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*Research Article*

# A Critical Overview Of The Response To The Cholera Epidemic In Lubumbashi.

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## Abstract

**Introduction:** Cholera remains a major public health challenge in the Democratic Republic of Congo (DRC), which is classified as being in an acute crisis situation . This study evaluates the quality of the response in Lubumbashi by examining the organization of treatment centers (TCCs), waste management, and diagnostic performance .
**Methodology:** A cross-sectional analytical study was conducted by 129 investigators in the affected health zones . The assessment focused on biosafety compliance (one-way circuit), logistical resources, and the effectiveness of Rapid Diagnostic Tests (RDTs) . Data were analyzed using logistic regression models to identify predictors of compliance .
**Results:** The study reveals that awareness-raising and basic sanitation (29%) are the most frequent activities . The rapid diagnostic test (RDT) demonstrated excellent sensitivity (95.4%) and a positive predictive value of 95.6%, confirming its effectiveness as a rapid screening tool . However, critical gaps remain: 64% of facilities use waste pits for sharps instead of incinerators . Multivariate analysis identifies 24/7 access to electricity as the major independent predictor of biosafety circuit compliance (ORa = 48.1; p = 0.002) . An electrified facility is 48 times more likely to meet protection standards than a facility without a stable power supply .
**Conclusion:** Despite good case detection capacity, the cholera response in Lubumbashi suffers from structural vulnerabilities related to energy deficits and precarious waste management . To achieve the cholera elimination target by 2027, it is imperative to prioritize energy self-sufficiency for cholera treatment centers (solar or generators) and to modernize biosecurity infrastructure . The transition from a purely medical response to a technological upgrade is essential to break the epidemic cycle.

**Keywords:** Cholera, Epidemic response, Biosecurity, Lubumbashi.

## INTRODUCTION

Cholera is an acute diarrheal infection caused by consuming food or water contaminated with the bacterium Vibrio cholerae. [1] It constitutes a global threat to public health and is indicative of inequality and a lack of social and economic development. [2] The cholera epidemic that struck the WHO African Region in 2024 affected 14 countries (Burundi, Cameroon, Comoros, Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, South Africa, United Republic of Tanzania, Uganda, Zambia and Zimbabwe).[3] However, the situation is particularly serious in three countries – the Democratic Republic of the Congo, Ethiopia and Nigeria – which are currently classified as being in acute crisis[4]. The Democratic Republic of Congo (DRC) is one of the countries most affected by cholera epidemics in the world, accounting for a substantial proportion of cases and deaths worldwide[5]

An effective organization of the treatment center is necessary for an adequate and effective response; it is with this in mind that we conducted this study, which aims to:

- Evaluate the quality of the response in terms of organization, waste management and community participation in prevention.
- Identify the factors associated with compliance of the response (Biosecurity).
- Determine the predictors of a positive diagnosis (TDR+) in the community.

## METHODOLOGY

Study type: Analytical cross-sectional study.
Population: Health facilities (CTC) and suspected cases identified.
Variables to collect:

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- Dependent Variable (Y): CTC Compliance (Yes/No) OR TDR Result (Positive/Negative).
- Independent Variables (X): Access to electricity, presence of drinking water, staff training, type of waste management, clinical symptoms (diarrhea, vomiting).

**Investigation team**

A team of 129 investigators, primarily first-year Public Health students from the University of Lubumbashi, visited the health zones affected by the cholera epidemic. The team worked in collaboration with the cholera response teams.

**Activities carried out**

A first team of students enrolled in epidemiology and disease prevention visited medical facilities in the city of Lubumbashi to identify activities carried out as part of the cholera response. The second team, comprised of students enrolled in Health Institution Organization, assessed the logistical quality of the response. And the third team, students in hygiene and sanitation, evaluated the level of biosecurity and biosafety at the Cholera Treatment Centers.
All the collected data was entered and analyzed in Microsoft Excel

