

Fatal Diphtheria in a Rohingya Refugee Settlement in Cox's Bazar, Bangladesh: A Case Study of Clinical, Surveillance and Health-System Gaps

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Abstract Diphtheria remains a significant threat in humanitarian settings with low vaccination coverage and fragile health systems. Global evidence indicates that outbreaks among displaced populations driven by overcrowding, immunity gaps, delayed clinical recognition, and weak surveillance systems, while limited availability of diphtheria antitoxin (DAT) further constrains effective case management. We conducted a descriptive case analysis of a fatal diphtheria infection, complemented by a public health investigation including contact tracing and surveillance review to identify gaps in clinical management and outbreak response. A 9-year-old unvaccinated boy residing in a Rohingya refugee camp in Cox's Bazar, Bangladesh, presented with fever and sore throat managed symptomatically without a throat examination. Rapid progression to severe disease with cervical swelling (bull neck) and respiratory distress occurred. On re-presentation, suspected diphtheria and later confirmed; however, delayed recognition, lack of access to DAT, and late referral led to death during transfer. Public health investigation identified 10 contacts who received prophylaxis but revealed delayed case notification, missed identification of a probable secondary case, and weak integration between clinical and surveillance systems. This case demonstrates how failures in early clinical recognition, timely access to DAT, and surveillance responsiveness, commonly reported in fragile and outbreak prone settings can converge to result in preventable mortality. Strengthening frontline clinical capacity, ensuring reliable DAT availability, improving real-time clinical-surveillance integration, and addressing immunization gaps are essential to reduce diphtheria deaths in humanitarian contexts.

Keywords Contact Tracing, Diphtheria, Humanitarian Settings, Refugee Health, Surveillance, Vaccination.

Introduction

Diphtheria is a vaccine-preventable disease caused by *Corynebacterium diphtheriae*, characterized by pharyngitis, pseudo membrane formation, and systemic toxicity. Despite the availability of effective vaccines, the disease persists in settings with low immunization coverage, particularly among displaced and conflict-affected populations, where outbreaks continue to occur with significant morbidity and mortality [1, 2].

Early clinical recognition and prompt administration of diphtheria antitoxin (DAT), alongside antibiotics, are critical to reducing case fatality. However, in humanitarian and resource-limited settings, delays in diagnosis, limited access to essential therapeutics, and weaknesses in surveillance systems frequently result in preventable deaths [3, 4].

Global evidence indicates that diphtheria outbreaks in fragile settings, displaced and conflict-affected populations, including Rohingya refugees driven by a combination of low vaccination coverage, overcrowding, delayed case detection, and inadequate health system capacity [5, 6]. Despite the existence of structured outbreak response mechanisms and surveillance platforms in many settings, fatal outcomes continue to occur, suggesting underlying systemic dysfunctions.

This case provides a micro-level illustration of systemic failures across clinical care, surveillance, and immunization systems in fragile humanitarian settings, demonstrating how gaps across the health system continuum can converge to result in preventable mortality [1, 6].

Background and Setting

Cox's Bazar hosts the world's largest refugee settlement, with over one million Rohingya refugees living in densely populated camps with poor sanitation and limited access to health care, conditions that facilitate transmission of vaccine-preventable diseases

such as diphtheria [7, 8]. Following the 2017 mass influx, a major outbreak resulted in widespread transmission and high disease burden [9]. Despite sustained response efforts, recurrent outbreaks have persisted, with surveillance data from 2019-2022 demonstrating ongoing transmission across multiple camps and low-level circulation since 2021. Transmission peaked in 2022 [10], with 335 suspected cases reported including 46 confirmed cases, including two deaths, and 24 probable cases or probable cases. The case fatality rate (CFR) is 4.3% (2/46), slightly below the global range of 5-10% with treatment [11, 12], yet substantially higher than the <1% achievable with timely and effective case management. Cases have been reported from 16 of 33 camps, with evidence of spillover into host communities.

Vaccination coverage among cases remains suboptimal, consistent with documented immunity gaps in this population [13]. Persistent transmission is driven by low immunization coverage, particularly among older children, poor vaccine completion, high population density, and mobility, compounded by gaps in surveillance sensitivity and diagnostic capacity, sustaining endemic risk for both refugee and host populations.

Methods

Study Design

We conducted a descriptive case analysis of a fatal diphtheria infection, complemented by a public health investigation including contact tracing and surveillance review to identify gaps in clinical management and outbreak response.

Case Definitions

According to the Surveillance Guidelines for Diphtheria in Rohingya Refugee's, Cox's Bazar Bangladesh by WHO, following are case definitions [14, 15].

