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Healthcare-seeking behavior and household economic burden of suspected cutaneous anthrax cases in endemic rural Bangladesh

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Abstract

Background

Cutaneous anthrax is a neglected zoonotic disease that remains an important public health concern among livestock-rearing communities. Vulnerable groups such as farmers and animal handlers face recurring outbreaks that not only endanger human health but also cause substantial economic losses through personal medical care, livestock deaths, and trade restrictions. This study aimed to assess the level of knowledge, healthcare-seeking behavior, and economic burden of cutaneous anthrax in an endemic community.

Methods

We conducted a cross-sectional survey of 452 suspected cases in Meherpur, a recurrent Anthrax outbreak area in Bangladesh, from October 2023 and February 2024. We used descriptive statistics to summarize socio-demographics, anthrax knowledge, and healthcare-seeking behavior. We also estimated the cost for each patient at the household level following a bottom-up costing approach.

Results

Of the suspected cutaneous anthrax cases surveyed, 45.1% (204/452) were male. Most respondents knew about cutaneous anthrax transmission through slaughtering (73%, 330/452), skinning (66.5%, 301/452), and processing meat (39.8%, 180/452) of sick animals. Suspected cases were exposed to several risk practices such as raw meat processing (45.6%, 206/452), meat processed prior to cooking (44.9%, 203/452), skinning (44.2%, 200/452), livestock slaughtering (41.8%, 189/452), handling (24.3%, 110/452), and observed slaughtering (2.2%, 10/452) of sick animals. Majority of the study participants preferred government hospitals (79.6%, 360/452) in contrast to pharmacies (12.6%, 57/452) and local health care providers (7.7%, 35/452) for treatment. On average, the estimated cost per case was US$23, which includes 52.8% (US$12.2) of direct costs and 47.2% (US$10.8) of indirect costs. The average cost per case (US$23) constitutes 14.9% of the monthly household income (mean US$153.6).

Conclusion

Although the majority of the suspected cases adhered to seeking care at government hospitals for treatment, most of them were involved in risky handling with sick animals. The average healthcare cost associated with cutaneous anthrax was substantial for patients, given their low household income. Strengthening community awareness on safe animal handling and carcass disposal, animal vaccination, and integrating one health approaches for prevention and control are critical to reducing both health risks and economic consequences associated with cutaneous anthrax.

Background

Anthrax is a globally important zoonotic diseaseaused by the gram-positive, spore-forming bacterium *Bacillus anthracis* [1–3]. The infection is highly fatal to domestic and wild mammals and has a wide range of hosts, including humans [1, 4] Bacterial spores of anthrax can persist in soil for many years, withstand various environmental stresses (desiccation, heat, UV radiation) and reversion to the vegetative state upon the availability of sufficient nutrients[5, 6]. Most animals acquire infection by ingesting spore-contaminated soil grass, or water [2]. There are three major types of anthrax in humans: cutaneous, gastrointestinal, and pulmonary [7]. Humans are exposed to infection through butchering, processing hides and consuming raw or undercooked meat of infected or deceased animals [6, 8, 9].World Health Organization (WHO) documented a worldwide incidence between 2000 to 20,000 cases of human anthrax annually in the 21st century [10]. Within the estimated human occurrences, 95% were cutaneous anthrax [11]. Most cutaneous cases (80–90%) can be effectively treated with antibiotics; however, untreated cases (10–40%) might lead to severe complications, including death [11]. Approximately 1.8 billion people residing in 70 nations are located within the anthrax risk zone, encompassing Asia, North America, Southern Europe, sub-Saharan Africa, and some parts of Australia [12].

Anthrax causes high mortality in livestock, while human infection varies from mild to severe depending on different forms of the disease. This results in substantial financial losses for farmers as well as affected individuals (13). A model assessing the economic impact of a bioterrorist attack in an anthrax scenario estimated a cost of 26.2 billion US$ per 100,000 persons (14). Another study in Turkey detailed a total economic loss of US$25.8 million PPP (Purchasing Power Parity) during the years 2016, 2017, and 2018 due to anthrax zoonoses in both animals and humans (15). *Bacillus anthracis* is also recognized as a potential bioweapon for its environmental stability and dispersion capabilities. It has a history of being used as a weapon during World War I and World War II, as well as in Japan in 1995 and in the US in 2001 [13]. Following 2001, the anthrax letter attack in the US resulted in five fatalities with 17 illnesses associated with a cumulative medical spending of 177 million US$ [14, 15].

