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RIPOSTE

Cameroon Red Cross Cholera Early Action Protocol

Development details

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En partenariat avec

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Introduction

Cholera: a global burden

Cholera continues to disproportionately affect the poorest and most vulnerable communities in high-risk countries. It is an acute diarrhoeal infection transmitted by ingestion of food and water contaminated with the causative agent, *vibrio cholerae* (WHO, n.d.). The incidence of cholera is exacerbated by rapid and unplanned population growth, climate change, extreme weather events and complex contexts, particularly in conflict zones where health and sanitation services are limited. The true burden of cholera is under-reported, but it is estimated that there are 1.3 to 4 million cases of cholera per year worldwide, including 21,000 to 143,000 deaths.

Cholera has been a recurrent epidemic in Cameroon since its first incidence reports in 1971 (Ngwa, et al., 2016a). The burden of cholera increased during the rainy season between 2000 and 2012 (Ngwa, et al., 2016b). Since 2018, cholera infections have been frequently reported in the South West, Central and Littoral regions of the country. Although the cholera mortality rate has decreased over the years, the burden of cholera persists in Cameroon. A cholera epidemic began in October 2021 and has become the most devastating in recent decades (Figure 1a and 1b). It was probably caused by a lack of drinking water in the affected communities, resulting in 6,652 suspected cases and 132 deaths by April 2022 (Aurore, 2022). Unfortunately, these figures are likely to have increased, as between August and October 2022, more than 314,000 people in Cameroon were affected by massive flooding, which exacerbated the epidemic (OCHA, 2023).

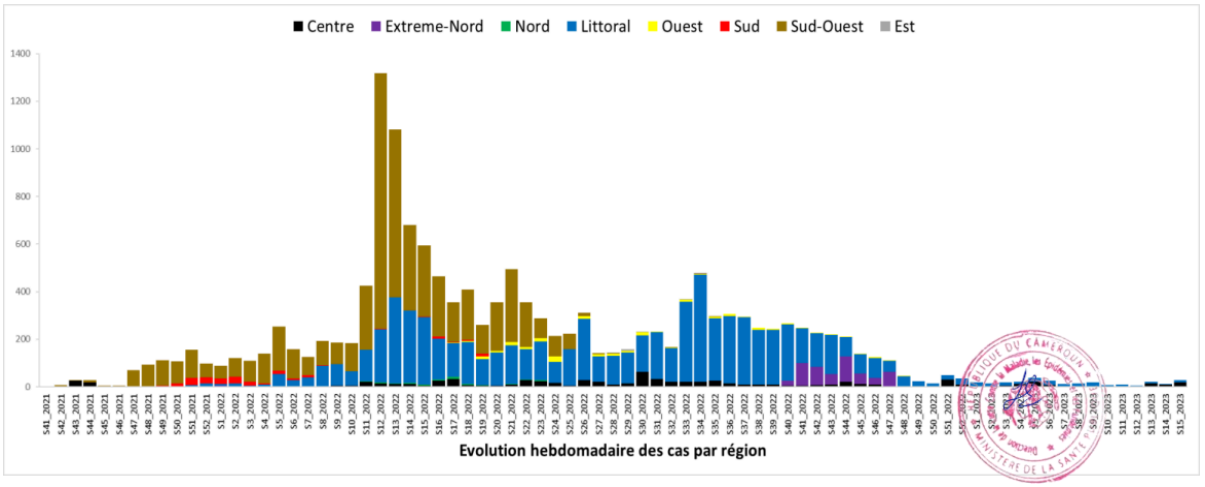


Figure 1a: Weekly change in cholera cases by region from 11 Oct 2021 to 14 April 2023, Cameroon Ministry of Health.

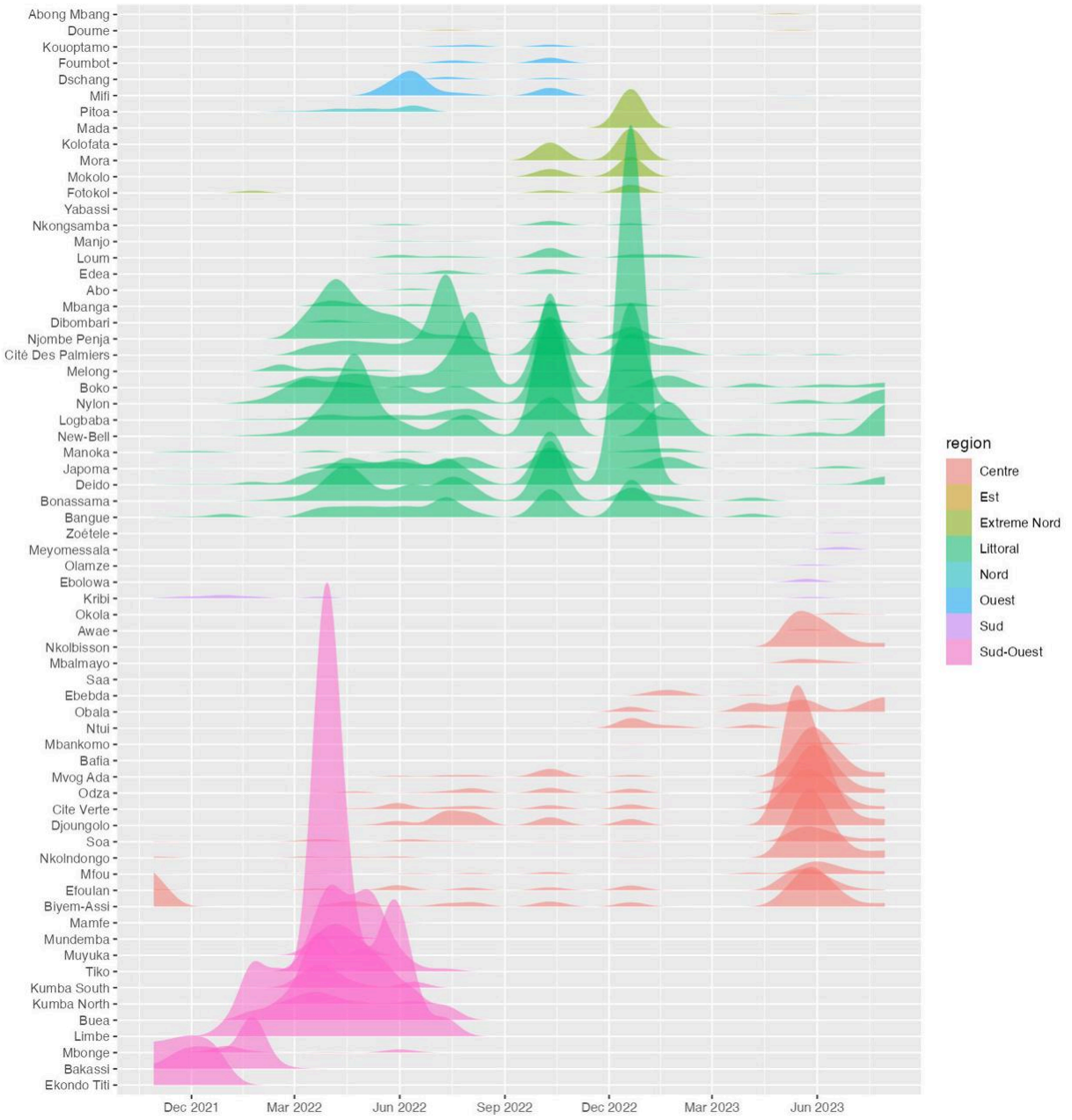


Figure 1b: Trends in cholera cases by district from October 2021 to July 2023 (based on Ministry of Health SitReps data). Prepared by the Ecole des Hautes Etudes en Santé Publique.

The incidence of cholera is closely linked to the physical and social environment. The natural habitat of *vibrio cholerae* is an aquatic environment (Colwell, 1996). Consequently, environmental factors such as heavy rainfall and flooding can cause contaminated water sources to mix with water sources intended for domestic use (Jutla, et al., 2013). This means that populations most at risk of cholera infection live close to water bodies and lack access to improved water, sanitation and hygiene (WASH) infrastructure (Idoga, Toucan, & Zayyad, 2019).

Objectives of the report

The report has many chapters, but there are three distinct themes in this report, namely: the response capacities of the Health System and the Cameroon Red Cross; Cholera Risk Analysis

in Cameroon; and Lessons Learned from the development of an Early Action Protocol (EAP) for epidemics.

Response capacity of the health system and the Cameroon Red Cross

This section aims to assess and highlight the current capacity of the Cameroon health system and the Cameroon Red Cross (CRC) to respond effectively to cholera epidemics. With a particular focus on anticipatory actions, the aim is to examine how these actors are able to prevent, rapidly detect and respond in a coordinated and effective manner to cholera-related health crises.

The main objective is to identify the structural, organisational and operational strengths and weaknesses of the health system and the CRC, while proposing strategic recommendations to strengthen their resilience in the face of this recurring threat. The report is based on an in-depth analysis of early warning mechanisms, information flows and collaborative practices between stakeholders, to ensure proactive and effective management of epidemic risks, particularly cholera.

This report draws heavily on the research work carried out by Danielle Rachman as part of her master's thesis at 510, the data and digital team of the Netherlands Red Cross. This thesis forms a solid basis for this in-depth analysis.

By integrating perspectives based on empirical data and relevant theoretical frameworks, this report aims to provide a pragmatic roadmap for the continuous improvement of response capacities by anticipating cholera epidemics in Cameroon.

