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Effectiveness of infectious disease surveillance and response: Finding the missing link in cholera contact tracing - insights from Lusaka's Response Teams, Zambia

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Abstract

Cholera continues to pose a major public health challenge globally, especially across Sub-Saharan Africa and South Asia. Zambia has long grappled with recurring cholera outbreaks, which have worsened over the years. To evaluate the effectiveness of current cholera response systems, we used mixed-methods using parallel convergent design. We used a questionnaire, focus group discussions, and non-participatory observations during field visits to collect data from 32 contact tracing team members. Our results showed that team member involvement was moderately and significantly positively correlated with cases found during contact tracing ($r = 0.521$, $p = 0.002$), indicating that comprehensive contact tracing is crucial for identifying cholera cases. However, we also found potential weaknesses in the contact tracing process, including low rates of household re-visitations and limited cases (symptomatic or asymptomatic) found during contact tracing. The study's findings suggest that optimizing contact tracing protocols and improving team effectiveness could help maximize the impact of outbreak response efforts.

Keywords: Public Health Surveillance; Cholera; Contact Tracing; Response; Asymptomatic; Mixed-Methods

1. Introduction

Cholera, a disease caused by Vibrio cholerae, remains a significant public health threat worldwide, particularly in areas with inadequate access to safe water and sanitation facilities [1-3]. The disease can spread through environment-to-human transmission pathways, where contaminated water or food is ingested, or through human-to-human transmission, where infected individuals contaminate their surroundings [4-6] Understanding the transmission dynamics of cholera is crucial for developing effective disease surveillance and control measures.

The global burden of cholera is significant, with an estimated 2.9 million cases and 95,000 deaths occurring annually across 69 cholera-endemic countries [7]. Sub-Saharan Africa and South Asia are disproportionately affected, with many cities acting as transmission hotspots [8,9]. In 2021, the global average case fatality ratio (CFR) for cholera was 1.9%, rising to 2.9% in Africa, which is significantly higher than the acceptable threshold of less than 1% [3]. The recent surge in cholera cases and associated deaths globally, including in Zambia, underscores the need for enhanced surveillance and control measures.

In Zambia, cholera outbreaks have been recurring, with a significant impact on public health [10,3]. A recent study by Kateule et al., reported 13,830 cholera cases with more community deaths (62.6%) reported than facility deaths. The majority of cases (64.6%) were clustered around two constituencies of Lusaka with an overall case fatality rate of 3.7% [11]. This disproportionate distribution of cases in Lusaka in recent outbreaks highlighted the need for improved surveillance and control measures. The current cholera surveillance system in Zambia relies on clinical diagnosis based

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on case definitions, which can be non-specific and is often challenged in identifying asymptomatic carriers as noticed in previous research by Ali, et al., [7], Kapata, et al., [12] and Lessler, et al., [9]. This may lead to underestimation or overestimation of cholera burden and risk, making it challenging to allocate resources effectively.

Given the recurring nature of cholera outbreaks in Lusaka, and possible limitations in the current surveillance system, there is a pressing need for a study to re-examine the surveillance system and propose a new model that considers the context and resource situation considering that only 10-15% individuals with the bacterial present ill [13]. Based on research by Islam, et al., [14] and Rebaudet, et al., [6] understanding the positivity of V. cholerae among symptomatic and asymptomatic cases in Lusaka, may improve active case finding, laboratory testing strategies, and estimates of cholera burden and risk. This will enable better allocation of resources, including oral cholera vaccines, to areas of high need and ultimately contribute to reducing the impact of cholera on public health in Lusaka and beyond.

2. Methods and materials

2.1. Study Design

This study employed a mixed-methods approach with a convergent parallel design, where quantitative and qualitative data were collected simultaneously and analyzed separately. The design allowed for a comprehensive understanding of cholera surveillance practices among contact tracing teams in Lusaka district.