Bangladesh is considered anthrax-endemic and has experienced recurrent outbreaks affecting both animals and humans [1].. Rural people tend to slaughter sick animals to minimize financial loss, which generates the possibility of anthrax transmission [16]. Several districts of Bangladesh had evidenced sporadic human cases [1]. Initial documentation of cutaneous anthrax cases occurred in 1986 [17]. Thereafter, it became endemic since 2010 with 607 cutaneous cases and recurred with 278 and 176 cases in 2011 and 2012 in different districts of Bangladesh [1]. Until 2016, the Institute of Epidemiology, Disease Control & Research (IEDCR) had reported 1,320 cutaneous anthrax cases across Bangladesh [18]. Insufficient vaccine coverage, traditional carcass disposal practices, difficulties in burying animals due to frequent flooding-associated inundation, soil and weather conditions, and inadequate public health education regarding the disease were primary barriers to preventing anthrax transmission in this country [1, 18].

While the clinical and epidemiological features of anthrax in Bangladesh have been described, the economic burden of cutaneous anthrax on affected households remains poorly understood. Understanding the economic burden will facilitate the efficient allocation of resources toward cost-effective interventions like public health awareness, vaccination programs, and healthcare system strengthening. Furthermore, healthcare-seeking behavior will portray the role of existing healthcare facilities in timely diagnosis and treatment, which are essential for preventing the spread of cutaneous anthrax. This study therefore aimed to quantify the household economic burden of cutaneous anthrax and to explore healthcare-seeking behavior, and knowledge among affected populations in endemic rural communities of Bangladesh.

Methods

Study area

We conducted this study in two unions (smallest administrative and local government unit), Kazipur and Bamundi of Gangni sub-district in the Meherpur district, located in the south-western part of Bangladesh along the border with India (Fig. 1). Gangni covers an area of 344km² and has a population of around 300,000 and is recognized as a hotspot for cutaneous anthrax. We selected these sites based on reports of several print media that highlighted the human anthrax outbreak in this particular region since 2011. Subsequently, the IEDCR enlisted this area as a part of the national anthrax surveillance program in 2019, continuing to identify an increased number of human cases till 2023 [19].

Study design, study period and participant enrollment

A cross-sectional study was carried out to collect data from suspected cutaneous anthrax cases between October 2023 and February 2024. We used snowball sampling approach to identify suspected cutaneous anthrax cases within the selected communities. We initially prepared a list of residents who had experienced characteristic skin lesions like papule, vesicle or eschar at any point in their lives. Those who presented cutaneous anthrax-like consistent visible scarring from the skin lesions were finalized and selected for a detailed interview. Considering this screening process, a total of 452 participants were enrolled and interviewed as suspected cutaneous anthrax case with a prior history[20].

Data collection

A structured questionnaire was used to collect information about demographics, knowledge of anthrax, clinical history, animal exposures, healthcare-seeking behavior, perceived challenges, recommendations, and household economic burden. Data was

collected through face-to-face interviews by an experienced team comprising an anthropologist and two trained field assistants from One Health Research unit, International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b). The questionnaire was developed in english and translated into local language to ensure effective communication with participants. The English version is available in Supplementary information (Supplementary document).

Economic burden estimation

We utilized a household-based bottom-up micro-costing approach to gather all relevant economic information associated with cutaneous anthrax cases. All forms of illness-related expenses were incorporated in household costs. Thus, we assessed both the direct costs resulting from out-of-pocket (OOP) payments made by the household members and the indirect costs incurred at the household level from interviewed participants. Direct costs were categorized into medical and non-medical costs. Direct medical costs included all types of medications (allopathic, homeopathic, and herbal) prescribed by physicians, local health care providers, pharmacists, traditional healers, or self-treated. Additionally, diagnostic tests and doctor's fees also accounted for direct medical costs. Only travel costs from respective residents to healthcare facilities were included as direct non-medical costs. Costs incurred with productivity loss and caregiving were associated with indirect costs. We gathered data on daily income from patients and their caregivers (involving family members, relatives, or neighbors). Then, we multiplied the recorded daily income by the cumulative number of workdays missed by the patient and their caregivers throughout the patient's healthcare-seeking period to calculate the indirect costs. We did not include the cost of free medication, diagnostics or other financial support provided by government or NGOs.

Statistical analysis

Quantitative variables related to demography, knowledge, clinical history, and healthcare-seeking behavior were demonstrated through frequencies, proportions, and confidence intervals (95% CI). Subsequently, cost components were represented in average (arithmetic mean) with standard deviation and percentage. We used local currency (BDT) to collect data on different expenditures and converted it into US dollars (US$) with an exchange rate of 119.71 BDT per 1 US$ at the end of 2024.