Cholera risk analysis in Cameroon

This section presents an in-depth analysis of cholera-related risks, highlighting particularly vulnerable areas based on climatic factors and hygiene conditions. The aim is to inform the development of an appropriate Early Action Protocol (EAP), enabling the effective anticipation of resource and intervention needs in districts identified as high risk. Based on robust data and rigorous methodology, this report draws on the research work of John Ifejube (Ifejube, et al., 2023), carried out as part of his internship with 510, the data and digital team of the Netherlands Red Cross, and aims to provide a robust risk analytical framework to support an EAP.

Lessons learned from the development of an Early Action Protocol (EAP) for epidemics

This section explores the steps required to develop an Early Action Protocol (EAP) for an outbreak of a certain disease, based on the principles of Forecast-based Financing (FbF) and available resources, including the official Forecast-based Financing manual and the working document on the implementation of anticipatory actions, in a conceptual framework for the International Red Cross and Red Crescent Movement. It also highlights the key lessons learned from the experience of the Red Cross movement's first comprehensive EAP for an epidemic, developed for cholera in Cameroon.

EVALUATION OF THE CAPACITIES OF THE CAMEROONIAN HEALTH SYSTEM

Surveillance and coordination systems

The health surveillance system in Cameroon is based on distinct protocols depending on whether an epidemic is in progress or not, highlighting an adaptive but complex approach. One of the major challenges identified is the communication gap between state and non-state organisations, which hinders effective collaboration. However, regular information sharing practices have been shown to strengthen relationships and resolve issues quickly. Diagram 1 illustrates the flow of information within the state pillar during a confirmed cholera outbreak.

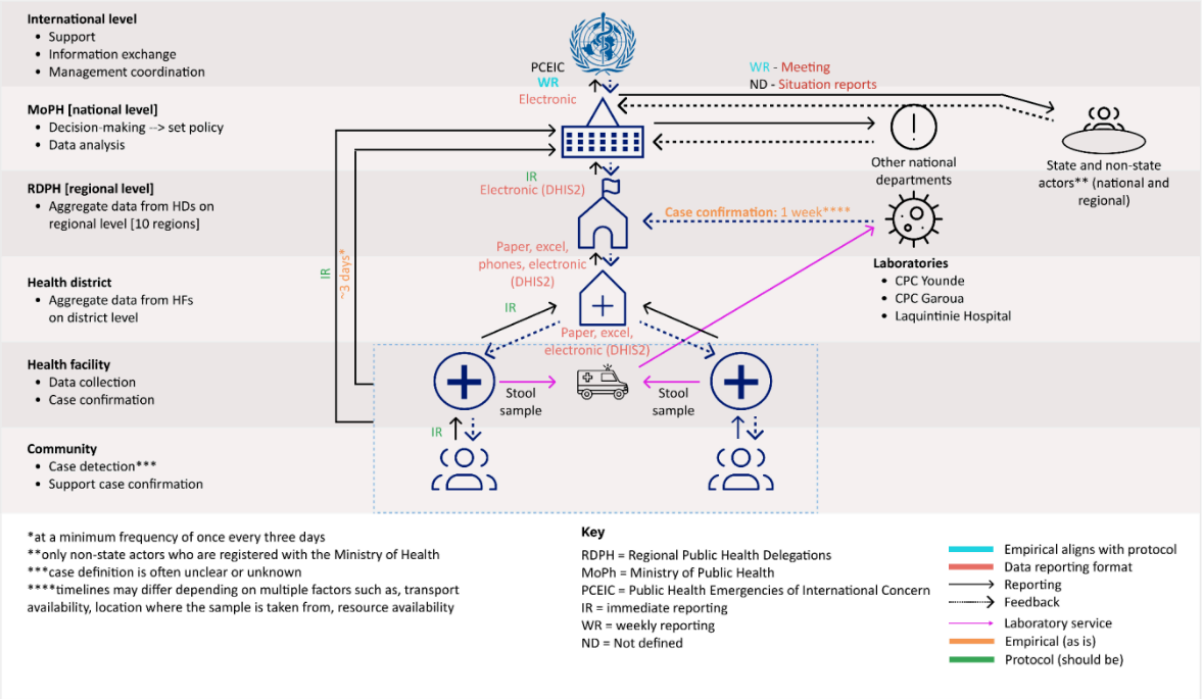


Diagram 1: Information flow within the state pillar in the event of a confirmed cholera epidemic (Danielle Rachman)

The frequency with which information is shared varies considerably depending on the type of response, the region concerned and the level of urgency. For example, in the event of an outbreak, both state and non-state actors agree that daily reports are essential to quickly adjust responses. One state informant pointed out that although the Ministry of Health (MoH) expects to receive daily updates from communities and health facilities, capacity, training and internet access constraints often limit the minimum frequency to once every three days.

On the non-state actor side, a regional informant expressed the importance of a mechanism for immediate data sharing in the event of an emergency. Non-state actors also insisted on the need to have scheduled briefings while providing mechanisms for immediate reporting of

urgent cases. However, informants did not formally identify a sustainable mechanism for sharing data as frequently as daily.

MinSan organises weekly meetings involving state and non-state actors to exchange data and coordinate efforts. Although these meetings are essential for rapid decision-making, they suffer from a lack of participation by certain players, which limits their effectiveness. For example, the Cameroon Red Cross sends its cholera focal point to this meeting, but if he is away, no one is sent to take part in his place.

In conclusion, although the current surveillance system has fundamental elements for responding to health emergencies, it is crucial to strengthen communication and coordination mechanisms, ensure wider stakeholder participation and develop digital tools for more regular and automated information sharing. This could transform the management of cholera epidemics and ensure a more rapid and coordinated response to outbreaks.

EVALUATION OF THE CAPACITIES OF THE CAMEROONIAN RED CROSS

This section has been compiled from a large amount of data collected by the Canadian Red Cross in relation to the CRC's contingency plan for diarrhoeal disease and cholera epidemics in Cameroon.

Role of the National Society and intervention mandate

The Cameroon Red Cross (CRC) acts as an auxiliary to the public authorities in the humanitarian field. Its main mandate is to prevent and alleviate the suffering of vulnerable populations, whether caused by natural disasters, armed conflict or other emergencies. In line with the seven fundamental principles of the International Red Cross and Red Crescent Movement, the CRC strives to ensure impartial, effective and sustainable assistance to those in need. It also plays a central role in raising community awareness of issues such as international humanitarian law, the values of solidarity and preventive health actions.

Mobilising human and community resources

The CRC benefits from a vast and diversified human network of committed volunteers who are essential to the implementation of emergency responses. Here are the main points concerning the mobilisation of human and community resources:

- **Volunteer network :**
    - Around 65,000 active volunteers across the country.
    - 20,000 volunteers trained in first aid.

- Volunteers divided into 58 departmental committees and 320 functional district committees, ensuring uniform national coverage.

- **Continuing education and specialisation :**
  - Specialised training to respond effectively to health needs: cholera, water, hygiene and sanitation (WASH), community and educational interventions (CEA).
  - **Specific training** :
    - 323 volunteers trained in Community-Based Surveillance and active in the CP3 zone (North, East...).
    - 633 volunteers trained in EPIC and WASH in several regions of the country (East-North, South-West, Littoral, South, North, East).
    - more than 10,000 volunteers trained in psychosocial first aid (PSP), with 25 dedicated trainers.
    - 25 mentors for DREF projects (one per region).
    - 11 trainers for dignified and safe burials (Southern region and CRC headquarters)
  - **Disaster management teams:**
    - **40 NDRT, 20 RDRT, 200 BDRT** (Disaster Response Team - Equipier de réponse d'urgence au niveau national(N), régional(R), et branche(B)) to intervene as close as possible to populations affected by crises and disasters.
    - **2 FACT** (Field Assessment and Coordination Team) **teams** for assessments and coordination on the ground in the event of a crisis.

Impact and role in the field

Cameroon Red Cross volunteers play a central role in the field, being the main actors in the immediate response to health emergencies. Their contribution is essential not only during crises, where they ensure the rapid provision of basic services to vulnerable populations, but also in mobilising local communities. These volunteers play an active role in building community resilience by working directly and continuously with local people. Their action is aimed at raising awareness and responding to the specific needs of communities, whether in times of crisis or peace, thereby ensuring a constant presence and providing valuable support for local development and the management of health emergencies.

Community-based surveillance

Often, the community is aware of a health risk, but those in a position to mobilise intervention resources receive this information too late to halt the spread of the disease and save as many lives as possible. Community-based surveillance (CBS) aims to remedy this problem and

improve the rapid detection of disease. The purpose of CBS is the systematic detection and reporting, by members of a community, of significant public health events within that community.

The CRC has launched DBS in 23 districts* since 2023 and plans to extend it to other districts** in the near future. Cholera is already one of the diseases monitored: cases of Acute Watery Diarrhoea (AWD) (see definition below) are collected by CRC volunteers at community level, verified by trained CRC supervisors and reported to the Ministry of Health through the health centres.

The SBC represents a major asset for a National Society that wants to start anticipatory actions like the CRC. The SBC makes it possible to trigger an Early Action Protocol based on community alert cases reported by CRC volunteers. This notification is transmitted more quickly than suspected or confirmed cases relayed by the Ministry of Health (MinSan) via health facilities, and then communicated to the CRC during weekly surveillance meetings. By incorporating community alerts, the CRC can intervene at an earlier stage and better direct its anticipatory actions.