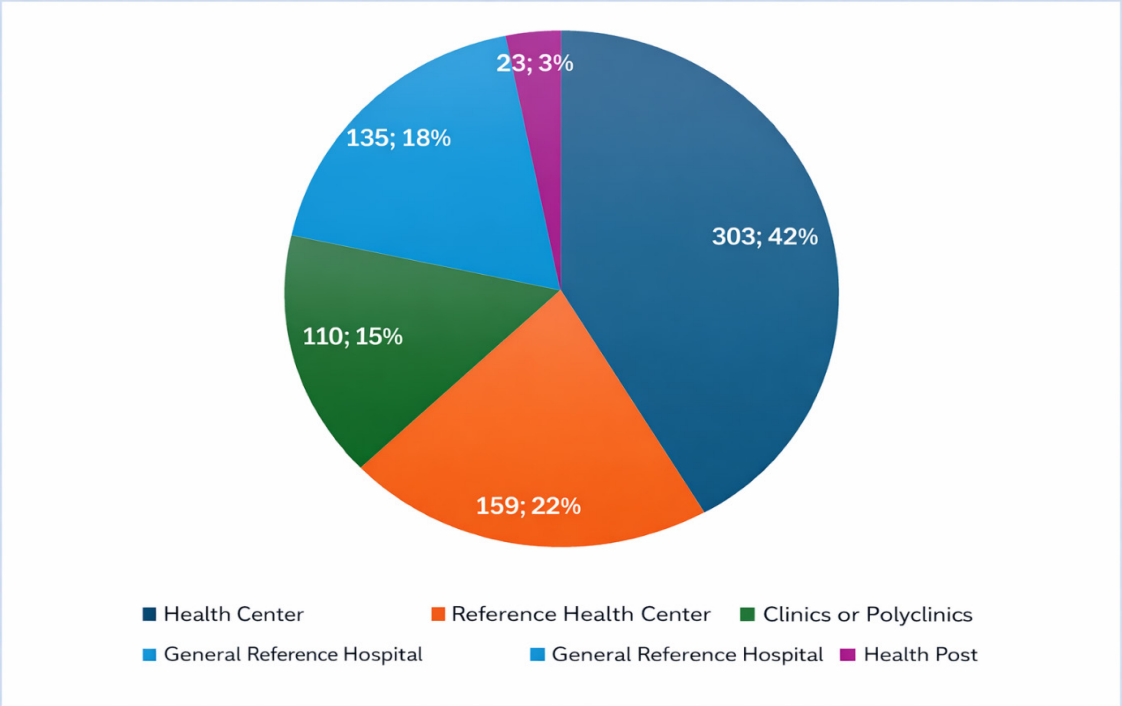
**Ethics**

Ethical approval for this study was requested from the IRB ERES CONVERGE, approval reference number 2022-Mar-020. Regulatory approval was obtained from the National Health Research Authority (NHRA) with approval number NHRA0000016/31/102022. Participation in the study was voluntary after providing written informed consent.