Results

Socio-demographic characteristics of the participants

Out of 452 participants, 415 (91.8%) were residents of Kazipur, and 37 (8.1%) were from Bamundi Union of the Gangni sub-district. Selected respondents had a mean age of 41 years, ranging from 3 to 82 years (median age 40 years). Majority of the participants were female (54.8%, 248/452) and involved in household activities (92.3%, 229/248), while male respondents (45.1%, 204/452) predominantly engaged with agricultural farming (35.7%, 73/204) (Table 1).

Table 1
Socio-demographic characteristics of suspected cutaneous anthrax patients in Meherpur (N = 452, October 2023-February 2024)

Variables	Number of Patients (%)	95% CI
Age in years		
3–17	27 (5.9)	3.9–8.5
18–34	99 (21.9)	18.1–26.0
35–54	240 (53.1)	48.4–57.6
≥ 55	86 (19.0)	15.4–22.6
Gender		
Male	204 (45.1)	40.5–49.7
Female	248 (54.8)	50.2–59.4
Union		
Kazipur	415 (91.8)	88.8–94.1
Bamundi	37 (8.1)	5.8–11.1
Education		
No formal education	165 (36.5)	32.0-41.1
Primary	131 (28.9)	24.7–33.1
Secondary	118 (26.1)	22.0-30.1
Higher secondary	26 (5.7)	3.7–8.3
Graduate or above	12 (2.6)	1.3–4.5
Occupation		
Farmer	73 (16.1)	12.7–19.5
Housewife	229 (50.6)	46.0-55.3
Day laborer	20 (4.4)	2.7–6.7
Business	45 (9.9)	7.3–13.0
Student	41 (9.1)	6.5–12.1
Others	44 (9.7)	7.1–12.8
Family Income		
≤ 26000BDT	392 (86.7)	83.2.0-89.7
> 26000BDT	60 (13.3)	10.3–16.7
Family size		
Small (1–4)	270 (59.7)	55.2–64.2
Medium (5–6)	145 (32.0)	27.8–36.4
Large (> 6)	37 (8.2)	5.8–11.1

Knowledge of cutaneous anthrax among suspected cases

All respondents were familiar with the disease by its common name, "Anthrax," or by the local name, “*Tarka*”. Regarding knowledge of anthrax etiology,77.2% (349/452) of respondents were unaware of the specific causal agent, while 20.6% (93/452) believed that anthrax was caused by a “germ”. About 88.2% (180/204) of males and 60.4% (150/248) of females stated the chance of anthrax spreading through slaughtering livestock. Only a small number of respondents (12.2%, 55/452) reported the capability of human-to-human transmission of anthrax, while the majority (62.4%, 282/452) disagreed. Out of surveyed participants, 91% (186/204) of males and 86% (215/248) of females believed that anthrax lesions were treatable. Among all respondents who felt anthrax was treatable, 46.1% (185/401) indicated that on-time medication was the best way to cure anthrax patients. Majority of the study participants (87.1%, 394/452) stated that anthrax was preventable. Among those, 44.9% (177/394) reported that avoiding sick animal slaughtering was an effective way to prevent anthrax (Table 2).

Table 2
Knowledge about anthrax among suspected cutaneous cases in Meherpur (N = 452, October 2023-February 2024).

Variables	Number of Patients (%)	95% CI
Familiar with anthrax	452 (100)	-
Cause of anthrax		
Germs	93 (20.6)	16.8–24.3
Bacteria	10 (2.2)	1.0–4.0
Anthrax spread through		
Slaughtering sick animals	330 (73.0)	68.9–77.1
Skinning sick animals	301 (66.5)	62.2–70.9
Processing meat of sick animals	180 (39.8)	35.3–44.3
Consuming sick animal meat	144 (31.8)	27.5–36.1
Meat processed prior to cooking	111 (24.5)	20.6–28.5
Handling sick animals	100 (22.1)	18.3–25.9
Capability of human-to-human transmission		
Capable	55 (12.2)	9.1–15.2
Incapable	282 (62.4)	57.9–66.8
Don’t know	115 (25.4)	21.4–29.4
Mode of human-to-human transmission		
Through wounds or discharges	33 (7.3)	5.2–10.1
Direct contact with affected person	18 (3.9)	2.5–6.2
Believe that anthrax is curable		
Yes	401 (88.7)	85.8–91.6
No	17 (3.7)	2.2–5.9
Don’t know	34 (7.5)	5.2–10.3
Ways to cure anthrax		
Medication on time	185 (40.9)	41.1–51.1
Quick treatment	70 (15.4)	13.8–21.5
Consult with physician	63 (13.9)	12.2–19.6
Believe that anthrax is preventable		
Yes	394 (87.1)	84.1–90.2
No	18 (3.9)	2.3–6.2
Don’t know	40 (8.8)	6.3–11.8
Precautions to prevent anthrax		
Avoid slaughtering sick animals	177 (39.1)	40.0-49.8
Avoid eating sick animal meat	104 (23.0)	22.0-30.7
Regular vaccination of animals	72 (15.9)	14.4–22.1