2.2. Participants

Study participants were purposively selected from contact tracing teams recognized by sub-district leadership across Lusaka district and community members identified from index cases in cholera treatment units and centers. A total of 32 participants from 6 contact tracing teams representing 6 sub-districts participated in the study.

2.3. Data Collection

Data collection involved two phases:

- *Phase 1*: "A structured, pretested questionnaire was administered electronically to team members to gather data on surveillance perceptions and practices."
- *Phase 2*: "Focus group discussions (FGDs) and non-participatory observations were conducted to contextualize team experiences and field operations.

2.4. Data Analysis

Thematic analysis was used to analyze qualitative data, following the approach described by Braun and Clarke [14]. Themes were identified, reviewed, and defined to understand participants' perceptions of cholera surveillance and factors moderating its effectiveness. Descriptive statistics (percentages and frequencies) were used to analyze quantitative data, and logistic regression models were estimated to understand factors associated with missed cases and positive perceptions. Statistical Package for the Social Sciences version 23 (SPSS v23) was used for quantitative data analysis.

3. Results

3.1. Demographic characteristics of Participants

Table 1 Demographic and Professional Characteristics of Participants

Variable	Indicator	Frequency	Percent
Gender	Male	13	41
	Female	19	59
Age	25 to 29 Years	8	25
	30 to 34 Years	8	25
	35 to 39 Years	9	28

	40 to 44 Years	3	10
	45 to 49 Years	3	10
	50 to 54 Years	1	2
Profession	Environmental Health Technologist	18	56
	Nurse	2	6
	Health Promotions Officer	2	6
	Clinician	4	13
	Lab Staff	6	19
Qualification	College Diploma	18	56
	Bachelor's Degree	12	38
	Masters	2	6

Table 1 presents the demographic and professional characteristics of the study participants (N=32). The majority of the sample was female (59%), with the most represented age group being 35-39 years (28%). Professionally, Environmental Health Technologists comprised the largest group (56%), reflecting a key focus within the study population. In terms of qualifications, a substantial portion of participants held a College Diploma (56%), followed by those with a Bachelor's Degree (38%). These characteristics provide a foundational understanding of the study's cohort, highlighting key demographic and professional distributions within the sample.

Table 2 Epidemic Response experience and team dynamics

Variable	**Indicator**	**Frequency**	**Percent**
Outbreak response Experience	1 Outbreak	6	19
	2 Outbreaks	6	19
	3 Outbreaks	8	25
	4 Outbreaks	8	25
	5 Outbreaks	4	12
Team Member Involvement	Team members active	18	56
	Members Not Active	6	19
	Members active sometimes	8	25
Perceived Team Effectiveness	Team is Effective	24	75
	Team is Not Effective	6	19
	Undecided	2	6
Households revisited after contact tracing	In the first 2 days	2	6
	After 2-4 days	4	13
	After 5 Days	4	13
	Whenever the team is in the Area	8	24
	Team Never Revisits	14	44
Contact tracing coverage around the index case	Less than 5 houses	4	13
	5-10 houses	8	25
	11-15 houses	10	31
	16-20 houses	2	6

	21-25 houses	3	9
	26-30 houses	1	3
	31 and above houses	4	13
Speed of Response	6-12 hours	13	41
	13-24 hours	9	28
	25-48 hours	8	25
	Over 48 hours	1	3
	Uncertain	1	3
Number of cases found during contact tracing	0-30%	23	72
	31-50%	4	13
	51-70%	4	13
	71-100%	1	3

Table 2 highlights key aspects of outbreak response, collaborative team effort, perceived team effectiveness, household re-visitation during contact tracing, contact tracing coverage, speed of response, and the number of cases found during contact tracing. Notably, a significant majority (75%) of respondents perceived their team as effective, and a substantial portion (56%) reported their team as comprehensive in collaborative efforts. However, a concerning 44% indicated that the team never revisits households during contact tracing, and a large percentage (72%) found a low number of cases (0-30%) during contact tracing. The speed of response was relatively efficient, with 41% responding within 6-12 hours.