In addition, the CRC uses a digital tool called Nyss, designed specifically to support the Red Cross Red Crescent Movement's DBS activities. Thanks to Nyss, the detection, reporting, aggregation and analysis of information on community health risks can be carried out in real time. This makes it possible to prevent, identify and respond rapidly to disease outbreaks through early warning and rapid response mechanisms. By combining these technological capabilities with the local presence of volunteers, the CRC's community-based surveillance is an essential lever for taking action in anticipation of a cholera epidemic.

**North Region: Garoua I, Garoua II, Guider, Bibemi, Tchollire, Figuil, Gashiga, Golombé, Lagdo, Mayo Oulo, Ngong, Pitoa, Reu Bouba, Touboro; Littoral Region: New Bell, Nkongsamba; South Region: Ambam, Sangmélima; Centre Region: Mfou, Bafia, Ndikinimeki; South West Region: Buéa, Limbé.*

***Far North region: Makary, Mada, Kousseri, Maroua 3, Moutourwa, Vélé; East region: Bertoua, Yokadouma, Batouri, Abong Mbang.*

Logistical and organisational skills

Operational lines

The Cameroon Red Cross (CRC) has structured its response to emergencies, particularly cholera, around three main operating lines: the operational line (Disaster Management), the technical support line and the strategic line. This modular organisation allows flexible adaptation to the specific dimensions of the response, by mobilising only the necessary technical referents. The main operational lines described below are visualised in diagram 2

created by the Canadian Red Cross.

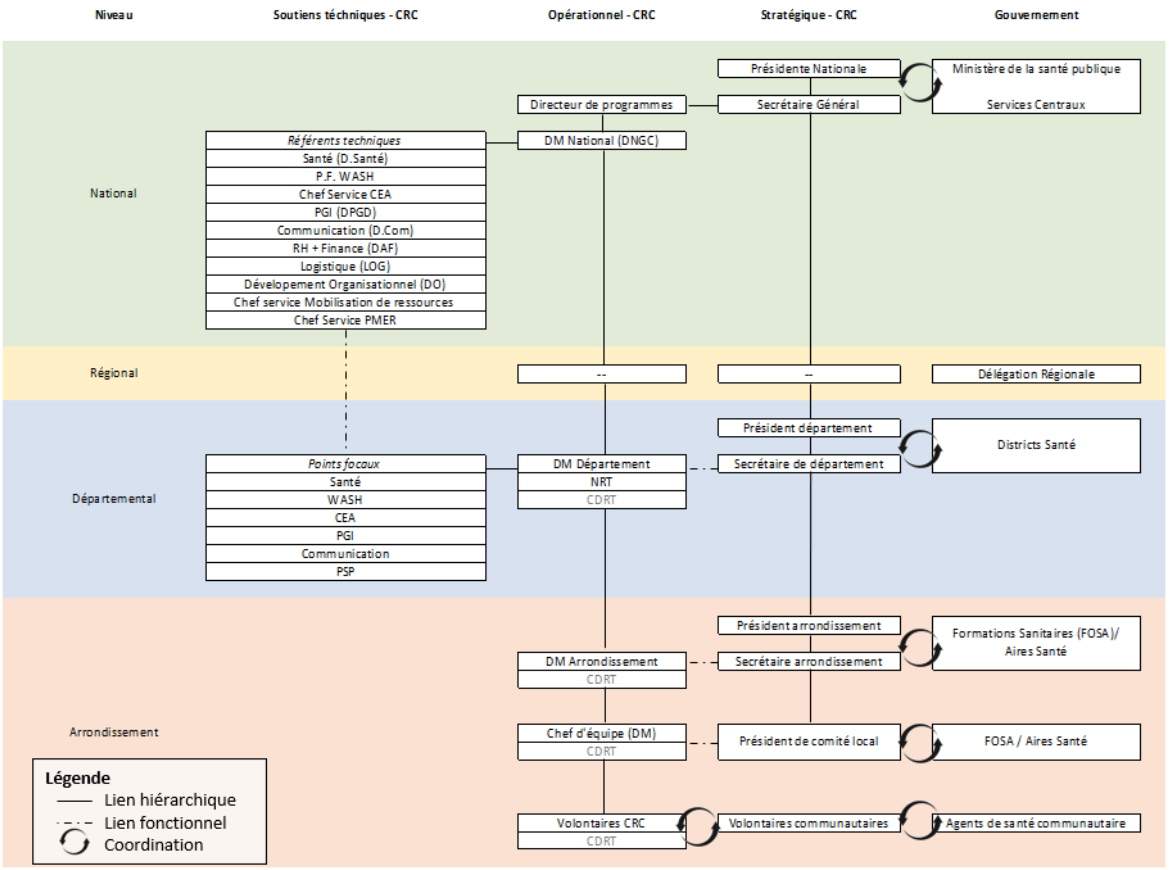


Diagram 2: Structure of the Cameroon Red Cross (Canadian Red Cross)

Operational line (DM)

The operational line is at the heart of operations and is responsible for decisions taken during the operation. It is based on a clear hierarchy:

- The **National Disaster Management Director (DNGC)** guides the technical referents at head office and the departmental Directors of Missions (DM) involved in the response.
- The **departmental DMs** provide guidance to the departmental focal points and the DMs in the arrondissements.
- The **district DMs**, in turn, supervise the team leaders responsible for volunteers in the field.

Technical support line

This line guarantees the quality of intervention activities by mobilising specific expertise.

- The technical referents at head office provide guidelines in their respective fields to the departmental focal points, while coordinating with the DMs where necessary.
- The departmental focal points pass on these guidelines to the operational team to ensure that they are applied in accordance with the standards.

Strategic line

The Strategy Line oversees overall coordination and interaction with government and other external stakeholders. If necessary, this responsibility can be delegated. In addition, the strategic line can help to mobilise the resources needed for the operation.

Diagram 2 is a specific organisation chart illustrating this response structure, also integrating the Ministry of Public Health players at each administrative level. This reflects the coordination mechanisms that are essential to ensure an effective and harmonised response.

Local capacity building

Where key positions in the response structure are held by people deployed outside the local area, they are responsible for mentoring, advising and supporting their local counterparts. The aim of this approach is to build local capacity for more autonomous and resilient operations in the future.

This strategic and operational structure, combined with a flexibility adapted to emergency situations, enables the CRC to respond effectively to major health and humanitarian challenges such as cholera.

Logistics capacity

The logistical capabilities of the Cameroon Red Cross (CRC) are a key factor in its effectiveness in responding to health emergencies, particularly during periods of cholera. The organisation has two medical ambulances and a medical minibus, enabling rapid coverage of the affected areas. The CRC has set up communication and community engagement (CEA) focal points in each committee, although the creation of specific job descriptions and the development and implementation of training still need to be strengthened. In addition, specialised focal points in various fields such as first aid (PF PS), food security and livelihoods (FSL), protection and security of populations (PSP), water, hygiene and sanitation management (WASH), as well as the integration of protection, gender and inclusion (PGI) are designated to optimise the effectiveness of interventions.

The CRC runs several health centres across the country, including those in Wouri, Noun (Foumban), Baigom, Mbalmayo, Océan (Kribi), and the Henry Dunant health centre in Yaoundé, but these facilities require regular staff training and retraining to ensure that they operate smoothly and provide quality services. In addition, the Infection Prevention and Control (IPC) programme at CRC health centres plays a crucial role in ensuring the continuity of health operations, particularly in response to epidemics. The CRC also remains a key partner for the government in managing health crises. In terms of materials and equipment, the CRC has a stock of protective equipment, including intervention suits and eight mannequins for first aid training, as well as intervention kits adapted to emergencies such as Ebola or cholera, depending on the specific needs of the areas affected. Finally, although the departmental and arrondissement committees (58 and 320 respectively) provide national coverage, some departmental headquarters are not present everywhere in the country, and the mobile cinema kits are deployed in key regions such as Mfoundi, Wouri, Mayo Sava and Mayo Tsanaga, enabling a mobile and flexible response.

Inventory management

Although stocks are available, managing them represents a major challenge for CRC. In the absence of a structured stock management system, stored inputs often exceed their expiry date, rendering them unusable. This not only wastes valuable resources, but also compromises the ability to respond quickly and effectively when needed.

In addition, the CRC's local branches do not have dedicated warehouses for storing equipment. Currently, existing office space is being reallocated to meet this need, which is neither an optimal nor sustainable solution. This creates risks of disorganisation and mismanagement of resources.

Another significant challenge is the unreliability of the use of stockpiles. When stockpiles are placed in a branch to support early actions or responses planned as part of a project, there is no guarantee that they will not be diverted to other activities without informing the project manager or keeping adequate records. Such a lack of centralised control undermines traceability, transparency and accountability, and can compromise the effectiveness of anticipatory actions.

To remedy these shortcomings, CRC must implement a rigorous and standardised inventory management system. This system should :

1. **Record all stock movements**: Each entry and exit of materials or inputs must be recorded, with detailed information on the type of product, quantity, expiry date and intended destination or use.

2. **Tracking expiry dates**: Systematically tracking the expiry dates of materials will ensure that they are used before they expire, thus avoiding wastage.

3. **Develop reliable traceability**: Each item should be assigned to a specific activity or project, with control mechanisms to ensure that it is only used for that purpose, unless prior authorisation has been obtained.

4. **Creating dedicated storage areas**: It is essential that each branch has a specific warehouse for storing equipment, to ensure that it is kept in good condition and avoids it being scattered or misused.