Suspect diphtheria case definition: An illness of upper respiratory tract associated with fever; sore throat characterized by laryngitis or

pharyngitis or tonsillitis, and adherent membranes of tonsils, pharynx, and/or nose.

Laboratory confirmed: A case that meets the clinical case definition where samples are collected, and laboratory results are positive for the suspected disease.

Epidemiologically linked: A case that meets the clinical case definition and is epidemiologically linked to a laboratory-confirmed case. In this situation, a person has had intimate respiratory or physical contact with a laboratory-confirmed case within the 14 days prior to onset of sore throat.

Clinical compatible: This type of case meets the definition of a suspected case and lacks both a confirmatory laboratory test result and epidemiologic linkage to a laboratory-confirmed case.

Discarded case: A discarded case is a suspected case that meets either of these criteria: *Corynebacterium* spp. but negative Elek test (nontoxigenic *Corynebacterium*) OR negative PCR for the diphtheria toxin (tox) gene.

Setting and Population

The study was conducted in Cox's Bazar, Bangladesh, home to one of the world's largest Rohingya refugee settlements, characterized by high population density and limited healthcare access. The population of interest comprised forcibly displaced Rohingya residents, particularly children with low immunization coverage, including an unvaccinated child from Camp 07.

Data Sources

Data for this case study were derived from a routine public health investigation conducted in Cox's Bazar. Information was collected through direct field engagement, including patient history obtained from caregivers, clinical records (where available), surveillance databases (EWARS and Go. Data), available on websites, laboratory reports, and contact tracing

records. Additional contextual information was obtained through discussions with healthcare providers and public health staff involved in the response. Data were collected in person as part of public health response activities and subsequently anonymized for analysis.

Laboratory Methods

Nasopharyngeal sample was collected and sent in Amies media ensuring cold chain to the nationalized IEDCR Field Laboratory in Cox's Bazar supported by WHO. Diphtheria Triplex Real Time PCR assay Positive Control Kit was used for lab confirmation.

Contact Tracing and Surveillance Review

A structured review of contact tracing and surveillance processes was conducted to assess performance across case detection, notification, reporting, and response. It evaluated timeliness of case identification and notification, initiation of contact tracing, completeness of contact identification, and follow-up mechanisms, as well as data management across surveillance platforms.

The review also examined data integration, outcome verification, and coordination between clinical services, surveillance systems, and community reporting channels, including informal pathways. Delays in laboratory confirmation and case classification and their impact on timely response were assessed.

Overall, the review identified gaps in timeliness, completeness, and system integration affecting early detection and outbreak response effectiveness.

Analytical Framework

We applied a systems-oriented analytical framework to examine determinants of a fatal diphtheria case in a humanitarian setting, integrating clinical pathway analysis, surveillance evaluation, and health system assessment to identify interacting failures across the continuum of care and public health response.

A cascade model was used to reconstruct the sequence from symptom onset to death and to identify critical points of delay and system breakdown across six domains: population vulnerability, initial clinical assessment, diagnostic recognition, therapeutic intervention, referral and case management, and surveillance detection and response. At each stage, deviations from standard clinical and public health guidance were identified and classified.

Clinical management was assessed against WHO-recommended standards, focusing on timeliness of assessment, early suspicion, and prompt administration of diphtheria antitoxin (DAT). Gaps were categorized as diagnostic, therapeutic, or decision-making failures.

Surveillance performance was evaluated using key attributes—sensitivity, timeliness, completeness, and integration, including mapping of reporting pathways, case notification, laboratory confirmation, and contact tracing. This enabled identification of breakdowns in data flow, delayed reporting, and weak linkage between clinical and surveillance systems.

Systemic determinants were analyzed using the WHO Health System Building Blocks framework, examining service delivery, workforce capacity, medical products, health information systems, governance, and financing to identify structural and operational constraints.

Findings were synthesized using a systems-thinking approach, classifying determinants as immediate, underlying, or structural causes. These were integrated into a cascade failure model to illustrate how multi-level delays and deficiencies interacted to amplify risk and culminate in a preventable death.

Results

A 9-year-old boy, originally from Myanmar, had been living in Camp 07, Ukhiya, Cox's Bazar since 2017. The child had no documented history of vaccination back from Myanmar nor received any diphtheria-containing vaccine since arrival in refugee camps.

Clinical Findings Diagnostic Assessment, Therapeutic Intervention, and Outcome

The child developed mild fever and sore throat on 21 April 2022, which were managed at home with traditional remedies. As the symptoms did not subside, on 23 April 2022, he presented to a sentinel health facility and was treated symptomatically at the outpatient level without detailed clinical evaluation. Within hours of this visit, his condition (around midnight) further deteriorated, with the onset of neck swelling and respiratory distress. The illness progressed rapidly to features consistent with severe respiratory diphtheria, including bull neck swelling and stridor, indicating advanced disease.