Variables	Number of Patients (%)	95% CI
Avoid handling sick animal meat	19 (4.2)	2.9–7.4
Traditional healers can treat anthrax patients		
Yes	21 (4.5)	2.8-7.0
No	420 (92.9)	90.5–95.2
Don't know	11 (2.43)	1.2–4.3

Clinical history and animal exposures

Maximum number of respondents (31.2%, 141/452) experienced their last clinical lesions within the past 1 to 2 years. All of them (100%, 452/452) observed skin lesions (vesicles, papules, ulcer, edema, black eschar etc.). Additionally, 34.7% (157/452) reported suffering from fever. Most of the male respondents (75.4%, 154/204) acquired anthrax infection during the period of slaughtering and skinning of sick livestock. In contrast, majority of female respondents developed cutaneous lesions resulting from exposure to handling raw meat (39.5%,98/248) and cooking (76.6%,190/248) (Table 3).

Table 3
Clinical history and animal exposures of suspected cutaneous anthrax cases in Meherpur (N = 452, October,2023-February 2024).

Variables	Number of Patients (%)	95% CI
Last occurrence of cutaneous lesions		
< 1 yr	93 (20.5)	16.8–24.3
1 to 2 years	141 (31.2)	26.9–35.6
3 to 5 years	97 (21.5)	17.8–25.5
> 5 years	121 (26.7)	22.7–31.1
Perceived reason for exposure to anthrax		
Processed raw meat	206 (45.6)	40.9–50.1
Meat processed prior to cooking	203 (44.9)	40.3–49.5
While skinned	200 (44.2)	39.6–48.8
Livestock slaughtering	189 (41.8)	37.2–46.3
Handled sick livestock	110 (24.3)	20.4–28.2
Observed slaughtering of livestock	10 (2.2)	1.0–4.0
Clinical presentation/features		
Skin lesions (vesicles, papule, ulcer, edema, eschar etc.)	452 (100)	-
Diarrhea	7 (1.5)	0.6–3.1
Fever	157 (34.7)	30.3–39.1

Healthcare-seeking behavior of the suspected patients

Of the 452 participants, 360 (79.6%) were treated in government hospitals, comprising Upazila Health complexes (UHCs) and district-level hospital. Over the period of illness, most of the patients (55.5%, 251/452) relied on single healthcare facility (either government hospital or pharmacy or local health care provider) in which 77.2% (194/251) of them were treated in government hospitals. The remaining participants (44.4%, 201/452) accessed multiple healthcare facilities. Within this group, 58.7% (118/201) consulted with local health care providers for initial treatment. However, majority of these participants (82.5%, 166/201) shifted to government hospitals for better care. Few respondents (4.8%, 22/452) also used home remedies or herbal treatment with the

guidance of traditional healers. The highest number of respondents (69.6%, 315/452) acknowledged that government hospitals were a convenient facility for treatment due to the availability of skilled physicians and quality treatment (23%, 104/452). The majority of cases (77.4%, 350/452) were cured within ≤ 1 month (Table 4).

Table 4
Healthcare-seeking behavior of suspected cutaneous anthrax cases from Meherpur (N = 452, October 2023-February 2024)

Variables	Number of Patients (%)	95% CI
Treated for illness	452 (100)	-
Primary source of treatment		
Govt. hospitals	360 (79.6)	75.6–83.2
Pharmacies	57 (12.6)	9.6–16.0
Local health care providers	35 (7.7)	5.4–10.6
Time between onset of illness and treatment		
≤ 1 week	408 (90.2)	87.5–93.0
> 1 week	44 (9.7)	7.1–12.8
Any advice along with treatment		
No advice	269 (59.5)	55.0–64.0
Antiseptic wash	142 (31.4)	27.1–35.7
Diseases confirmed by		
Govt. hospital physicians	356 (78.7)	72.3–80.3
Local health care providers	92 (20.3)	16.7–24.3
Pharmacist	91 (20.1)	16.5–24.1
Neighbors	53 (11.7)	8.9–15.0
Most convenient/satisfactory treatment providers		
Govt. hospitals	315(69.6)	65.2–73.8
Pharmacies	42 (9.3)	6.7–12.3
Local health care providers	38 (8.4)	6.0-11.3
Reason for choosing those source		
Skilled physicians and quality treatment	104(23.0)	19.2–27.1
Close proximity	19(4.2)	2.5–6.4
Available medicine	15(3.3)	1.8–5.4
Cutaneous lesion cured within		
≤ 1 month	350 (77.4)	73.7–81.6
≥ 1 month	102 (22.5)	18.7–26.7
Decisions/suggestions for healthcare facilities made by		
Patient themselves	80 (17.7)	14.2–21.5
Family member	291 (64.3)	59.7–68.7
Neighbors	268 (59.2)	54.6–63.8
Followed preventive measures		
Maintain cleanliness	173 (38.2)	33.7–42.7
Avoid slaughtering sick animals	114 (25.2)	21.2–29.2