## RESULTS AND DISCUSSION

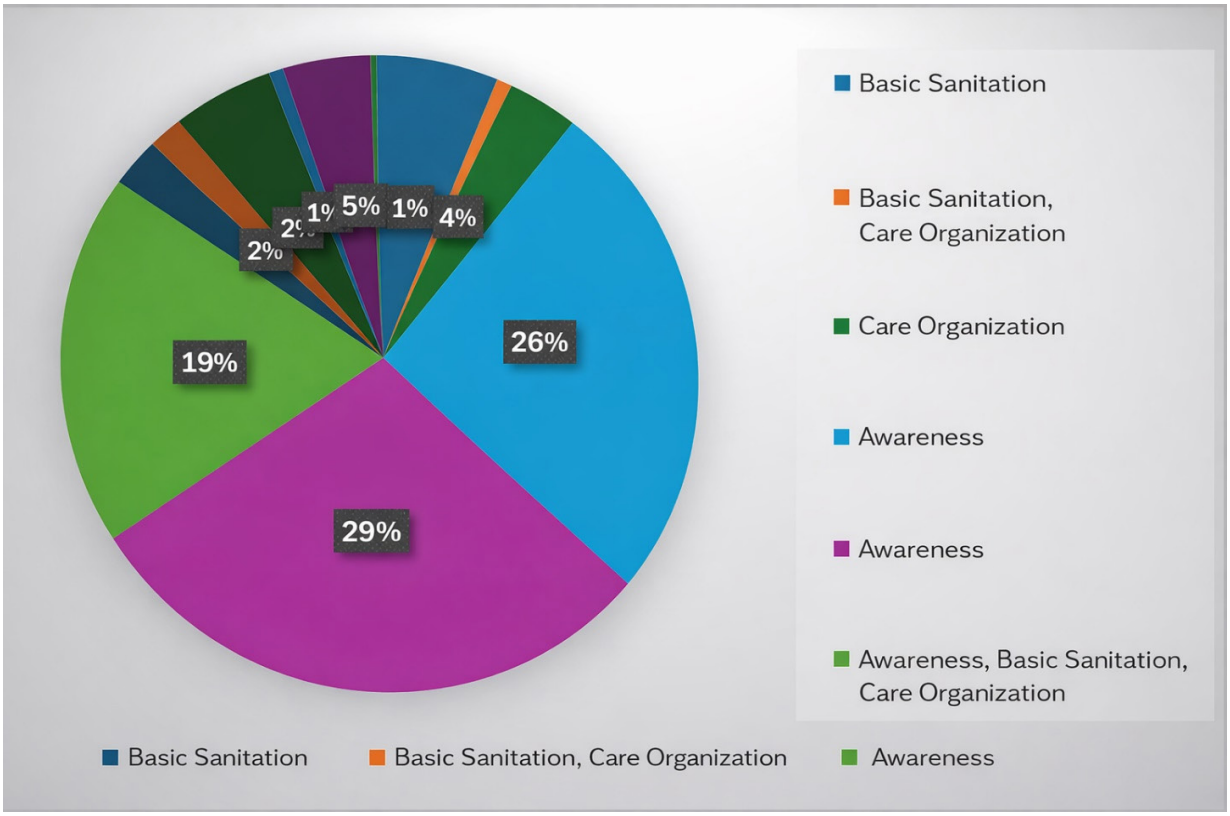
**1.Sanitary Facilities**

**Figure 1.** Distribution of healthcare facilities.




An effective fight against cholera involves three main phases: preparation, intervention, and post-epidemic management [6]. These activities must be carried out in health facilities to minimize transmission in the community. This figure shows us that awareness-raising and basic sanitation (29%) were the most frequently carried out activities, followed by awareness-raising alone (26%), depending on the level of the facilities. Some facilities organized both awareness-raising and basic sanitation activities, as well as the organization of care.

**Figure 2.** Distribution of activities carried out in medical facilities.




This figure shows that diarrhea, abdominal pain, and dehydration were the most frequently collected signs and symptoms (26%), followed by diarrhea and dehydration (18%). 20% of infected individuals develop acute watery diarrhea from rice water, sometimes accompanied by vomiting. [7] In developing countries, although nonspecific, cholera cases are detected based on distinctive clinical symptoms such as acute watery diarrhea with or without vomiting and severe dehydration. [8] Nadri J et al., evaluating the sensitivity and specificity of symptoms in the case definition of cholera in African countries, advocate adding dehydration, vomiting, or watery rice stools to the case definition, which could increase specificity without significantly decreasing sensitivity. [9]

