) and deaths (c & d) for both 2022 and 2023. The red dashed line indicates the average for each month across the 2 years. The interquartile range and whiskers are represented similarly to Figure 2. This visualization highlights potential seasonal trends in dengue outbreaks, including the observed surge in cases and deaths during the period of August to December 2023.

9109 in 2022 to 44,373 in 2023 (Figure 2 [a, b]). Other divisions, including Barisal, Khulna, Rajshahi, and Rangpur, reported a range of cases between 34,689 and 5538 in 2023. Sylhet remained the least affected division throughout the period, with only 1435 cases reported in 2023 (Figure 2 [a, b]).

Consistent with case numbers, Dhaka experienced the highest mortality burden (Figure 2 [c, d]). Fatalities in Dhaka increased from 175 in 2022 to 1161 in 2023. Although Chittagong initially had a lower death toll (69 in 2022), a concerning shift occurred in 2023, with Barisal emerging as the second-worst affected region, experiencing a significant rise to 203 fatalities. Previously, Mymensingh, Khulna, Rajshahi, and Barisal reported relatively low mortality rates (6-12 deaths in 2022). However, the 2023 outbreak extended to these regions, with fatalities ranging from 10 in Rangpur to 125 in Khulna (Figure 2 [c, d]).

Monthly trends and prolonged peak in 2023

A month-by-month analysis of the data (year 2022-2023) reveals distinct patterns in dengue incidence and mortality (Figure 3). In 2023, the peak incidence occurred in September (79,598 cases), followed by August (71,976 cases) and October (67,769 cases). Although both years exhibited outbreaks from August to November, with case numbers exceeding 19,000 in 2022, the 2023 peak was more prolonged. A total of 3 consecutive months (September to November) in 2023 witnessed over 40,000 cases each, accompanied by an increase in fatalities (Figure 3 [c, d]). Notably, both years displayed similar patterns of rapid surges in cases during September and October, followed by a gradual decline starting in December.

The significant rise in dengue cases underscores a critical challenge in Bangladesh: the limited healthcare capacity to effectively manage such outbreaks. Although the geographic distribution of hospitals across the eight divisions and their bed capacity is insufficient to meet the needs (Figure 4). Data from the Population & Housing Census and the Ministry of Health and Family Welfare, Bangladesh reveal that the number of public hospital beds in Barisal, Chittagong, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet divisions ranges from 3147 to 8138 beds. Dhaka leads the pack with 9987 beds (Figure 4). However, even this seemingly higher number translates to a meager one bed for every 3114 citizens—a mere 0.03% of the total population. This imbalance persists across the nation, with divisions such as Barisal and Chittagong struggling with similar shortfalls, showcasing ratios of one bed per 4379 and 2480 residents, respectively.

Discussion

Our findings revealed several unique trends in the spatial and temporal distribution of dengue cases in Bangladesh. In this segment, we will explore the potential factors contributing to these observed trends. One