5. **Carry out monthly inventories:** an inventory should be carried out at the end of each month or quarterly, depending on the quantities of products and materials in stock, and the inventory report should be shared with project managers.

By implementing these measures, the CRC will not only increase the efficiency of its stock management, but also the transparency and responsiveness of its actions on the ground. This will ensure that available resources are optimally mobilised to support anticipatory actions and respond to humanitarian needs in a timely manner.

PARTNERSHIPS AND MULTI-SECTOR COORDINATION

In the context of cholera management in Cameroon, the organisational structures that govern collaboration between state and non-state actors play a crucial role in the effectiveness of the early warning system (EWS) and health interventions. These structures are marked by partnership agreements, shared protocols, joint responsibilities, and collaborative and information-sharing practices. However, a number of challenges have been identified in setting up these structures.

Partnership agreements

Partnership agreements are fundamental to ensuring smooth collaboration, particularly when it comes to sharing sensitive data within SAP. However, it has been noted that these agreements often take time to finalise, sometimes several months or even years, due to the complexity of the data to be shared. In addition, non-state actors emphasise the importance of long-term partnerships, to ensure a gradual transition of EWS responsibilities to the state once the intervention phase is over.

Shared protocols

Shared protocols are essential to ensure a rapid and coordinated response. There are differences of opinion as to whether protocols should be defined primarily by the state or developed collaboratively between all the actors involved. However, it is widely recognised that clear but adaptable protocols are needed to improve the management of the epidemic. Adjustments, such as redefining acute watery diarrhoea, are often necessary as new information emerges.

Shared responsibility

Shared responsibility is another major challenge, especially given Cameroon's centralised decision-making system. Non-state actors point out that although the state is generally open to collaboration, decision-making is often slow, especially when it comes to responding rapidly to the spread of cholera. As a result, non-state partners express frustration at the delays in implementing certain interventions.

Sharing knowledge and mutual respect

Sharing knowledge is a key element in the effective management of cholera. The lack of a clear division of labour can lead to duplication of effort and inconsistent decisions, particularly with regard to the early detection of cholera. The CRC was often cited as a key player in sharing information and coordinating efforts between the various partners. The relational dimension, in particular mutual respect, is also essential for successful collaboration. Non-state actors stress the importance of gaining the trust of the public authorities, who are responsible for the final decision on the health response.

CRC partnerships

The CRC maintains strategic partnerships with state actors, NGOs and international agencies such as the International Committee of the Red Cross (ICRC) and the International Federation of Red Cross and Red Crescent Societies (IFRC). This multi-sectoral cooperation is crucial to maximising the impact of interventions, avoiding duplication and ensuring alignment of objectives between the various players. According to one UN non-state actor, "people easily come together around a shared problem", such as cholera management, which facilitates collaboration.

Before coordination begins, it is essential to define common objectives, which is sometimes neglected and can lead to challenges in managing interventions. While some feel that this is primarily a role for state actors, others stress that NGOs should also be involved in coordination and alignment of their objectives. The EWS is recognised by all players as essential in the fight against cholera, even if alignment on the sub-objectives is sometimes difficult to achieve.

Collaboration with MinSan in the development of the EAP

During the development of the EAP, the CRC submitted a request to MinSan to share cholera incidence data. These data are crucial for establishing the trigger thresholds and ensuring the effective operation of the surveillance system once the EAP has been validated.

Chronology of interactions with MinSan

1. **First data request (mid-2023)**
   The first request for data sharing was made during 2023. However, this request was made without a thorough presentation of the project's objectives or a clear explanation of the intended use of the data. At that time, the project was mainly managed by the French Red Cross (FRC), with more limited involvement from the CRC, which may have slowed progress.

2. **Second data request (July 2024)**
   In 2024, CRC renewed the data sharing request following several key steps to strengthen alignment and collaboration with MinSan:

   - A CRC focal point for the EAP has been appointed.
   - A workshop was organised, with the participation of MinSan, to explain the objectives and methodologies of the EAP.
   - The CRC and the project's technical experts took part in a MinSan coordination meeting, where the project's interim results were presented.

These concerted efforts led to a better understanding of the project by the MinSan and enabled the dossier to move forward for validation.

3. **Signing of the letter of collaboration (October 2024)**
   In October 2024, the letter of collaboration and data sharing was finally signed. The data was sent to the CRC and the EAP's technical development partners a few weeks later.

Lessons learned and opportunities for improvement

Although this process has been completed, there are still opportunities for improvement:

- Had the data analysis methodologies been shared earlier with MinSan, this could have accelerated the validation and data sharing process. In-depth technical collaboration from the outset would have helped to build greater trust and a mutual understanding of needs and objectives.

- MinSan had expressed a need for technical support for their data analysis methodology, but this request was not included as part of the expert support to the CRC. This limited the project's ability to fully meet the Ministry's expectations.

Conclusion

Closer coordination, from the outset of the project, between the CRC, the technical experts and MinSan could have facilitated smoother collaboration and speeded up the process. The lessons learnt from this project provide a basis for improving future partnerships and guaranteeing optimum results.

Challenges in multi-sector teams

Team management is also a key factor in the success of the collaboration. A multi-sectoral approach, which includes departments beyond the health sector such as water, sanitation and urban planning, is essential for effective cholera surveillance. However, high staff turnover in both state and non-state organisations often disrupts the continuity and implementation of established processes. Practices such as co-working, where actors share a workspace, have shown positive results in building trust and collaboration.

Cost sharing and rewards

Financial constraints remain one of the main challenges in implementing an EWS in Cameroon. The government relies heavily on external funding, which can be unstable, making it difficult to prepare for epidemics. Non-state actors sometimes step in to fill these financial gaps, but the sustainability of this commitment remains a concern, especially with the planned gradual withdrawal of external partners.

STRATEGIC RECOMMENDATIONS

In the context of optimising the management of cholera epidemics and strengthening the EWS in Cameroon, several key recommendations have been identified to improve collaboration between state and non-state actors. These recommendations, based on interviews and data

analysis, aim to facilitate more effective coordination, more fluid management of resources and a rapid and appropriate response in the event of a crisis.

1. Shared objectives

The alignment of objectives at all levels is crucial for effective surveillance at community level, within healthcare establishments and at regional level. Disparities in objectives between state and non-state actors, and a sometimes blurred understanding of respective expectations, represent a major obstacle to the success of interventions. It is therefore essential that all actors, from national to community level, are aligned on common objectives. This includes the engagement of community leaders in the development of the EWS and a better understanding by non-state actors of the expectations of state actors.

Recommended strategies:

- Include national and regional players in meetings to coordinate objectives.
- Involve community leaders in the development and management of the EWS to improve local responsiveness.
- Clarify the expectations of cooperation between non-state actors and state actors during the implementation of an EWS.

2. Regular meetings

Regular working meetings play a key role in sharing information, pooling knowledge and building trust between stakeholders. However, they can be time-consuming and require effective management if they are not to become a burden. Integrating them into existing mechanisms, while adding extra meetings in the event of a crisis, is a pragmatic approach.

Recommended strategies:

- Identify existing mechanisms used by non-state actors to share information.
- Set up a meeting rhythm that facilitates the accurate and timely sharing of information, without overloading participants.

3. Protocols developed in collaboration

The development of simple and easily applicable protocols is essential in the management of cholera, especially in areas with limited resources. To ensure a rapid and appropriate response, it is crucial that these protocols can be implemented without hindrance. A step-by-step approach, starting with a simple protocol by one stakeholder, makes it possible to adapt to local contexts and test effectiveness while developing shared protocols. The co-creation of early action protocols between NGOs and the MinSan, by sharing the same triggering model but separate funding sources, can facilitate more complex and impactful interventions.

Recommended strategies:

- Co-create early action protocols with interdisciplinary and inter-organisational teams.
- Start with a simpler early action protocol and gradually build on it as the situation evolves.
- Adapt early action protocols to the local context to ensure they are relevant and effective.

4. Shared Information Systems

Integrating the Early Warning System (EWS) for epidemics into the existing information system (SNIS, DHIS2) means that data can be shared efficiently, using the country's established systems. This approach improves the sustainability of the EWS while facilitating the coordination and continuity of information exchanges between stakeholders. For example, the EAP includes SBC data automatically, but the MinSan's data on suspected and confirmed cases is included manually. A direct link between the SAP and the DHIS2 could facilitate the use of suspected and confirmed case data thanks to an automatic trigger link.

Recommended strategies:

- Understand the flow of information and the current organisation of SAP.
- Identify parts of the system that can be exploited to improve data sharing.
- Implement mechanisms to support ongoing information sharing, aligning incentives and ensuring ongoing collaboration between users and data providers.

5. How to select and train staff

Building solid relationships based on trust is essential for successful cooperation. This requires time, effective communication and mutual respect. Non-state actors, who are often faced with frequent staff turnover, need to stay in the country long enough to build lasting relationships. Active collaboration, including co-working, as well as participation at all administrative levels, are key elements in strengthening these relationships.

Recommended strategies:

- Ensuring a prolonged presence of non-state actors to support the development of long-term relationships.
- Facilitate collaborative working (co-working) with local players to strengthen cooperation.
- Promote a participatory capacity at all levels, including lower administrative levels, to encourage bottom-up and top-down collaboration.

6. Creation of a dedicated team

The development of a dedicated SAP implementation team ensures that the necessary resources and expertise are available and optimally managed. Three key roles need to be assigned within the team: a data manager to provide accurate reporting and analysis, a

monitoring coordinator to ensure the ongoing adaptation of monitoring activities, and a collaboration manager to manage coordination between the various players.