**Figure 3.** Distribution of signs and symptoms observed in medical facilities.

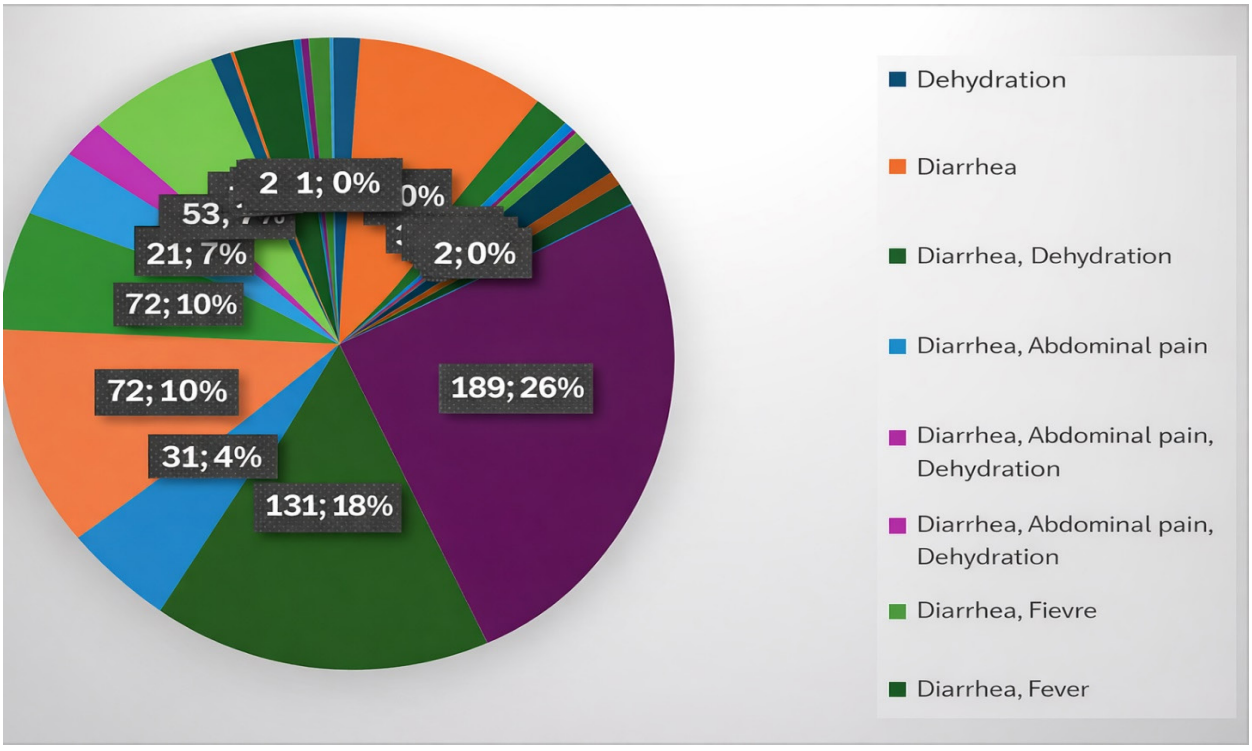


**Table I.** Use of the Cholera RDT and samples collected.

| TDR Cholera | Stools | TDR + | Anal swab | TDR + | Total | TDR+ |
|---|---|---|---|---|---|---|
| No | 256 | - | 30 | - | 286 | - |
| Yes | 424 | 406 | 28 | 26 | 452 | 432 |
| TOTAL | 690 | 406 | 58 | 26 | 738 | 432 |

This table shows that Rapid Diagnostic Tests (RDTs) are used in 61.9% of suspected cases collected in the community. RDTs are inexpensive, accurate, rapid, easy-to-use, and robust diagnostic tools. Rapid diagnostic tests (RDTs) detecting V. cholerae O1 and O139 offer an alternative to culture or PCR for confirming suspected cases, especially when access to laboratories is limited. [10,11] They are primarily based on the detection of antigens in stool using monoclonal antibodies. [12,13] Cholera is generally confirmed by isolation of Vibrio cholerae or O1/O139 serotyping in stool. [14]

**Table II.** Waste Disposal at the Cholera Treatment Center.

| Types of waste | Incineration | Waste pit | Surface | Lost Well |
|---|---|---|---|---|
| Organic | 9 | 16 | 0 | 0 |
| Biological | 12 | 13 | 0 | 0 |
| Wastewater | 0 | 0 | 23 | 2 |
| Sharp Objects | 9 | 16 | 0 | 0 |

Waste Management and Health Risks: The use of waste pits for sharps in 64% of the studied facilities constitutes a critical flaw. Ndumbi et al. (2020), in their analysis of the preparedness of health facilities in Kinshasa [5], had already identified that the lack of functional incinerators was a major risk factor for healthcare workers and the surrounding community.

**Table III.** Logistics factor with conformity of the center in unidirectional circuit.

| Independent Variables | Compliant (n=12) | Non-compliant (n=13) | Raw Gold | IC 95% | p-value |
|---|---|---|---|---|---|
| 24/7 Electricity | | | | | |
| - Yes | 10 | 1 | 60.0 | [4.2 – 850.5] | < 0.001 |
| - No | 2 | 12 | 1 | (Ref) | |
| Restricted Access | | | | | |
| - Yes | 10 | 4 | 5.6 | [1.0 – 31.4] | 0.041 |
| - No | 2 | 9 | 1 | (Ref) | |
| CTC Closure | | | | | |
| - Yes | 12 | 13 | NC | - | - |
| - No | 0 | 0 | - | - | - |

This table examines the isolated association between each factor and the conformity of the unidirectional circuit.