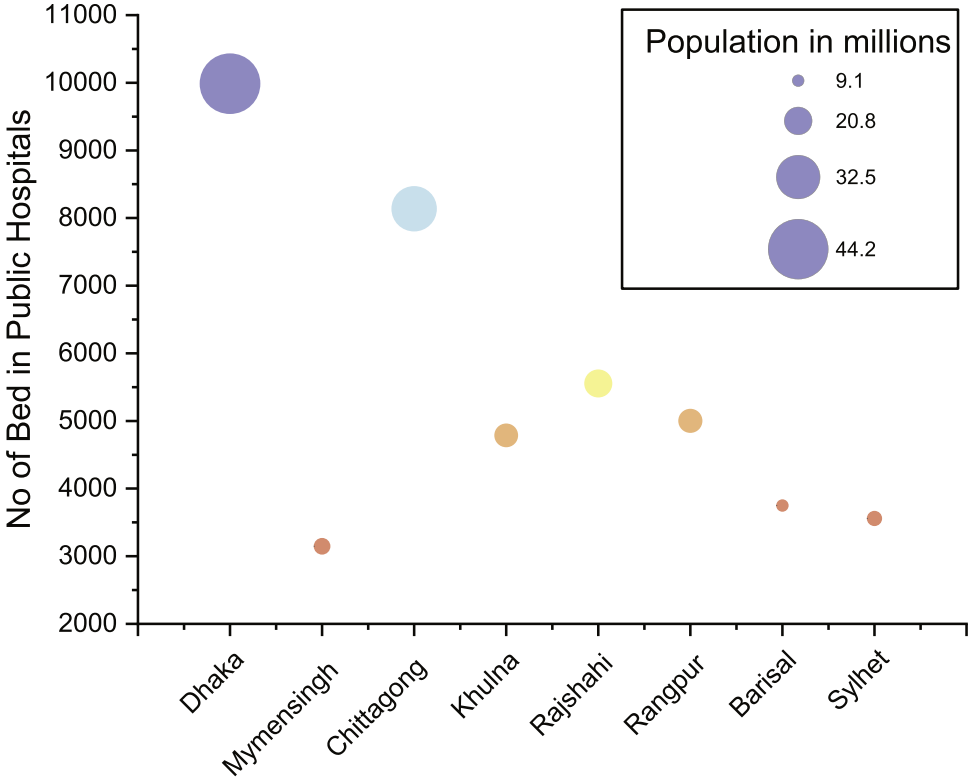

Figure 4. Public hospital bed availability vs population by division (Millions). This figure depicts the availability of public hospital beds compared with the population size (in millions) across administrative divisions of Bangladesh. Each circle represents a division's population, with the size of the circle proportional to its population. This visualization reveals the distribution of hospital bed resources relative to population density. Notably, although Dhaka has the highest number of beds, it still faces a significant shortage relative to its massive population. Similar shortfalls are evident in Barisal and Chittagong, highlighting the widespread imbalance in hospital bed availability across the country.

of the key highlights of our findings is the consistent reporting of a more substantial incidence of dengue cases in densely populated regions, such as Dhaka and Chittagong, in contrast to regions with lower population densities. This trend aligns with existing works demonstrating a correlation between population density and human-mosquito contact, a key factor in dengue transmission [20]. Furthermore, inadequate sanitation infrastructure, characterized by improper waste disposal and stagnant water, is prevalent in these urban areas. These conditions provide abundant breeding grounds for mosquitoes, facilitating their rapid multiplication and increasing the likelihood of human-mosquito contact. Improper waste disposal results in the accumulation of garbage and debris, which can collect rainwater and create small, stagnant pools. These stagnant water sources are perfect for mosquito breeding. Similarly, blocked drainage systems and inadequate sewage facilities contribute to the formation of standing water, further exacerbating the problem [21].

Differential access to healthcare facilities and diagnostics might contribute to the observed spatial distribution of cases. A comprehensive, country-wide, cross-sectional study in Bangladesh found that residents in remote areas have less knowledge and awareness about dengue than urban populations [20]. In addition, another study highlighted that inadequate healthcare infrastructure at the district level, limited financial resources, and cultural beliefs often discourage villagers, particularly, women, from seeking medical care [5]. These barriers collectively lead to the underreporting of dengue cases. Conversely, urban areas with better access to healthcare facilities and diagnostics might experience a higher number of reported cases due to increased testing and diagnosis capabilities. This potential bias in reporting due to healthcare access highlights the importance of considering underreporting when interpreting spatial patterns of dengue incidence.

In addition, heavy rainfall has a complex effect. Although it can disrupt breeding sites and disperse larvae, it can also create temporary habitats, potentially expanding mosquito distribution [22]. Interestingly, our study revealed that Sylhet, despite having the highest rainfall in Bangladesh, consistently reported the lowest number of cases. One plausible explanation is that the lower population density in Sylhet may lessen the effect of rainfall on mosquito breeding and, consequently, dengue transmission. A study on dengue hemorrhagic fever in South Jakarta Administrative City also found a similar trend where lower populated areas had lower numbers of dengue cases [23].

Our study also revealed a shift in the peak dengue season, with September now registering the highest number of infections, followed by a decline after December. This shift from the traditional August peak [5] may be due to environmental changes and climatic conditions affecting mosquito breeding and transmission dynamics. It has been reported that the average mean rainfall from June to August has decreased by 60 mL [24]. In contrast, the mean monthly rainfall for September has increased by 43 mL, extending the monsoon period and creating ideal conditions for mosquitoes, thereby increasing the risk of dengue spread [24].