Diphtheria was clinically suspected only at representation and subsequently laboratory confirmed, reflecting delayed recognition at initial contact. Initial management was limited to symptomatic treatment without adequate clinical evaluation, and although treatment was initiated later, diphtheria antitoxin (DAT) was not administered due to unavailability, despite classical clinical features. The patient's condition deteriorated rapidly, necessitating referral; however, death occurred during transfer due to progressive airway obstruction and systemic toxicity. A chronological summary of the clinical course, management actions, and missed opportunities is presented in Table 1.

Timeline

Table 1. Clinical Timeline with Key Analytical Interpretations

Date	Clinical Events	Analytical Interpretation (Missed Opportunities)
21-Apr-22	Onset of symptoms with fever, sore throat, cough, and runny nose	Treated at home considering usual
23-Apr-22	Initial presentation with fever and sore throat; managed symptomatically without further clinical evaluation	Early opportunity for clinical suspicion missed; absence of thorough examination delayed recognition of diphtheria
23 April 2022 (later same day)	Within hours (around midnight), progression to neck swelling and respiratory distress	Rapid disease progression highlights the critical need for early diagnosis and intervention
24-Apr-22	Re-presentation: clinical assessment performed; throat swab and blood samples collected for laboratory confirmation	Delay in diagnostic suspicion; laboratory confirmation initiated but treatment decisions not rapidly aligned with clinical suspicion
25-Apr-22	Referral to a tertiary facility due to clinical deterioration	Referral occurred at an advanced stage, indicating limited early case management and escalation capacity
25 April 2022 (en route)	Death occurred during transfer	Fatal outcome reflects cumulative delays across diagnosis, treatment access, and referral processes

Public Health Investigation

Health facilities screen suspected diphtheria cases using WHO case definitions and report through EWARS. Suspected cases are referred to one of five sentinel sites with isolation and laboratory capacity, where samples are collected, cases isolated, and data recorded in Go. Data. Case notifications are also shared informally (e.g., WhatsApp) to trigger public health actions, including contact tracing, which is expected to start on day zero with reporting within 48 hours. Response activities, such as active case search, immunization, contact tracing, and surveillance are implemented by multiple stakeholders, often with coordination gaps.

In this case, key breakdowns occurred across the clinical and surveillance pathway. The child developed symptoms on 21 April 2022 and was presented to a sentinel facility on 23 April 2022

where he was managed symptomatically without suspicion of diphtheria and was not reported in EWARS. The condition worsened the same evening, and on re-presentation, there was a delay in assessment and admission. Diphtheria was clinically suspected on 24 April 2022, following progression to classical signs, and a sample was collected and entered into Go. Data. Despite treatment with antibiotics, DAT was unavailable, and referral to a tertiary center was initiated; however, the child died during transfer on 25 April 2022. The death was not promptly updated in Go. Data.

Contact tracing began on 26 April 2022 following delayed notification, identifying 10 contacts who received azithromycin prophylaxis but no vaccination. On the same day, the 5-year-old sibling of the deceased developed fever and throat pain. The caregiver sought care outside the formal health system,

where diphtheria was not suspected and no diagnostic testing was performed. The child was treated symptomatically for whitish patches over both tonsils associated with pain and fever. Despite being symptomatic, the sibling was not identified or reported by the contact tracing team.

Laboratory confirmation was received two days after death (27 April 2022), delaying final case classification. The death was later detected through community-based surveillance on 10 May 2022, reflecting poor integration between surveillance platforms and delayed reconciliation of data.

Subsequent review identified systemic gaps in case detection, reporting, and data integration, which were escalated to the Health Sector and WHO. A concurrent stockout of diphtheria antitoxin across Cox's Bazar, due to procurement challenges and global shortages, further constrained case management, eliminating the only intervention capable of neutralizing circulating toxin and increasing mortality risk.

Discussion

This case illustrates a cascade of interconnected system-level failures contributing to a fatal outcome in a diphtheria patient within a humanitarian setting. Guided by the WHO Health System Building Blocks framework, multiple gaps were identified across service delivery, workforce capacity, medical products, information systems, governance, financing, and community engagement.

Delayed clinical recognition at first contact and late referral reflected deficiencies in service delivery, compounded by the need for strengthened frontline training. The absence of diphtheria antitoxin (DAT), due to procurement

challenges and global shortages, represented a critical limitation in case management and was a key determinant of mortality [16-18]. Timely clinical suspicion and early DAT administration are essential, as disease progression can be rapid and life-threatening.