Understanding dynamics, the team employed in searching for cholera symptoms based on confirmed cases from Cholera treatment centers and treatment units. We sought to document the roles of team members in the response and the following were the prominent roles played based on focus group discussion;

- To ensure all immediate contacts are traced, disinfect affected households, give health education, determine the cause of our break and ascertain preventive measures to say the least (Environment Health Staff).
- Visiting homes where cholera suspected cases are coming from, offer health education and counseling aimed at preventing further spread of the disease (Surveillance Staff).
- Sample collection, packaging and transportation (Laboratory Staff).
- Giving sensitization (Health Promotion Officer).

Based on the roles highlighted, we sought their opinion on the effectiveness of the teams particularly regarding the comprehensiveness of the carders in the teams. Consensus from discussion highlighted the themes represented in the following verbatims;

- *It's not that proactive as certain measures become dormant after the storms of an outbreak and hence revamping it to an effective efficient mitigation against any outbreak it's quite slow in calming the outbreak* (Discussant 1).
- *Response was slow and took time before we received all the resources we required* (Discussant 2).
- *Surveillance is not proactive due to lack of resources and we respond late to events* (Discussant 3).
- *When it comes to surveillance all cases reported were captured and contact tracing was done* (Discussant 4).

Team composition was of concern, therefore, we naked discussants to highlight the work other team members did in their team that would affect their effectiveness positively and negatively. The majority of the discussants observed health promotional efforts while indicating that the environmental health staff would usually step in to fill the gap. However, their input could not cover the gaps created by clinician's absence. The following are responses from the interviews regarding these aspects above;

- *Surveillance- investigation of further cases, who is affected, isolation EHT- collect water sample and food sample to confirm the cause Health promotion- Helps disseminate information on cholera for prevention and promotion. Create awareness on the outbreak, demand creation for medication/drugs CBVs- To help disinfect houses and latrines* (Discussant 13).

- *Administering medicine, Surveillance, health education, disinfection of premises, Health education, providing hygiene products, inspection of places where cases might be coming from and public places like schools, churches, bars ETC* (Discussant 22).
- *EHT - Inspection, water sampling, supervise disinfection and give health Education Surveillance fills case investigation form and collects coordinates CBV -Disinfection* (Discussant 12).

The nature of questions asked to identify cases;

- Is there anyone here presenting with Cholera symptoms, how many people are exposed, what could have the sauce of infection, how do people handle garbage in the area, how do people treat foods and water before consuming them, when do they have to report the case to the hospital? (KI 1).
- Names of the patient, age, location, landmark, water source, are there any family members with rice water like diarrhea frequently going to the toilet more than 3 times? (KI 2).
- Is there anyone else suffering from Cholera, what food they ate and where, how many people share the same sanitary facilities, source of water? (KI 3).
- If there has been any vomiting or diarrhea from any family members (KI 4).

Based on these questions, we noted the need for clinicians that could screen contacts for a more informed perception of the contacts condition. We further sought any additional questions the teams asked households just to gain clarity on cases and the following were the prominent revelations;

- Does any family member show signs and symptoms of cholera? (KI 11).
- Where do you draw water from? Who else frequents your household (KI 12).
- What do you know about cholera? (KI 13).
- The places the patient has been before manifesting symptoms, the age etc. (KI 14).
- Any visitors who got sick in order to trace them well or If they had anyone who visited the household (KI 15).

These findings suggest strengths in team effectiveness and comprehensiveness, which are crucial for effective outbreak management. However, the low rate of household re-visitations and the limited number of cases found during contact tracing point to potential weaknesses in the contact tracing process itself. This could imply a need for improved protocols or training in follow-up procedures and case identification during contact tracing to maximize its impact. The relatively fast response time is a positive aspect that should be maintained and leveraged in future outbreak responses.

Further responses on identification of asymptomatic cases from discussants.