Notably, despite having over 43,925 hospital beds, Bangladesh's healthcare infrastructure struggles to accommodate the surge in patients with dengue during outbreaks. The disparity in bed availability per capita across different divisions worsens the healthcare system's ability to manage the surge in dengue cases. Regions with fewer beds are especially vulnerable, lacking capacity for adequate care during outbreaks. This highlights the pressing requirement to increase the number of beds and enhance the distribution of resources, especially in regions with a low per-capita hospital bed count (as shown in Figure 4). In addition, deploying mobile clinics and temporary health facilities during outbreaks and increasing trained healthcare workers can mitigate this issue.

Effectively combating rising dengue cases requires a multifaceted approach encompassing improved sanitation, community education, research into seasonal shifts, and robust healthcare systems. Healthcare systems must be equipped for peak season surges, with strategic resource allocation ensuring timely access to critical beds and care [20]. Promising advancements such as the ChimeriVax Dengue (Acambis, Inc., Cambridge, Massachusetts, USA) tetravalent vaccine offer hope for protection against various serotypes [25]. However, a critical barrier remains, which is the lack of readily available real-time PCR kits for definitive

Table 1
Division-wise dengue cases and deaths in 2022-2023.

Year 2022					
Month	Division	Total Cases	Monthly Cases	Total Death	Monthly Death
January	Dhaka	60	60	0	0
	Mymensingh	1	1	0	0
	Chittagong	56	56	0	0
	Khulna	1	1	0	0
	Rajshahi	0	0	0	0
	Rangpur	1	1	0	0
	Barishal	7	7	0	0
	Sylhet	0	0	0	0
Total		**126**	**126**	**0**	**0**
February	Dhaka	70	10	0	0
	Mymensingh	1	0	0	0
	Chittagong	59	3	0	0
	Khulna	2	1	0	0
	Rajshahi	0	0	0	0
	Rangpur	2	1	0	0
	Barishal	12	5	0	0
	Sylhet	0	0	0	0
Total		**146**	**20**	**0**	**0**
March	Dhaka	81	11	0	0
	Mymensingh	2	1	0	0
	Chittagong	63	4	0	0
	Khulna	5	3	0	0
	Rajshahi	1	1	0	0
	Rangpur	2	0	0	0
	Barishal	12	0	0	0
	Sylhet	0	0	0	0
Total		**166**	**20**	**0**	**0**
April	Dhaka	100	19	0	0
	Mymensingh	2	0	0	0
	Chittagong	66	3	0	0
	Khulna	6	1	0	0
	Rajshahi	1	0	0	0
	Rangpur	2	0	0	0
	Barishal	12	0	0	0
	Sylhet	0	0	0	0
Total		**189**	**23**	**0**	**0**
May	Dhaka	261	161	0	0
	Mymensingh	2	0	0	0
	Chittagong	67	1	0	0
	Khulna	7	1	0	0
	Rajshahi	1	0	0	0
	Rangpur	2	0	0	0
	Barishal	12	0	0	0
	Sylhet	0	0	0	0
Total		**352**	**163**	**0**	**0**
June	Dhaka	965	704	1	1
	Mymensingh	10	8	0	0
	Chittagong	83	16	0	0
	Khulna	15	8	0	0
	Rajshahi	1	0	0	0
	Rangpur	3	1	0	0
	Barishal	12	0	0	0
	Sylhet	0	0	0	0
Total		**1089**	**737**	**1**	**1**
July	Dhaka	2263	1298	4	3
	Mymensingh	26	16	0	0
	Chittagong	306	223	6	6
	Khulna	29	14	0	0
	Rajshahi	3	2	0	0
	Rangpur	3	0	0	0
	Barishal	30	18	0	0
	Sylhet	0	0	0	0
Total		**2660**	**1571**	**10**	**9**
August	Dhaka	5136	2873	10	6
	Mymensingh	53	27	0	0
	Chittagong	836	530	11	5
	Khulna	72	43	0	0

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Table 1 (*continued*)