Recommended strategies:

- Appoint a data manager, a surveillance coordinator and a person responsible for collaboration.
- Identify and assign clear responsibilities within the team for effective system management.

7. Shared costs and rewards

Funding remains a major challenge for the implementation of preventive and reactive measures against cholera. Flexible funding mechanisms that allow funds to be released in advance are essential to ensure rapid action as soon as an epidemic breaks out.

Recommended strategies:

- Put in place flexible funding mechanisms that allow funds to be released rapidly before epidemics occur, to facilitate preventive action.

RISK ANALYSIS METHODS AND DATA SETS

Several methods can be used to construct a risk index. Due to differences in structural design, the distinct methods for constructing the risk index are the deductive, hierarchical and inductive methods (Tate, 2012). The deductive method produces a risk index that is simply the product of normalising and aggregating all the indicators. The hierarchical method ensures that the associated indicators are first grouped into sub-indices or dimensions before the final risk index is obtained. The inductive method uses principal component analysis to reduce the risk indicators to smaller, uncorrelated factors before completing the risk index.

The INFORM model is a form of hierarchical method as it ensures that risk indicators are grouped into dimensions. Risk indicators are also reduced within each dimension when high correlations with other risk indicators are identified (Marin Ferrer, Vernaccini, & Poljansek, 2017). The INFORM model allows risk dimensions to be combined and compared within and across countries. As shown in Figure 5, the INFORM Epidemic Risk Index (ERI) dimensions are hazard and exposure, vulnerability and lack of adaptive capacity (Marin Ferrer & Vernaccini, 2017). As this assessment focuses on cholera and includes climatic factors, the categories and components differ from those of the ERI. For this assessment, the adapted definitions of the risk dimensions are as follows:

- **Danger & exposure** represents the probability of exposure to *Vibrio cholerae*. Danger and exposure are grouped together because they are interdependent if a cholera epidemic is to occur.

- **Vulnerability** describes how people at risk in an administrative unit may be affected by a cholera epidemic, depending on the social, economic and behavioural characteristics of the population.

- **Response capacity** is the ability of the population in an administrative unit to carry out activities before, during and after a cholera outbreak. To ensure that higher values of indicator 6 mean higher risk, the response capacity dimension is transformed into lack of response capacity.

The INFORM model was the first risk index method used in this research due to its frequent use in risk assessment research and its epidemic-friendly approach. A second risk index method was used in an attempt to create a more accurate risk assessment. The deductive method was used for its simplicity, but weightings were then applied to the indicators. The INFORM model uses an equal weighting approach, but to ensure that the risk index is well aligned with cholera incidence, a weighted approach using the calculated correlation coefficients between incidence and indicators as weights results in risk scores more closely associated with cholera incidence.

Literature review

A systematic and thorough review of the literature was carried out to determine the risk factors for cholera. Table 1 shows the risk factors identified and their influence on cholera, the corresponding citations, and the reason why they were included or not in the risk index.

Indicator	Definition	Justification	Use
Precipitation[1]	Extent and duration of rainfall. Over a prolonged period, abundant rainfall is generally observed during the rainy season.	High or very low rainfall can increase the risk of infection. Heavy rainfall causes flooding, which contaminates water sources (mainly rivers and streams) with dirty objects and human and animal waste. During a period of drought, water shortages can force people to consume water from non-potable sources and reduce hygiene practices such as hand-washing, thereby increasing the risk of cholera transmission during an epidemic.	Yes
Earth's surface temperature[2]	Earth's surface temperature	Earth's surface temperature	Yes
Climate-related disasters[2]	Natural disasters (hydrometeorological) such as floods and droughts.	Disasters increase the risk of infection.	Yes

[1] Idoga PE, Toycan M, Zayyad MA. Analysis of Factors Contributing to the Spread of Cholera in Developing Countries. Eurasian J Med 2019; 51(2): 121-7.

[2] Usmani, M., Brumfield, K. D., Jamal, Y., Huq, A., Colwell, R. R., & Jutla, A. (2021). A Review of the Environmental Trigger and Transmission Components for Prediction of Cholera. *Tropical Medicine and Infectious Disease*, *6*(3), 147. https://doi.org/10.3390/tropicalmed6030147

Population density[3]	Number of people in a geographical area.	A higher population concentration means that individuals are more exposed to infection.	Yes
Proximity to bodies of water[2]	Distance from any type of water body (rivers, lakes, ditches, streams).	The closer people live to bodies of water, the more likely they are to be exposed to cholera. Zooplankton blooms lead to an abundance of V. cholerae in coastal waters. V. cholerae is also found in high densities near aquatic organisms.	Yes
Poverty/Income level[4]	Income refers to the money a person or entity receives in exchange for their work or products. Poverty is defined as the inability to meet basic needs, such as food, clothing and housing.	Low income and poverty are associated with an increased risk of cholera.	Yes
Overcrowded residence[5]	An environment where the number of occupants exceeds the capacity of the available space.	A greater concentration of individuals in a household increases exposure to infection.	Yes
Conflicts[1]	The result of behaviour aimed at destroying, injuring or controlling a group of people or another country.	Populations affected by armed conflict are at increased risk of cholera due to limited access to safe drinking water and lack of adequate sanitation, leading to insecurity, social imbalance and perceived institutional neglect, all of which facilitate the spread of cholera.	Yes
Access to healthcare[6]	The opportunity to use healthcare, limited by the availability of transport and proximity to a health facility.	Poor transport links and long distances to healthcare facilities increase the risk of cholera.	Yes

[3] Ngwa MC, Ihekweazu C, Okwor T, Yennan S, Williams N, et al. (2021) The cholera risk assessment in Kano State, Nigeria: A historical review, mapping of hotspots and evaluation of contextual factors. PLOS Neglected Tropical Diseases 15(1): e0009046. https://doi.org/10.1371/journal.pntd.0009046

[4] Guévart, Édouard & Noeske, Juergen & Solle, J & Essomba, J & Edjenguele, Mbonji & Bita, André & Mouangue, A & Manga, B. (2006). Factors Contributing to Endemic Cholera in Douala, Cameroon. Médecine tropicale: revue du Corps de santé colonial. 66. 283-91.

[5] Al-Abdulla, Orwa & Alaref, Maher (2022). The forgotten threat of Cholera in Syria. Journal of Water and Health. 20. 10.2166/wh.2022.262.

[6] Dutta, Biswa Prakash1,; Kumar, Nishant2; Meshram, K. C.3; Yadav, Rajesh4; Sodha, Samir V.5; Gupta, Sonia6. Cholera Outbreak Associated with Contaminated Water Sources in Paddy Fields, Mandla District, Madhya Pradesh, India. Indian Journal of Public Health 65(5):p 46-50, January 2021. | DOI: 10.4103/ijph.IJPH_1118_20

Health competence[7]	Training in public health.	Appropriate health promotion and timely delivery of interventions to the target population can reduce the size of cholera epidemics.	Yes
Population per care facility[6]	The ratio of individuals per health facility.	The risk is higher where there are fewer diagnostic/treatment centres.	Yes
WASH factors[4]	Global water, sanitation and hygiene. Includes behaviours and facilities.	Cholera is spread through contaminated food and water. WASH facilities influence the transmission of cholera.	Yes
Sea surface temperature[8]	Sea surface temperature.	Warmer seas increase the risk of infection.	No, because it is collinear with the proximity of water bodies
Water salinity[8]	Salinity of water bodies.	Higher salinity increases the risk of infection.	No, because it is collinear with the proximity of bodies of water
Population movement in urban areas[9]	Intra-urban movement.	Mobility in high-risk areas such as common markets and main roads makes individuals more exposed.	No, because it's very complicated to model people's everyday movements.
Population migration[9]	Local and international travel.	Moving to epidemic areas increases the risk of cholera.	No due to data unavailability
Percentage of vaccination[10]	The percentage of the population vaccinated.	A lower percentage of vaccination increases exposure to infection.	No due to data unavailability
Supplies and equipment[7]	Availability of supplies and materials to manage a disease.	The limited availability of supplies and the restricted capacity of services increase the risk of cholera.	No due to data unavailability

[7] D'Mello-Guyett, L., Cumming, O., Rogers, E. *et al.* Identifying transferable lessons from cholera epidemic responses by Médecins Sans Frontières in Mozambique, Malawi and the Democratic Republic of Congo, 2015-2018: a scoping review. *Confl Health* 16, 12 (2022). https://doi.org/10.1186/s13031-022-00445-1

[8] Constantin de Magny G, Colwell RR. Cholera and climate: a demonstrated relationship. Trans Am Clin Climatol Assoc. 2009;120:119-28. PMID: 19768169; PMCID: PMC2744514.