- Stool culture more especially for exposed people, testing the waters and foods they mostly eat (KI 16).
- Through laboratory testing (KI 17).
- Laboratory confirmation of stool (KI 18).
- The specimen remains the gold standard for the laboratory diagnosis of cholera (KI 19).
- The specimen remains the gold standard for the laboratory diagnosis of cholera (KI 20).

3.2. Linear Regression Analysis

To assess the collective impact of contact tracing activities on the daily percentage of cholera cases identified, a one-way Analysis of Variance (ANOVA) was conducted which revealed a statistically significant effect of the contact tracing predictors on the average daily percentage of cholera cases found, $F(5, 26) = 3.361$, $p = 0.018$. The model accounted for a significant portion of the variance in the dependent variable (Sum of Squares Regression = 8.625)."

Table 3 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.625	5	1.725	3.361	0.018[b]
	Residual	13.344	26	0.513		
	Total	21.969	31			

a. Dependent Variable: Number of cases found

b. Predictors: (Constant), Coverage around index case, interval between revisits, perceived team effectiveness, team member involvement, role played in the contact tracing team.

This significant finding indicates that the combined factors related to contact tracing efforts, including the number of households visited, revisit frequency, perceived team effectiveness, and team member involvement, are influential in determining the success of identifying cholera cases during outbreaks. Further investigation into the individual contributions of each predictor would provide more granular insights. We sought to establish the direction and strength of relationship between independent and the dependent variable as outlined in table 4.

Table 4 Pearson's correlation between variables

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
1. Team member involvement	1						
2. Perceived Team effectiveness	-0.119	1					
3. Revisits	0.171	-0.034	1				
4. Interval between Revisits	0.109	0.011	0.450**	1			
5. Coverage around Index Case	-0.133	-0.159	0.279	-0.022	1		
6. Response speed	-0.036	0.312	0.365*	0.287	0.132	1	
7. Cases found	0.521**	0.085	-0.149	0.204	0.100	-0.220	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

Table 4 shows a significant positive correlation between "Team member involvement" and "Cases found" ($r = 0.521$, $p = 0.002$). This finding suggests that full contact tracing team member involvement leads to the identification of more positive cases. This is expected, as a more thorough contact tracing team by composition would naturally uncover a larger number of infected individuals if they exist. Further, a moderately significant positive relationship exists at the 0.05 level between contact tracing revisits and Response Speed ($r = 0.365$, $p = 0.040$), suggesting that more revisits are associated with faster response speed.

There is a negative correlation between "Cases found" and "Response speed" ($r = -0.220$, $p = 0.227$). This negative correlation implies that a faster response speed is associated with a lower number of cases found. This could suggest that early and swift intervention in an outbreak leads to poor containment and fewer detected positive cases, highlighting the importance of understanding the incubation period if the detection is based on symptoms. However, this relationship was not significant leading to rejection of the assertion that swift contact tracing led to missing cases.

Further, table 4 shows a significant negative correlation is present between "Revisits" and "Interval between Revisits" ($r = -0.450$, $p = 0.010$). This indicates that a higher number of revisits is associated with shorter intervals between those revisits. This could reflect a strategy where more frequent revisits are conducted when closer monitoring or follow-up is deemed necessary, leading to shorter time gaps between visits.

4. Discussion

This study underscores the multifaceted challenges of responding to cholera outbreaks in resource-limited settings like Lusaka, Zambia. While 75% of contact tracing team members perceived their teams as effective, and 56% described strong collaboration, significant weaknesses were identified—including low household revisit rates and limited case detection during tracing efforts.

These findings echo global observations. Effective team dynamics are consistently highlighted as critical in managing cholera epidemics [16,17], a well-coordinated team response is critical in managing cholera epidemics. Our study's findings on team effectiveness and comprehensiveness are consistent with this assertion, highlighting the need for continued investment in team building and collaboration [11,17]. Our data reinforce the importance of multidisciplinary collaboration, aligned with Haiti's success using case-area targeted rapid response strategies [6].