Year 2022					
Month	Division	Total Cases	Monthly Cases	Total Death	Monthly Death
	Rajshahi	4	1	0	0
	Rangpur	5	2	0	0
	Barishal	74	44	0	0
	Sylhet	1	1	0	0
Total		**6181**	**3521**	**21**	**11**
September	Dhaka	12558	7422	27	17
	Mymensingh	173	120	0	0
	Chittagong	2018	1182	24	13
	Khulna	628	556	0	0
	Rajshahi	282	278	0	0
	Rangpur	20	15	0	0
	Barishal	403	329	4	4
	Sylhet	10	9	0	0
Total		**16092**	**9911**	**55**	**34**
October	Dhaka	27761	15203	86	59
	Mymensingh	553	380	4	4
	Chittagong	4697	2679	38	14
	Khulna	1916	1288	6	6
	Rajshahi	1245	963	2	2
	Rangpur	72	52	0	0
	Barishal	1713	1310	5	1
	Sylhet	67	57	0	0
Total		**38024**	**21932**	**141**	**86**
November	Dhaka	40147	12386	157	71
	Mymensingh	940	387	6	2
	Chittagong	7950	3253	60	22
	Khulna	3116	1200	12	6
	Rajshahi	2000	755	7	5
	Rangpur	160	88	0	0
	Barishal	2926	1213	12	7
	Sylhet	119	52	0	0
Total		**57358**	**19334**	**254**	**113**
December	Dhaka	43325	3178	175	18
	Mymensingh	1020	80	6	0
	Chittagong	9109	1159	69	9
	Khulna	3350	234	12	0
	Rajshahi	2111	111	7	0
	Rangpur	175	15	0	0
	Barishal	3167	241	12	0
	Sylhet	125	6	0	0
Total		**62382**	**5024**	**281**	**27**

Year 2023					
Month	**Division**	**Total Cases**	**Monthly Cases**	**Total Death**	**Monthly Death**
January	Dhaka	330	330	3	3
	Mymensingh	7	7	0	0
	Chittagong	140	140	3	3
	Khulna	24	24	0	0
	Rajshahi	7	7	0	0
	Rangpur	2	2	0	0
	Barishal	53	53	0	0
	Sylhet	3	3	0	0
Total		**566**	**566**	**6**	**6**
February	Dhaka	422	92	6	3
	Mymensingh	9	2	0	0
	Chittagong	179	39	3	0
	Khulna	30	6	0	0
	Rajshahi	7	0	0	0
	Rangpur	2	0	0	0
	Barishal	80	27	0	0
	Sylhet	3	0	0	0
Total		**732**	**166**	**9**	**3**
March	Dhaka	498	76	6	0
	Mymensingh	10	1	0	0
	Chittagong	196	17	3	0

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Year 2023					
Month	**Division**	**Total Cases**	**Monthly Cases**	**Total Death**	**Monthly Death**
	Khulna	34	4	0	0
	Rajshahi	7	0	0	0
	Rangpur	2	0	0	0
	Barishal	93	13	0	0
	Sylhet	3	0	0	0
Total		**843**	**111**	**9**	**0**
April	Dhaka	592	94	8	2
	Mymensingh	11	1	0	0
	Chittagong	229	33	3	0
	Khulna	38	4	0	0
	Rajshahi	7	0	0	0
	Rangpur	2	0	0	0
	Barishal	104	11	0	0
	Sylhet	3	0	0	0
Total		**986**	**143**	**11**	**2**
May	Dhaka	1487	895	10	2
	Mymensingh	23	12	3	3
	Chittagong	310	81	0	3
	Khulna	45	7	0	0
	Rajshahi	7	0	0	0
	Rangpur	2	0	0	0
	Barishal	144	40	0	0
	Sylhet	4	1	0	0
Total		**2022**	**1036**	**13**	**2**
June	Dhaka	6387	4900	37	27
	Mymensingh	118	95	0	3
	Chittagong	792	482	9	9
	Khulna	162	117	0	0
	Rajshahi	33	26	0	0
	Rangpur	29	27	0	0
	Barishal	416	272	1	1
	Sylhet	41	37	0	0
Total		**7978**	**5956**	**47**	**34**
July	Dhaka	34374	27987	201	164
	Mymensingh	1294	1176	4	4
	Chittagong	6649	5857	24	15
	Khulna	1901	1739	6	6
	Rajshahi	1056	1023	4	4
	Rangpur	841	812	1	1
	Barishal	5293	4877	11	10
	Sylhet	424	383	0	0
Total		**51832**	**43854**	**251**	**204**
August	Dhaka	74989	40615	457	256
	Mymensingh	3567	2273	7	3
	Chittagong	17433	10784	57	33
	Khulna	6410	4509	19	13
	Rajshahi	4163	3107	9	5
	Rangpur	2565	1724	4	3
	Barishal	13750	8457	40	29
	Sylhet	931	507	0	0
Total		**123808**	**71976**	**593**	**342**
September	Dhaka	115522	40533	722	265
	Mymensingh	5679	2112	11	4
	Chittagong	29476	12043	83	26
	Khulna	14620	8210	45	26
	Rajshahi	8556	4393	20	11
	Rangpur	3903	1338	7	3
	Barishal	24462	10712	100	60
	Sylhet	1188	257	1	1
Total		**203406**	**79598**	**989**	**396**
October	Dhaka	147086	31564	955	233
	Mymensingh	7047	1368	11	0
	Chittagong	38435	8959	98	15
	Khulna	25220	10600	89	44
	Rajshahi	14382	5826	36	16
	Rangpur	4936	1033	10	3
	Barishal	32716	8254	148	48
	Sylhet	1353	165	1	0
Total		**271175**	**67769**	**1348**	**359**
November	Dhaka	165111	18025	1117	162
	Mymensingh	7977	930	13	2
	Chittagong	43009	4574	117	19
	Khulna	33155	7935	117	28
	Rajshahi	18652	4270	57	21
	Rangpur	5395	459	10	0
	Barishal	37173	4457	190	42
	Sylhet	1419	66	1	0
Total		**311891**	**40716**	**1622**	**274**
December	Dhaka	169321	4210	1163	46
	Mymensingh	8268	291	16	3
	Chittagong	44435	1426	124	7
	Khulna	34722	1567	125	8
	Rajshahi	19409	757	60	3
	Rangpur	5540	145	10	0
	Barishal	38049	876	206	16
	Sylhet	1435	16	1	0
Total		**321179**	**9288**	**1705**	**83**