[9] Asadgol Z, Mohammadi H, Kermani M, Badirzadeh A, Gholami M (2019) The effect of climate change on cholera disease: The road ahead using artificial neural network. PLoS ONE 14(11): e0224813. https://doi.org/10.1371/journal.pone.0224813

[10] Trevisin Cristiano, Lemaitre Joseph C., Mari Lorenzo, Pasetto Damiano, Gatto Marino and Rinaldo Andrea 2022Epidemicity of cholera spread and the fate of infection control measures. *J. R. Soc. Interface.*19: 20210844 http://doi.org/10.1098/rsif.2021.0844

Vulnerable groups - health problems[11]	For cholera, this includes: malnourished people, those suffering from chronic illnesses, those without access to rehydration therapy and medical services (access to healthcare), those suffering from achlorhydria, those with blood group O.	These are groups at increased risk of serious illness.	No due to data unavailability
Demographics	Demography refers to age and gender. NB: Various age and sex groups appear to be at greater risk of infection and mortality based on the literature in the right hand column. Many other publications have found no significant relationship between gender, age and cholera incidence.	Some studies show that women are more exposed to cholera. In Mandla, India, women carry out certain seasonal agricultural activities and, during the epidemic, this coincided with heavy rainfall, but they continued to drink water from open wells. This also concerns the age at risk, mainly the working age.[12]	No, because of conflicting information about which sex is more vulnerable, with evidence of bias and lack of a significant link in most publications. gender is more vulnerable, with evidence of bias and lack of significant association in most publications. The same applies to age.
		Other studies in Ethiopia show that men are more exposed to cholera, even when they are of working age.[13]	
		In Douala, Cameroon, age over 40 is a risk factor for death from cholera. 55% of cholera patients were men.[14]	
		UNICEF recognises that cholera is not gender-neutral because of the influence of gender roles on daily activities.[15]	
		The risk of cholera by age varied considerably between studies and may reflect differences in populations living in epidemic versus endemic areas, where natural immunity may play a role. The	

[11] Cholera | Epidemic Control Toolkit

[12] Dutta, Biswa Prakash1,; Kumar, Nishant; Meshram, K. C.; Yadav, Rajesh; Sodha, Samir V.; Gupta, Sonia. Cholera Outbreak Associated with Contaminated Water Sources in Paddy Fields, Mandla District, Madhya Pradesh, India. Indian Journal of Public Health 65(5):p 46-50, January 2021. | DOI: 10.4103/ijph.IJPH_1118_20

[13] Letta, T.T., Belay, D.B. & Ali, E.A. Determining factors associated with cholera disease in Ethiopia using Bayesian hierarchical modeling. *BMC Public Health* 22, 1779 (2022). https://doi.org/10.1186/s12889-022-14153-1

[14] Hemmer, Christoph J.; Nöske, Jürgen; Finkbeiner, Stefan; Kundt, Günter; Reisinger, Emil C.. The cholera epidemic of 2004 in Douala, Cameroon: A lesson learned. Asian Pacific Journal of Tropical Medicine 12(8):p 347-352, August 2019. | DOI: 10.4103/1995-7645.262563

[15] UNICEF Briefing Note Gender Cholera Gender and Cholera UNICEF

		influence of gender could not be analysed due to evidence of publication bias.[16]	
		Among 423 samples tested for cholera, 150 (35.5%) were positive, while age-related prevalence was highest among 18-29 year olds (OR=3.21; P=0.001) with 70.8%, followed by 5-10 year olds (OR=2.12) with 51.4%. Gender-related prevalence was higher in females (OR=2.23; P=0.037) with 42.6%, while their male counterparts (OR=1.01) had 27.5% of the infection. The associations of the two factors are significant.[17]	
		In the cholera epidemic in Cameroon in June 2023, the International Federation of Red Cross Societies (IFRC) reported that twice as many men are estimated to be affected as women.[18]	

Table 1: Literature review to identify cholera risk indicators

Following this literature review, workshops were held with national stakeholders to discuss the design of this risk index. These consultations enabled additional indicators to be incorporated into the analysis, based on local expertise and the participants' recommendations.

Additional indicators include the location of prisons, cross-border areas, areas along major communication routes and hard-to-reach populations. Prisons are often in a poor state of hygiene, which increases the likelihood of a cholera epidemic, and with prisoners being visited by their families, localities with prisons are at high risk of epidemics. Cross-border areas and those on communication routes are at high risk due to the large number of people who pass through them every day and the density of these movements. Finally, hard-to-reach populations are at high risk of suffering severe consequences from cholera because the Ministry of Health and the Red Cross are unable to reach them easily for health interventions.

In addition, interactions with stakeholders led to the removal of certain indicators deemed irrelevant to the national context. These include temperature and health skills. These adjustments reflect the importance of adapting the index to the specific realities of the country and to the priorities identified by local experts.

[16] Richterman A, Sainvilien DR, Eberly L, Ivers LC. Individual and Household Risk Factors for Symptomatic Cholera Infection: A Systematic Review and Meta-analysis. J Infect Dis. 2018 Oct 15;218(suppl_3):S154-S164. doi: 10.1093/infdis/jiy444. PMID: 30137536; PMCID: PMC6188541.

[17] Okoroiwu.G.I.A, & Onah.M.C. (2023). CHOLERA AND ASSOCIATED RISK FACTORS IN GWAGWALADA AREA COUNCIL, FCT, ABUJA, NIGERIA. International Journal of Novel Research in Healthcare and Nursing, 10(2), 49-57. https://doi.org/10.5281/zenodo.8017352

[18] 20230629_ACAPS_Briefing_note_Cameroon_increase_in_cholera_cases.pdf

Data collection and preparation

Depending on the information requirements for each factor, a data search was carried out to identify potential sources. The metadata for each dataset was then checked to ensure its suitability for the risk assessment (see deliverable 2.2 Database).

The datasets obtained were available at various spatial and temporal resolutions. In order to carry out a proper assessment, the data had to be prepared and transformed so that they could be harmonised at a uniform level.

Spatial manipulation

Although a higher resolution would have been preferable, data on cholera incidence was only available at health district level. Therefore, all datasets were reclassified to show a value per health district.

The datasets concerned were transformed using different methods:

Average value per district: Given the high resolution of the raster files, such as those for precipitation and temperature, they have been reclassified to represent the average of the values in each district. This is expressed by the following equation:

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i$$

- Where:
  - $\bar{x}$ = average value per district ;
  - x_i = observed values of the indicator per pixel ;
  - N = number of pixels.

For bodies of water, a buffer of 0.1 decimal degrees (11 km) has been applied around administrative boundaries so that coastal districts count the ocean as a body of water.

- **Value per district population**: The number of people in vulnerable population groups divided by the total population, to obtain a fraction of the vulnerable population per district. When the indicator mentioned a number of people greater than the total population of a district, a *NaN* value was assigned due to the invalidity of this value.

Number of health facilities per population in each district: To obtain the population/health facility ratio. The point data (for each facility) were superimposed on the base map, and a calculation was made to obtain the ratio per district:

$$x_c = \frac{P}{\sum_{i=1}^{N} x_i}$$

- Where:
  - x_c = population/health facility ratio;

- x_i = health establishments;
- N = number of health facilities per district;
- P = population per district.

Time manipulation

Incidence data was available at a temporal resolution of two weeks. Therefore, all datasets were aggregated to obtain monthly values by district, in order to obtain more data points in the risk assessment. For non-temporal datasets, their values were duplicated over the months so that all variables had the same number of data points. Precipitation was extracted from the *Copernicus Data Store* at daily and monthly frequencies. Daily data was used to analyse the correlation between cholera cases and rainfall with a lag time of 14 days. Monthly data were used for the risk maps.

Elimination of outliers

To improve the reliability of the analysis, an outlier elimination procedure based on the interquartile range (IQR) was implemented. This method, which identifies and excludes extreme data that deviates significantly from the central trends, uses a threshold set at three times the IQR, calculated from the first and third quartiles. Values outside this range have been removed, minimising the impact of anomalies while preserving the statistical integrity of the data.

The analysis focused on the attack rate (number of cases normalised by the size of the population), in line with the objective of anticipatory actions: to reduce the risk of cholera epidemics, rather than to limit the risk of deaths once cases have been declared. Lines containing missing values for incidence data (unique combination of month and district) have also been removed.

This method of eliminating outliers was applied only to the attack rate, the main incidence variable used in the analysis. A total of 22 outliers were removed from the dataset.

Standardisation

To ensure consistency, each indicator has been standardised to fall within a range of [0,10] :

$$x_{norm} = \frac{x - min(x)}{max(x) - min(x)}$$

Where:

- x_{norm} = standardised value of the indicator ;
- x = value of the indicator.

A regression analysis was then carried out to determine the coefficients of association between the indicators and the attack rate.

Finally, the datasets were aggregated to remove the time variable, taking the average of each variable over the period studied.

Adjustment for under-declaration

It is highly likely that populations living far from health facilities are less likely to report cases of cholera. Consequently, an adjustment of the incidence data to account for this bias was initially envisaged. Health facilities in Cameroon were identified from OpenStreetMap (OSM), excluding pharmacies and dentists in order to retain only hospitals and clinics relevant to the analysis.

In conflict zones, particularly in the Far North region, it was assumed that health facilities would not be operational. These facilities were therefore excluded from the analysis. A distance as the crow flies was calculated for each pixel in the population density raster (at a resolution of 1km) to identify the nearest health facility. These distances were then standardised, and the resulting factors were used to weight the incidence data.

The methodology adopted was based on a simplified approach inspired by a study of dengue fever in the Philippines (Hierink et al., 2022). It was based on the assumption that the probability of under-reporting is between 5% (minimum) and 95% (maximum), thus defining the limits of standardisation. This probability was not calculated for each healthcare facility, but only for the one closest to each zone.

However, this methodology was not applied to the data for the later stages of the analysis. The data used, extracted from the Ministry of Health's situation reports, already had quality limitations, and their adjustment risked introducing additional errors. For example, a poorly calibrated adjustment could have wrongly identified cases of cholera in areas where there had been none. In the absence of direct validation with solid data or the involvement of the Ministry of Health, the application of this method was not reliable.