However, operational gaps persist. The 44% of teams that reported never revisiting households and the 72% that found less than 30% of cases suggest lapses in surveillance rigor. This aligns with concerns raised in Malawi, Nigeria and Latin

America about underestimation of cholera burden due to fragile contact tracing mechanisms [18-20]. Notably, the emergence of autochthonous cases in Brazil after nearly two decades underscores the need for proactive surveillance strategies [21].

On the other hand, some studies have reported successful contact tracing efforts in cholera outbreaks. A study in the Democratic Republic of Congo found that a case-area targeted intervention was effective in reducing cholera cases, with contact tracing playing a critical role in identifying and treating cases [17]. Similarly, a study in Zambia found that a multisectoral approach to cholera control was effective in reducing cases, with contact tracing and surveillance being key components of the response [11].

The study's findings on the importance of team member involvement in contact tracing are also noteworthy. The significant positive correlation between team member involvement and cases found ($r = 0.521$, $p = 0.002$) suggests that a more comprehensive team approach can lead to better case detection. This is consistent with previous research, which has emphasized the importance of multidisciplinary teams in outbreak response [19,17,12]. For example, a study in Haiti found that a multidisciplinary team approach was effective in controlling cholera, with community health workers playing a critical role in identifying and treating cases [2].

The negative correlation between response speed and cases found ($r = -0.220$, $p = 0.227$) suggests that early and swift intervention may not always lead to better case detection as observed by Ratnayake et al., [22]. This finding is consistent with previous studies, which have highlighted the importance of understanding the incubation period of cholera in designing effective outbreak response strategies [5,23]. However, other studies have found that rapid response and timely intervention are critical in controlling cholera outbreaks [24-26]. Beyond operational measures, innovations such as event-based surveillance [27] and integrated multi-sectoral systems [28] are emerging as vital tools for outbreak preparedness.

5. Conclusion

This study illustrates both the strengths and the fragilities of cholera outbreak response systems in Lusaka. Strong team dynamics were evident, but inconsistent contact tracing execution limited overall effectiveness. Strengthening protocols for household follow-up, boosting inter-disciplinary training, and adapting interventions to cholera's epidemiology—especially its asymptomatic carriers—are essential next steps. Further research should investigate digital tools for active surveillance, cost-effective rapid diagnostic solutions, and scalable models for urban cholera control. With these improvements, outbreak response in resource-constrained settings can become more anticipatory, targeted, and resilient.

Compliance with ethical standards

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Author Contributions

MC drafted the manuscript and coordinated reviews with MK, who contributed to the research design and conceptual framework. Both authors participated in data collection and analysis. The final manuscript was approved by all authors, who take responsibility for the study's findings and outcomes.

Disclosure of Conflicts of Interest

The authors declare no conflicts of interest.

Statement of ethical approval

This study was conducted in accordance with relevant guidelines and regulations. Given the urgent nature of the cholera outbreak and the retrospective analysis of existing data, a waiver was applied as per ministry of health protocol in epidemic settings.

Statement of informed consent

It was observed and all identifiable information was anonymized to protect participant confidentiality ensuring compliance with ethical standards for research during public health emergencies.

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Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to the sensitive nature of the data and participant confidentiality concerns but are available from the corresponding author on reasonable request.

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Author's short Biography

Mulungu Choongo, a Public Health Expert with a strong background in Environmental Health and Research, has contributed to numerous publications in esteemed journals focusing on addressing pressing health challenges. As a researcher and educator, his work is driven by a passion for advancing knowledge and improving health outcomes, particularly in the context of Emerging Infectious Diseases and global health security.

	**Kapungwe Macmillan** is an Environmental Health expert with a proven record in cholera research in Zambia. He also possesses strong experience in epidemic preparedness and response in the context of Cholera, COVID-19 and other Emerging Infectious Diseases.