Variables	Number of Patients (%)	95% CI
Bury the dead animal	84 (18.5)	15.0-22.1
Vaccinate domestic animals	50 (11.1)	8.3–14.3

Challenges and recommendations for anthrax treatment

The most commonly reported challenges were inadequate physicians at hospitals (33.6%, 152/452) and limited healthcare facilities (33.4%, 151/452) to effective anthrax treatment. To address these challenges, participants recommended that adequate medical facilities (27.2%, 123/452), including expert (trained) physicians (18.5%, 84/452), would be necessary (Table 5).

Table 5
Challenges for cutaneous anthrax treatment, along with potential recommendations to address these challenges (N = 452, October 2023-February 2024)

Variables	Number of Patients (%)	95% CI
Major challenges of anthrax		
Inadequate physicians at hospitals	152 (33.6)	29.2–38.1
No hospital nearby	151 (33.4)	29.0-37.9
High price of medicine	106 (23.4)	19.6–27.6
Medicine shortage	32 (7.0)	4.8–9.8
Lack of awareness	23 (5.0)	3.2–7.5
Recommendations		
Reduce medicine prices	64 (14.1)	11.0-17.7
Sufficient expert (trained) physicians	84 (18.5)	15.1–22.4
Available hospital nearby	123 (27.2)	23.1–31.5
No recommendations	122 (26.9)	22.9–31.3

Economic burden of cutaneous anthrax

The average household cost of a cutaneous anthrax case was US$ 23 (23 ± 30.2). The estimated cost was higher in male (US $31.6 ± 40.4) compared to female (US $15.8 ± 14.5) patients. The total cost per patient comprised of direct costs (52.8%, US$ 12.2) and indirect costs (47.2%, US$ 10.8). Medical costs constituted 80.3% of the direct costs (42.5% of average cost per patient, US$ 9.8) which included cost of drugs (US$ 9.2,39.9% of average cost per patient), doctor's fees (US$ 0.4,1.7% of average cost per patient) and diagnostic cost (US $0.2, 0.9% of average cost per patient) while non-medical expenses (only travel cost) accounted for the remaining 19.6% (10.2% of average cost per patient, US$ 2.4). Furthermore, 78.7% of the indirect costs were attributed to loss of productivity (36.9% of average cost per patient, US$ 8.5), and the remaining 21.3% were associated with caregiver cost (10.2% of average cost per patient, $2.3) (Table 6).

Table 6
Costs (US$) associated with treatment of suspected cutaneous anthrax patients from Meherpur (N = 452, October 2023– February 2024).

Expenditure	Costs per Male (Mean ± SD) (N = 204)	Costs per Female (Mean ± SD) (N = 248)	Total costs of patients (N = 452)	Average Costs per patient ± SD, Range (Min-Max)
Direct costs	**13.4 ± 16.3**	**11.1 ± 9.3**	**5483.6**	**12.2 ± 12.9 (0.02–137.8)**
Medical costs	**10.8 ± 14.5**	**8.9 ± 8.6**	**4416.0**	**9.8 ± 11.7 (0-108.6)**
Medicine cost	9.9 ± 12.8	8.6 ± 8.3	4145.5	9.2 ± 10.6 (0-100.2)
Doctor's visit	0.5 ± 1.6	0.3 ± 0.9	175.7	0.4 ± 1.2 (0-12.7)
Diagnostic cost	0.4 ± 1.9	0.06 ± 0.3	94.8	0.2 ± 1.3 (0-16.7)
Non-medical costs	**2.6 ± 3.3**	**2.2 ± 1.9**	**1067.6**	**2.4 ± 2.6 (0-29.2)**
Travel cost	2.6 ± 3.3	2.2 ± 1.8	1067.6	2.4 ± 2.6 (0-29.2)
Indirect costs	**18.2 ± 30.2**	**4.7 ± 9.0**	**4898.9**	**10.8 ± 22.3 (0-271.4)**
Productivity loss	17.3 ± 29.5	1.2 ± 7.3	3835.8	8.5 ± 22.0 (0-250.4)
Caregiver cost	0.9 ± 3.3	3.5 ± 5.9	1063.1	2.3 ± 5.0 (0-41.7)
Overall cost	**31.6 ± 40.4**	**15.8 ± 14.5**	**10382.6**	**23.0 ± 30.2 (0-409.2)**