For this reason, the Python scripts and documentation associated with this method have been archived and may be used at a later date if a direct collaboration with the Ministry of Health enables this approach to be validated and adjustments made based on tangible evidence.

ANALYSIS OF THE CORRELATION BETWEEN RAINFALL AND CHOLERA CASES

This correlation analysis is more in-depth than the one described in the following section, because of the importance of determining whether rainfall can be used as a predictor of cholera epidemics. The data is received at a daily interval, but the key question is whether the correlation is significant enough to demonstrate and establish a reliable relationship between the two variables.

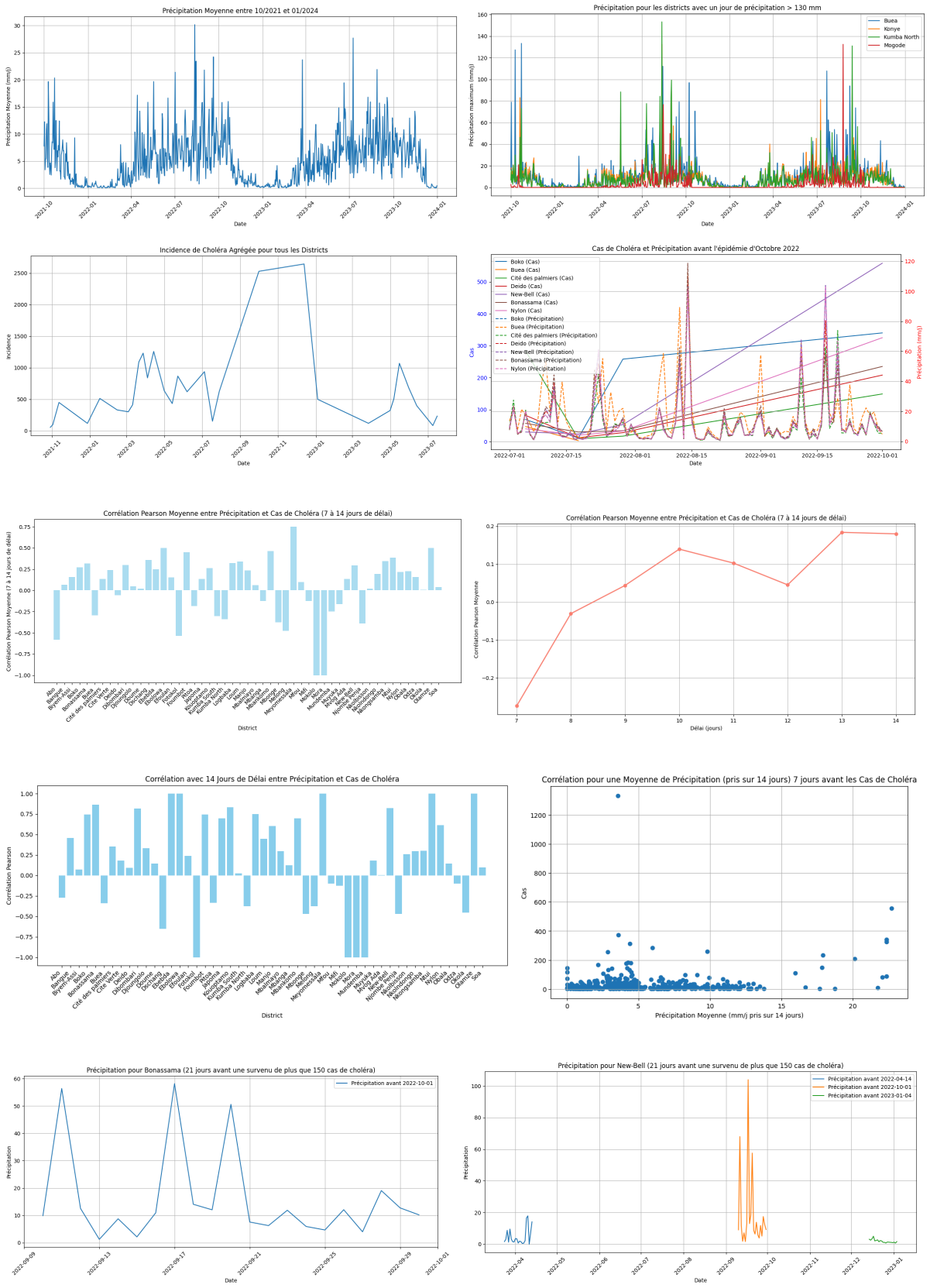


Figure 2: From left to right by line (1) Average precipitation between 10/2021 and 01/2024 (2) Precipitation for districts with one day of precipitation more than 130 mm (3) Aggregate Cholera Incidence for all Districts (4) Cholera Cases and Precipitation before the October 2022 epidemic (5) Average Pearson Correlation between Precipitation and Cholera Cases (7 to 14 days lead time) by District (6) Average Pearson Correlation between Precipitation and Cholera Cases (7 to 14 days lead time) by Lead Time (7) Correlation with 14 Days Lead Time

between Precipitation and Cholera Cases (8) Correlation for Average Precipitation (taken over 14 days) 7 days before Cholera Cases (9) Precipitation for Bonassama (21 days before an occurrence of more than 150 cholera cases) (10) Precipitation for New-Bell (21 days before more than 150 cases of cholera)

The aim of this analysis was twofold, as illustrated in Figure 2: firstly, to understand whether a correlation exists between rainfall and cholera cases, and secondly, to determine an appropriate trigger threshold for the EAP (Early Action Protocol) based on this correlation.

Preliminary analysis of rainfall and cholera cases

As a first step, rainfall trends were examined, both as a national average per day (graph 1) and as a daily maximum per district (graph 2). Graph 2 highlights four districts where rainfall exceeded the 130 mm/day threshold.

The data on cholera cases was then analysed. This analysis confirmed that cholera is endemic in Cameroon, with confirmed cases reported continuously in at least one district (graph 3). Focusing on the year 2022, before the major epidemic in Douala (graph 4), peaks in rainfall were observed, but the relationship between rainfall and cholera cases is not as clear as hoped.

Testing the hypothesis of a delay between rainfall and cholera cases

It is assumed that after heavy rainfall, the first cases of cholera would appear within 7 to 14 days. Graphs 5, 6 and 7 explore this hypothesis by testing the correlation between cases and rainfall with a time lag of 7 to 14 days. The results show that the 13-14 day lag appears to produce the best correlation, although this fluctuates from district to district. It is therefore impossible to assert that, in all districts of Cameroon, cases of cholera will systematically occur after rainfall.

To investigate this further, an additional analysis was carried out (graph 8) to examine the relationship between certain rainfall values and cholera cases, taking the average rainfall over a period of 14 days prior to the 7-day lag. This method ensures that the correlation does not depend on a single value, but on an average of rainfall over a period of 7 to 21 days prior to the notification of a case.

After removing the outlier visible in graph 8, the results show a Pearson correlation coefficient of 0.2302 and a P-value of 8.18e-07. These figures show a weak positive correlation between rainfall and cholera cases, meaning that an increase in rainfall is weakly associated with an increase in cholera cases. However, this relationship remains insufficient to establish robust causality.

To examine in detail the cases where a relationship could exist over 21 days prior to the notification of a case of cholera, graphs 9 and 10 analyse the 21 days preceding notifications of more than 150 cases in two districts of Douala. The results show that the October 2022 epidemic was preceded by heavy rainfall. However, in New-Bell, two other epidemics occurred with no apparent link to the rainfall of the previous 21 days.

Determining a trigger threshold for the EAP

Based on the results of this analysis and the local knowledge of stakeholders, it was decided to include rainfall in the EAP trigger model. To determine an appropriate threshold, it was necessary to assess how many consecutive days with average rainfall in excess of 50 mm/day would result in a trigger in accordance with the EAP rules, i.e. approximately once every five years.

Based on a rolling average over the period analysed (October 2021 to December 2023), the results are as follows:

- **Average over 2 consecutive days**: 303 occurrences in at least one district.
- **Average over 3 consecutive days**: 86 occurrences in at least one district.
- **Average over 4 consecutive days**: 39 occurrences in at least one district.
- **Average over 5 consecutive days**: 11 occurrences in at least one district.
- **Average over 6 consecutive days** : No occurrences.

These results show that a threshold based on a sliding average of 4 or 5 consecutive days with rainfall exceeding 50 mm/day is optimal. These thresholds have only been crossed 11 and 39 times in 2.25 years, making it suitable for limiting excessive triggering while guaranteeing sufficient reactivity in the face of risk. This method offers a pragmatic balance between operational relevance and feasibility.

Then, when we look at the second epidemic trigger, we see that the threshold of 5 suspected cases is not exceeded in districts with 5 consecutive days of rain, but is exceeded in districts with 4 consecutive days of rain, so this variable is retained.

CONSTRUCTION OF THE RISK INDEX AND RISK MAPS

Methodology

Two main methodologies were considered for developing the risk maps and the final risk index: the INFORM approach and the risk weighting method. These methodologies, widely used in risk analysis, offer robust frameworks for integrating multiple data and producing decision-making tools.