(*continued on next page*)

DENV diagnosis in many endemic areas [26]. These tests are often expensive and require skilled personnel [27], hindering early intervention and potentially worsening case severity. Molecular point-of-care tests could enable quicker diagnoses than traditional methods. For instance, the RT-PCR test requires 150 minutes (ranging from 65 to 90 minutes), whereas the Reverse transcription-insulated isothermal Polymerase Chain Reaction (RT-iiPCR) test takes only 60 minutes (with a range of 40 minutes) to detect dengue [28]. Therefore, tests such as RT-iiPCR could serve as effective point-of-care testing for the DENV.

Our study offers a valuable contribution through its comprehensive approach. It unveils dengue cases and deaths at the divisional level, analyzes the availability of hospital beds in relation to population density, and identifies high-risk areas (dengue hotspots) within Bangladesh.

We also address some limitations present in the overall health care data acquisition system in Bangladesh; for instance, regions with better access to health care might exhibit higher testing rates, potentially inflating the number of confirmed cases compared with remote areas. In addition, the absence of division-wise climate data, such as breeding percentages associated with water body coverage, restricts the depth of analysis regarding the full spectrum of factors influencing dengue transmission. Despite these limitations, the data and analysis presented in this study provide valuable insights into the factors influencing dengue prevalence and severity in Bangladesh.

Conclusion

Our study identifies Dhaka and Chittagong as the most high-risk zones for dengue transmission due to their dense populations. September emerges as the prime breeding month for dengue, coinciding with the highest incidence of cases. The insufficient number of hospital beds emphasizes the urgent requirement, especially considering the increase in cases and fatalities in 2023. Based on the findings action should be taken at individual, community, and regional levels. This includes the implementation of vector control measures in identified hotspots; launching targeted public awareness campaigns promoting community-based prevention practices such as using mosquito nets, larvicides, and protective clothing; and addressing healthcare infrastructure disparities by scaling up resources and personnel in high-risk zones. Through proactive implementation and the adoption of a comprehensive strategy, Bangladesh has the potential to efficiently combat impending dengue outbreaks and reduce the impact of dengue infections on public health.

Declarations of competing interest

The authors have no competing interests to declare.

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Ethical approval

This study relied on data sourced from publicly accessible domains and had no direct involvement with human or animal subjects during this study, hence ethical approval was not required for this study.

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Author contributions

RS was responsible for the conception of the idea, the compilation and curation of the data, the execution of the statistical analysis, and the writing of the manuscript. ZS contributed by editing the manuscript.

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