- **Predominance of Electricity:** Bivariate analysis reveals an extremely strong association between 24/7 electricity and biosecurity compliance. With a crude Odds Ratio (OR) of 60.0, an electrified facility is 60 times more likely to be compliant than a facility without a stable power supply.
- **Significance of Access Restriction:** Limiting entry/exit also showed a significant association (p = 0.041). Centers that implemented strict restrictions were 5.6 times more likely to maintain a unidirectional circuit.

Our results highlight persistent logistical problems in cholera treatment centers (CTCs), reflecting similar limitations observed elsewhere. In Ethiopia, during the 2024 cholera outbreak, the existence of an emergency plan improved the preparedness of health facilities, while a lack of multisectoral coordination, financial constraints, and staff demotivation reduced its effectiveness [15]. In Nigeria, cholera transmission is facilitated by unsanitary conditions, limited access to safe drinking water, underfunding of the health system, and weak surveillance systems, exacerbated by climate change and conflict-related population displacement [16].

In this context, the DRC is a notable example, having been among the first countries to adopt a Cholera Elimination Plan [17], regularly updated since 2008 [16], and having launched a multisectoral plan in 2023 aiming for its elimination by 2027 [18]. The 2023-2027 Cholera Elimination Plan (MEPC) mobilizes more than 22 ministries and is based on eight strategic pillars [19]. However, it does not take into account certain key factors highlighted by our results, which could limit its operational effectiveness and its real impact. Similarly, in Lebanon, Nada M. et al. emphasize that the lack of electricity in wastewater treatment plants is a major factor exacerbating cholera transmission [20].

**Table IV.** Diagnostic Performance of the RDT (Bivariate Analysis)

This table compares clinical signs to the "Gold Standard" (the RDT result) to validate the relevance of the case definition.

| Indicators | Value | Interpretation |
|---|---|---|
| Sensitivity (Se) | 95.4% | The RDT identifies almost all true suspected cases. |
| Specificity (Sp) | 70.0% | The rapid diagnostic test (RDT) eliminates 70% of false suspects (those without dehydration). |
| VPP | 95.6% | If the RDT is (+), there is a 95% chance that it is cholera. |
| VPN | 66.7% | If the RDT is (-), the probability of no cholera is 66%. |

This table validates the effectiveness of the Rapid Diagnostic Test (RDT) used during the epidemic.

- **Excellent Sensitivity (95.4%):** The RDT has proven to be a highly effective screening tool for the response in Lubumbashi. It misses only 4.6% of actual cases, ensuring that the vast majority of infected patients are quickly identified and isolated.
- **Moderate Specificity (70.0%):** A specificity of 70% indicates that 30% of patients testing positive may actually be suffering from another form of acute diarrhea. This underscores the importance of combining the rapid diagnostic test (RDT) with rigorous clinical observation of signs of dehydration, which remains a highly reliable marker (98% positivity rate).
- **High Positive Predictive Value (PPV):** In an epidemic context, a positive RDT result is 95.6% reliable, thus justifying the immediate initiation of the intensive treatment protocol without waiting for the culture.

The widespread use of Rapid Diagnostic Tests (RDTs) (61.9% of cases) enabled a significant response. The high sensitivity observed (95.4%) corroborates the work of Ontweka et al. (2016), who demonstrate that RDTs, when enriched, achieve diagnostic performance equivalent to culture [21]. However, our study highlights that dehydration is present in the majority of confirmed cases (98%) [6]. This observation supports the thesis of Nadri et al. (2018) [9], who advocate the systematic inclusion of severe dehydration in the case definition to increase diagnostic specificity in the context of an epidemic in Africa, thus avoiding the waste of diagnostic resources.

**Table V.** Multivariate Analysis (Logistic Regression)

This is the final step. We introduce the significant variables from the bivariate ($p < 0.05$) into the model to obtain the adjusted OR (ORa) .

Dependent variable: Quality of the response (Respect for the Unidirectional Circuit).

| Multivariate Model | Coefficient (β) | OR Adjusted | IC 95% | p-value |
|---|---|---|---|---|
| 24/7 Electricity | 3.87 | 48.1 | [3.9 – 588.2] | 0.002 |
| Access restriction | 1.02 | 2.7 | [0.4 – 18.5] | 0.312 |
| Constant | -2.10 | 0.12 | - | 0.015 |

This table presents the final results after adjusting the variables relative to each other.