Discussion

Human anthrax cases in Bangladesh are significantly associated with the endemicity of animal anthrax [1]. This study focused on the areas with the highest reported outbreaks to examine the socio-demographic, behavioral, cultural, and economic factors. Study findings demonstrated the highest number of suspected cases in the adult population compared to other age groups which is consistent with the previous investigations conducted Bangladesh and Turkey [7, 21]. Although human cutaneous anthrax may be expected to be more common in males due to their involvement of livestock slaughtering and processing [16, 22], our study a identified greater number of female cases rather than males [21]. Similar to our findings, a previous study in rural Turkey also reported housewives (54%) and livestock farmers (14%)as the most vulnerable occupational group for cutaneous anthrax infection [23]. This highlighted the active participation of rural women in livestock management, including the handling and processing of raw meat prior to cooking, which likely exposed them to infections through cuts and other injuries [23, 24]. However, another study in Bangladesh evidenced equal proportions (50%) of male and female cases, suggesting no effects of gender in the occurrence of cutaneous anthrax [25].

Our study findings indicated that suspected cutaneous anthrax survivors may have direct or indirect contact with Anthrax infected livestock and livestock derivatives, which is aligned with the previous outbreak reports in Bangladesh [22, 25]. We explored the diverse risk practices among suspected cases that might contribute to cutaneous anthrax infection. These risky practices included managing sick animals, slaughtering, skinning, handling raw meat immediately post-slaughter, and processing raw meat before cooking. The presence of *Bacillus anthracis* vegetative cells and endospores in the bloodstream of infected animals poses a contamination risk to individuals performing risky practices [26]. The chance of infection is intensified by the presence of wounds or cuts on the hand during animal contact [27]. Raising awareness about anthrax transmission because of risky practices, animal vaccination, and proper disposal of carcasses might be useful in preventing cutaneous anthrax among livestock raisers and other community residents in at-risk areas.

Upazila Health Complexes (UHCs)—the government sub-district hospitals served as the primary healthcare facilities in providing diagnostics and treatment support for the suspected anthrax patients in Bangladesh [28, 29]. Reliable and efficient government physicians, along with low-cost treatment, encouraged patients to seek care from the UHCs [30]. In rural communities, choice of healthcare depends on the proximity of the facility from a patient's home, perceived availability and quality of healthcare support,

severity of illness, and financial conditions. Nevertheless, a considerable portion of the respondents received treatments from local informal health care providers (often known as "*gram dakter*") and pharmacies [28]. Case reports from previous studies conducted in a tribal village of West Bengal and rural Haiti also represented instances of patients receiving treatment from local quacks [31, 32]. Traditional healers locally known as "*kabiraj*" were involved in the provision of cutaneous anthrax treatment within the investigated area. A number of cases consulted with these traditional practitioners and used herbal medications prescribed by them [33]. An earlier study regarding knowledge, attitude, and practice towards anthrax in Northern Ethiopia also provided evidence of using traditional medicine for treating anthrax among rural residents [34]. Unavailability of qualified physicians, limited access to government healthcare facilities, and a lack of awareness regarding cutaneous anthrax in the endemic community might contribute to patients seeking treatment from unqualified practitioners. Study findings also documented a common perception among anthrax survivors that the disease is entirely curable through proper physician consultation and prompt medication. This low-risk perception might lead to underestimation of illness severity and potentially devastating consequences of the disease and indirectly promote risky practices that could contribute to the recurring outbreaks in this area. Similar findings were reported in a study of awareness and practices among cattle owners of rural Zimbabwe communities [35]. Understanding the importance of UHCs and providing proper counselling to both patients and at-risk communities through public health education programs may reduce misconceptions about the treatment of cutaneous anthrax and subsequently improve hospital adherence and treatment compliance.