Health information systems showed poor integration, with inconsistencies across EWARS, Go. Data, and community-based surveillance, leading to delayed case notification, incomplete data capture, and fragmented outbreak response. Weak governance mechanisms further contributed to unclear accountability for outcome reporting. Financing and procurement constraints, including the excessive cost and limited global availability of DAT, restricted access to essential treatment.

Contact tracing was initiated and prophylaxis provided; however, limitations in timeliness, completeness of case identification, and follow-up verification reduced its effectiveness. A symptomatic household contact was not reported or investigated, highlighting gaps in surveillance sensitivity and community linkage.

Underlying immunization gaps increased population vulnerability, consistent with evidence that unvaccinated populations are disproportionately affected during diphtheria outbreaks, while vaccination significantly reduces severe disease [1, 13].

In addition, the fatal outcome eroded community trust, resulting in delayed care-seeking and preference for informal healthcare providers, further increasing the risk of transmission. Table 2 summarizes the key health-system gaps identified across the WHO Health System Building Blocks and their contribution to the fatal outcome.

Table 2. Health System Gaps Identified

Building Block	Identified Gap
Service delivery	Delayed clinical recognition and referral
Health workforce	Need for strengthened frontline training
Medical products	DAT stockout
Information systems	EWARS, Go.Data, and community surveillance not fully reconciled
Governance	Unclear accountability for outcome reporting
Financing & procurement	Excessive cost and global DAT shortages
Community engagement	Reduced community trust following death

Overall, failures across clinical care, supply chains, and surveillance systems reduced the effectiveness of case management and outbreak response. Strengthening early recognition, ensuring DAT availability, improving surveillance integration, and rebuilding community trust are essential to reduce preventable mortality in similar settings.

Lessons Learned

Early clinical evaluation, particularly thorough throat examination, is essential for timely suspicion of diphtheria, and prompt administration of diphtheria antitoxin without awaiting laboratory confirmation is critical to reduce mortality. Effective outbreak control depends on strong integration between clinical care and surveillance systems to ensure timely reporting and investigation of cases. Addressing immunity gaps through catch-up vaccination, especially among older unvaccinated children, remains vital in displaced populations. Strengthening monitoring mechanisms and maintaining community trust are key to improving care-seeking behavior and ensuring an effective outbreak response.

Key Operational Recommendations

Immediate (0-6 months)

1. Ensuring uninterrupted supplies and decentralized DAT availability should be

prioritized in outbreak-prone humanitarian settings [6-18].

2. Implement standard operating procedures (SOPs) for active case detection, contact tracing, and outbreak response [19].
3. Conduct targeted training for frontline health care providers.

Short-Term (6-12 months)

1. Strengthening surveillance systems with clear case definitions and reporting pathways.
2. Improve integration between clinical and public health response systems [15].

Long-Term (12-18 months)

1. Implement large-scale catch-up vaccination campaigns (6 weeks–15 years) [1].
2. Strengthen routine immunization and retention strategies.

Limitations

This case has several limitations. Clinical details were incomplete due to unavailable medical records, including confirmation of DAT administration. Parts of the timeline relied on caregiver recall, introducing potential bias, while limited facility-level data restricted verification of clinical decision-making. Delays and gaps in surveillance reporting may have affected epidemiological reconstruction. As a single-case report, findings have limited generalizability but highlight important

systemic gaps relevant to similar humanitarian settings.

Conclusion

This case demonstrates how failures across clinical care, surveillance, immunization, and community engagement can converge to produce preventable mortality. Reducing diphtheria-related deaths requires not only strong clinical competence but also a well-integrated health system that ensures early diagnosis, timely access to essential treatment, responsive surveillance, and sustained immunization coverage [20].

Conflict of Interest

The authors report no conflicts of interest relevant to this work.

Ethical Considerations

This study was conducted as part of a routine public health investigation and complied with WHO guidelines for the use of routinely collected public health data. Ethical principles, including confidentiality, anonymity, and informed consent, were strictly maintained. Verbal informed consent was obtained from the parents of the deceased child for use of anonymized clinical and public health information. All personal identifiers were removed to ensure confidentiality. As the investigation involved routine public health practice rather than experimental research, formal ethical review was not required. Nevertheless, principles of privacy,

beneficence, and respect for persons were rigorously maintained throughout.

Data Availability

The data used in this case study were obtained from publicly available open-source materials and information collected through interviews with the parents of the deceased. Due to privacy and confidentiality considerations, interview data are not publicly available but may be shared by the corresponding author upon reasonable request and subject to ethical considerations.

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