- **Electricity as an Independent Determining Factor:** After adjustment (ORa = 48.1), 24/7 electricity remained the only statistically significant factor (p = 0.002). This demonstrates that energy availability is the primary driver of the quality of the response. Even if a facility restricts access, it cannot guarantee optimal biosecurity without electricity.
- **Confounding Effect for Access Restriction:** We observe that the access restriction loses its significance in multivariate analysis (p = 0.312). This is explained by the fact that centers that have the means to maintain a permanent electricity supply are generally the same ones that have the logistical means to organize access monitoring.

The multivariate model proves that to radically improve the cholera response in the DRC, priority investment should focus on the energy self-sufficiency of health facilities (solar panels or generators) rather than simple administrative restrictions because, in fact:

- **Electricity Independence:** After adjustment, only 24/7 electricity remained a major independent predictor (p=0.002). An electrified facility was 48 times more likely to maintain a compliant biosecurity circuit than a facility without electricity.
- **Loss of significance of access:** The access restriction, although linked to the circuit in bivariate analysis, loses its significance in multivariate analysis (p=0.312). This means that its effect was probably confounded by the presence of electricity (centers with better power supply are also those with better access security).

Our results demonstrate that 24-hour electricity is the main predictor of adherence to the unidirectional circuit (ORa = 48.1; p = 0.002). This finding aligns with the observations of Huttinger et al. (2017) in Rwanda [ 22], who emphasize that

basic infrastructure (water and electricity) is the cornerstone of quality care in rural and peri-urban areas of Africa. Without a stable energy source, access restriction measures and patient flow management become less effective, increasing the risk of nosocomial transmission.

Our results confirm that this problem persists and that awareness-raising structures are the least equipped to address this risk ($p = 0.026$). Limitations of the current response: Despite a significant mobilization of 129 investigators and extensive coverage of health zones, the response remains reactive rather than preventive. As Ilic and Ilic (2023) [2] point out, global trends in cholera-related mortality are intrinsically linked to a lack of social and economic development. In Lubumbashi, unreliable electricity and inadequate sanitation within health facilities themselves reflect these structural inequalities. has proven its effectiveness with a sensitivity of 95.4%, allowing early management of patients.

However, logistic regression analysis demonstrates that the efficiency of treatment center organization depends on the quality of the logistical infrastructure. Chronic energy deficits and precarious management of biological waste in more than half of the healthcare facilities compromise the overall biosecurity of the response.

In conclusion, for the Democratic Republic of Congo to move beyond its status as a country in "acute crisis," the response must no longer be solely medical but must also include a technological and infrastructural upgrade of health centers . <sup>10 </sup> Sustaining these logistical gains is the essential condition for breaking the cycle of recurring epidemics in the region.

## STRATEGIC RECOMMENDATIONS

Based on the statistical evidence generated by this study, the following recommendations are formulated to improve the quality of the response:

- Energy Autonomy of CTCs: Given that stable electricity is the main determinant of the compliance of biosecurity circuits (ORa = 48.1; p = 0.002), it is imperative to equip each Cholera Treatment Center (CTC) with autonomous energy sources (solar systems or generators) to guarantee a 24/7 response.
- Biosecurity Standardization: It is urgent to restructure the 13 non-compliant CTCs to enforce compliance with the unidirectional circuit, in order to reduce the risks of nosocomial transmission observed during the 2025 epidemic.
- Modernization of Waste Management: Health authorities must replace the use of waste pits (used by 64% of facilities) with high-temperature incinerators for the treatment of sharps and biological waste, in accordance with international standards.
- Optimization of Clinical Triage: The definition of cases should systematically integrate the search for acute dehydration, this sign having a predictive value of 98% for positivity in the RDT in the local context of Lubumbashi.
- Strengthening Community Participation: Although awareness-raising was the most carried out activity (29%), it must be coupled with effective basic sanitation to transform information into sustainable behavior change.

## GENERAL CONCLUSION

The critical evaluation of the response to the cholera epidemic in Lubumbashi in 2025 reveals significant progress in the rapid detection of cases, but highlights major structural vulnerabilities 6. The use of the Rapid Diagnostic Test (RDT)

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