This study provides an overview of the economic burden associated with the treatment of suspected cutaneous anthrax patients in Bangladesh. The current study estimated an average household cost of US$ 23for each patient. However, an earlier policy brief from the Ugandan government classified anthrax as a disease of public health importance and assessed approximate losses of US$ 140 per human case management [36]. Variations in healthcare policies, research population, forms of the disease (inhalation and gastrointestinal vs. cutaneous anthrax), cost components, and geographical distributions might help explain such cost variations. Furthermore, a model on economic impact of bioterrorist attack in the USA assumed a cumulative expenditure of US$ 422 (inflation not adjusted) for non-hospitalized anthrax patients [37]. Discrepancies in presumptive scenario, course of recommended prophylaxis, and the expected higher costs associated with diagnosis and treatment in the high-income setting of the USA likely resulted in a much higher cost in the USA compared to our study findings.

The estimated economic burden among males (mean US$ 31.6) was approximately twice that among females (mean US$ 15.8). Productivity losses among female housewives were not valued using a minimum wage level, which likely resulted lower economic costs relative to males. We observed a minor variation between the direct (mean US$12.2) and indirect costs (mean US$10.8) in our study. The cost of drugs (mean US$9.2) and productivity loss due to illness (mean US$ 8.5) were the highest expenditures incurred by a patient, while doctor's visit (mean US$ 0.4) and diagnostic costs (mean US$0.2) represented the lowest cost components. The healthcare-seeking behavior and the challenges faced by suspected patients (Table 4 and Table 5) provide an insight into the differential distribution of cost components. We observed cases who required prolonged courses of antibiotic therapy were not always subsidized by local UHCs, compelling patients to purchase medicines from pharmacies at their own expense. Most patients sought treatment in government healthcare facilities where doctor's consultation and medication fees were almost negligible. Although all the suspected cases of cutaneous anthrax were diagnosed based on visual lesions and clinical presentation, a few of them were suggested to undergo additional diagnostic tests by physicians depending on the patient's health illness severity and financial affordability. None of patients required hospitalization during the course of illness. These factors might also contributed to the comparatively lower cost per case observed in our study relative to the findings of other countries. However, a single infected animal can generate multiple human cases, resulting in a substantial cumulative household-level economic burden despite relatively low individual-level cost[38].

Our estimated monthly household income (mean US$ 153.6) of the suspected cases was lower than the national average household income at the rural level (US$ 218.8). These case households frequently faced difficulty to meet monthly expenditures [39]. Each suspected case spent 14.9% (US$ 23) of monthly household income on healthcare support for cutaneous anthrax. 52.8% (direct cost, US$ 12.2) of the total spending was out-of-pocket expenditure, imposing a distressing financial crisis on the affected families. According to previous studies in Bangladesh, out-of-pocket expenditures accounted for 74% of total health costs and contributed to pushing 3.3% of the population into poverty [40]. Therefore, risky practices such as slaughtering sick animals and selling their meat and byproducts at reduced prices to alleviate financial burden became common practice among livestock-rearing communities [22, 25].

Although the study contributes potential inputs, it has few limitations. We selected participants from an anthrax-endemic zone and the findings might not be representative of the whole country. Since the study relied on retrospective data collection, there might be the possibility of recall bias.

Conclusions

This study provides valuable insights about health-care seeking behaviors and economic burden of cutaneous anthrax among rural residents of Meherpur, Bangladesh. A substantial proportion of respondents sought care from the government hospitals, indicating appreciable healthcare-seeking behaviors. Participants engaged in high-risk practices, such as slaughtering, skinning, processing raw meat, and managing sick livestock, which directly exposed them to anthrax infection. Enhancing community awareness, particularly on the risks associated with slaughtering sick animals and handling their products may help reduce both the magnitude of cutaneous anthrax outbreak and its associated economic burden. Furthermore, the estimated economic burden in this study will help establish a baseline for future research and provide justifications to the policy makers for investing in anthrax prevention in low and middle-income country settings.

Abbreviations

WHO	World Health Organization
IEDCR	Institute of Epidemiology, Disease Control & Research
icddr,b	International Centre for Diarrhoeal Disease Research, Bangladesh
UHC	Upazila Health Complex
CI	Confidence Intervals
OOP	Out-of-pocket

Declarations

Ethics approval and consent to participate

Ethical clearance of this study was obtained from the Institutional Review Board (IRB) of icddr,b. Before participating in the interview, each participant signed a written informed consent. Participants under 18 years of age, written consent was provided by their parents or legal guardians. Participation was voluntary, maintained confidentiality and were aware of their right to withdraw at any time without any consequences. The study procedures and methods were fully compliant with the Declaration of Helsinki.

Clinical trial number

Not applicable.

Consent for publication

Not Applicable

Availability of data and materials

Collected data from this study are not available to the public; however, they are available on valid request to the corresponding author.

Competing interests

The authors declare no competing interests.

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Authors' contributions

TKD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft. SB: Conceptualization, Data collection, Data curation, Formal analysis, Supervision, Writing – review & editing. UKM: Conceptualization, Methodology, Supervision, Writing – review & editing. MSU: Conceptualization, Methodology, Supervision, Writing – review & editing. SIS: Formal analysis, Visualization, Writing – review & editing. NNC: Conceptualization, Formal analysis Visualization, Writing – review & editing. SA: Conceptualization, Formal analysis, Visualization, Writing – review & editing. MG: Conceptualization, Supervision, Writing – review & editing. FH: Conceptualization, Supervision, Writing – review & editing. SC: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – review & editing.

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Figures

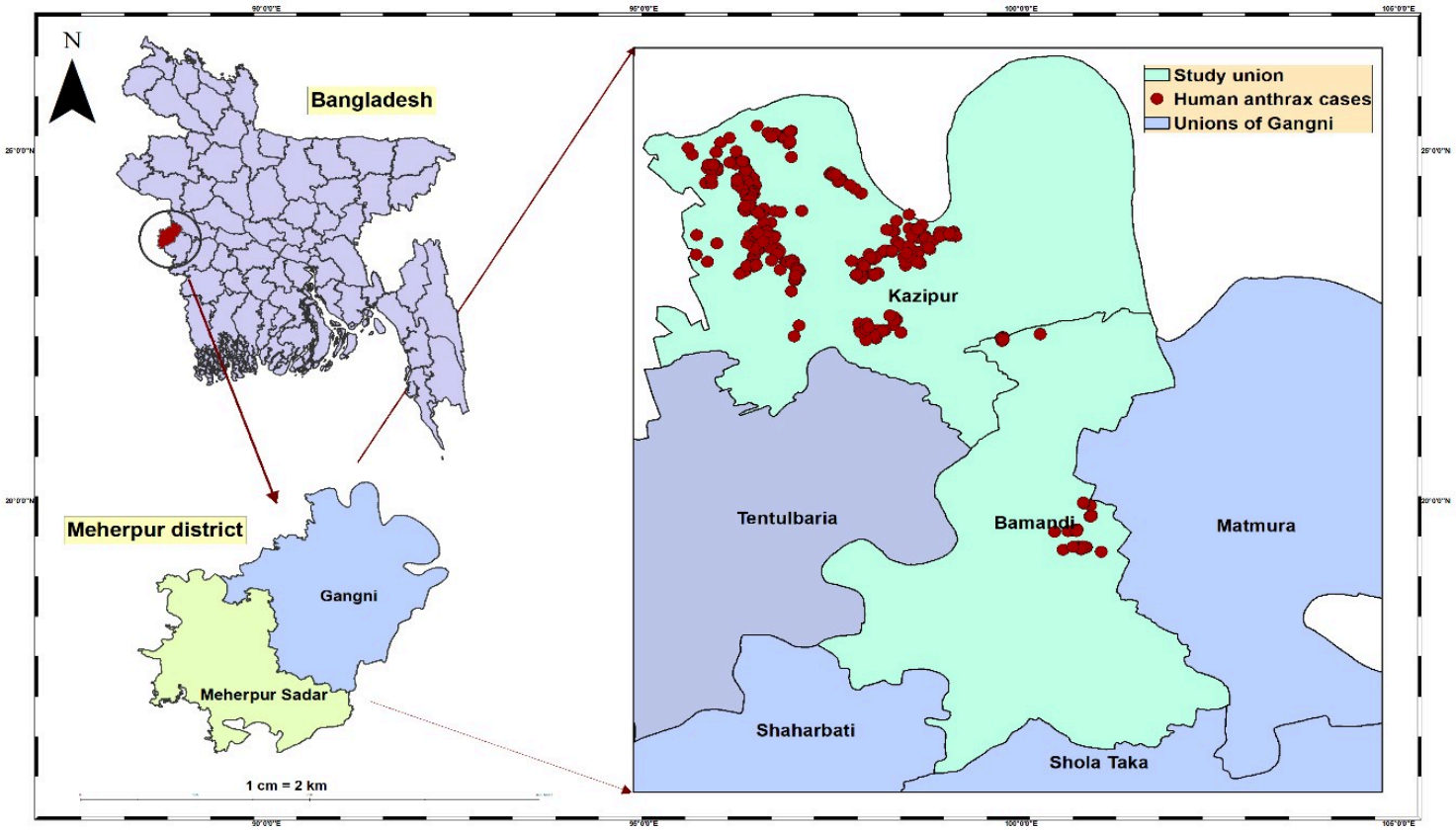


Figure 1

Specific geolocations of suspected cutaneous anthrax cases (n=452) in Meherpur, 2023-24

Supplementary Files

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