INFORM methodology

The INFORM Index (Index for Risk Management) is a standardised approach developed by international organisations such as the European Union and the United Nations to assess

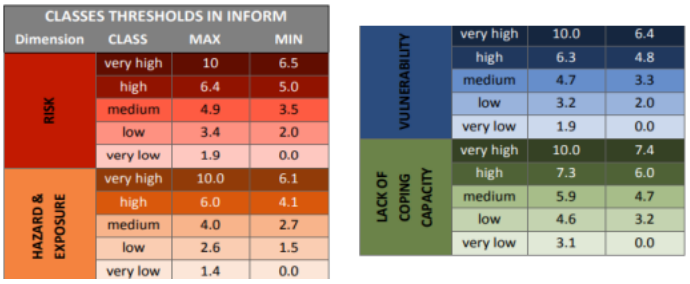
humanitarian risks. The method is based on a conceptual framework that combines three main dimensions:

1. **Hazards and exposure**: Measures exposure to natural or man-made threats.
2. **Vulnerability**: Assessing the capacity of populations to absorb or cope with the impact of these threats.
3. **Lack of adaptive capacity**: Analyses the institutional, infrastructural or economic shortcomings that limit people's resilience.

To obtain the final risk score, the INFORM aggregation method uses an equal weighting approach, where each dimension contributes equally to the overall risk[19] . This is based on the assumption that the three dimensions play a balanced role in the overall level of risk[20] . The risk score for each district is calculated by multiplying the standardised values for each dimension by their respective weights:

$$Risk = (Hazard\ an\ Exposition)^{1/3} \times (Vulnerability)^{1/3} \times (Lack\ of\ Adaptation\ Capacity)^{1/3}$$

The risk scores thus obtained are then classified into five categories, according to the INFORM[22] classification: very high, high, medium, low and very low (Figure 3). This method guarantees an objective and standardised assessment, enabling consistent and reproducible geographical comparisons.



CLASSES THRESHOLDS IN INFORM

Dimension	CLASS	MAX	MIN
RISK	very high	10	6.5
	high	6.4	5.0
	medium	4.9	3.5
	low	3.4	2.0
	very low	1.9	0.0
HAZARD & EXPOSURE	very high	10.0	6.1
	high	6.0	4.1
	medium	4.0	2.7
	low	2.6	1.5
	very low	1.4	0.0
VULNERABILITY	very high	10.0	6.4
	high	6.3	4.8
	medium	4.7	3.3
	low	3.2	2.0
	very low	1.9	0.0
LACK OF COPING CAPACITY	very high	10.0	7.4
	high	7.3	6.0
	medium	5.9	4.7
	low	4.6	3.2
	very low	3.1	0.0

Figure 3: INFORM[22] category thresholds

By integrating this approach into cholera risk analysis, INFORM is proving to be particularly robust, particularly given the limited quality of the data. The use of this standardised methodology compensates for these shortcomings, providing a reliable assessment to inform decision-making and the initiation of preventive actions.

Risk weighting method

[19] European Commission, n.d. INFORM Epidemic Risk Index [WWW Document]. URL https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/INFORM-Epidemic-RiskIndex#inline-nav-2 (accessed 12.21.22)

[20] Marin Ferrer M, Vernaccini L, Poljansek K, 2017. INFORM Index for Risk Management: Concept and Methodology, Version 2017 5-90. https://doi.org/10.2760/08037

The risk weighting method is based on a flexible approach that assigns specific weights to each indicator according to its correlation with cholera attack rates. The correlation coefficients between each indicator and cholera cases, calculated during the analysis, are used as weights. These coefficients are then multiplied by the corresponding indicator values to generate the overall risk score.

Other possible methodologies

In addition to the two approaches selected, several other methods could have been considered:

- **Multi-criteria analysis (MCA**): A systematic method for evaluating options according to multiple criteria, adapted to incorporate both quantitative and qualitative data.
- **Bayesian approach**: A probabilistic method for estimating risk based on the dynamic interactions between different factors, enabling data to be updated continuously.
- **Expert weighting approach**: This method allows weightings to be fully customised, taking into account local knowledge, national priorities and sector specificities. This approach is particularly useful in contexts where standardised indicators may not capture the full complexity of risks.

Results

Risk Index

Table 2 shows the risk index constructed based on the literature review and data availability.

Hazards and exposure	Vulnerability	Lack of adaptability
Precipitation	Poverty level	Number of health facilities available per 1000 inhabitants
Climate-related disasters	Conflicts	Hygiene, water and sanitation (WASH) factors
Population density	Household size	Hard-to-reach populations
Proximity to bodies of water		
Prisons		
Cross-border zones		
Zones located along major communication routes		

Table 2: Risk index

Regression analysis and prediction models

A full regression analysis was carried out to investigate the relationship between the identified risk factors and cholera cases using several regression models. The independent variables (risk factors) and the dependent variable (cholera attack rate) were analysed to understand the impact of each factor on cholera outbreaks. A total of 369 data points were used in these regression analyses.

One of the techniques used was multiple linear regression, which models the relationship between several independent variables and a dependent variable. Unlike correlation analysis, multiple regression generates a statistical model that predicts the value of the dependent variable based on the values of the independent variables. This provides a more detailed insight into the interactions between risk factors and cholera cases.

Regression coefficients and indicators

The indicators selected for this analysis are assumed to have a positive correlation with cholera incidences, but some showed a negative correlation. These results were not adjusted, and the values of the regression coefficients were used as is for weighting the risk scores. The results of the analysis reveal that some indicators such as *Dangers*, *Poverty* and *Number of people per health facility* are not correlated with cholera incidence, which highlights the challenges of modelling in complex contexts such as this.

Table 3 summarises the regression coefficients for each indicator, as well as their interpretation in the context of risk map construction:

Indicator	Regression coefficient
Total precipitation	0.243897855
Climate-related disasters	-1.33788162
Inadequate WASH services	-1.33116135
Population density	0.0284090854
Bodies of water	0.0003642931
Poverty	0.144914786
Conflicts	0.400197813
Average household size	1.12069108
Lack of public health infrastructure	0.919938708
Prisons	-0.0433629284
Connected areas	0.109650387
Border areas	-0.503392346
PAMI (Priority Areas for Multisectoral Interventions)	0.131471926

Table 3: Table summarising the regression coefficients for each indicator

It is important to note that all indicators were selected with the expectation of a positive correlation with cholera incidence. However, some indicators show a negative correlation, so using these results poses a risk because of their reliability.

Results of machine learning models

In addition to multiple linear regression, other regression models were tested to see if the coefficients of determination (R^2) could be improved to assess the effectiveness of machine learning in predicting cholera cases. These models included Ridge regression and random forest. A separation of the data into training and test sets was completed.

Model	Training R^2	Test R^2
Linear regression	0.0987	0.0263
Regression Ridge	0.0983	0.0278
Random forest	0.8881	-0.00016

Table 3: Results of model performance analysis

The poor performance of the linear and Ridge regressions (Table 3), as well as the overfitting observed with the random forest, show that these models are not sufficient to effectively predict cholera epidemics in this particular context. The low R^2 values for the linear and Ridge regressions suggest that there is little direct linear relationship between the indicators and cholera incidence, while the overfitting in the random forest model indicates that this model fits the training data too closely and cannot generalise well to the test data.

Conclusion

The results of the regression analysis make it possible to quantify the impact of risk factors on the incidence of cholera. However, the poor performance of the linear and Ridge regression models, as well as the overfitting observed with the random forest model, suggest that better quality data is needed to better predict cholera epidemics in this context.

Risk maps using the INFORM methodology

The risk maps shown in Figure 4 were developed using the INFORM methodology. These maps provide a visual representation of risk levels in the various districts, making it easier to identify priority areas for intervention.

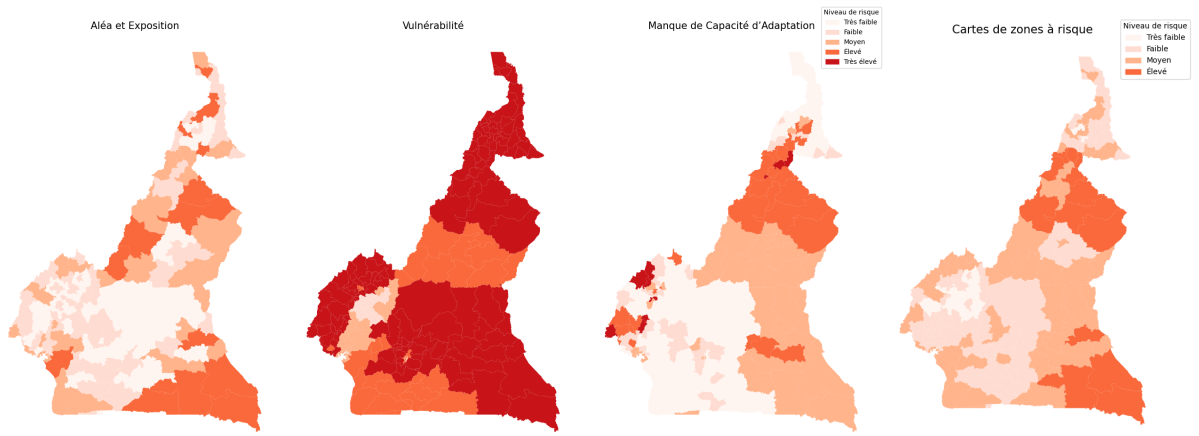


Figure 4: Risk maps using the INFORM methodology

Risk maps with weighting methodology

The results of the multiple linear regression analysis were used as the basis for the creation of risk maps and risk indices, providing an assessment of the risk associated with cholera outbreaks in the different districts. The regression coefficients derived from this model were used as weights for each risk indicator, according to their influence on the cholera attack rate. These weights were applied as part of the aggregation of results to calculate risk scores for each district, which were then plotted on risk maps (Figure 5). The risk maps were represented in the risk categories defined by the INFORM methodology to facilitate comparison of the results.

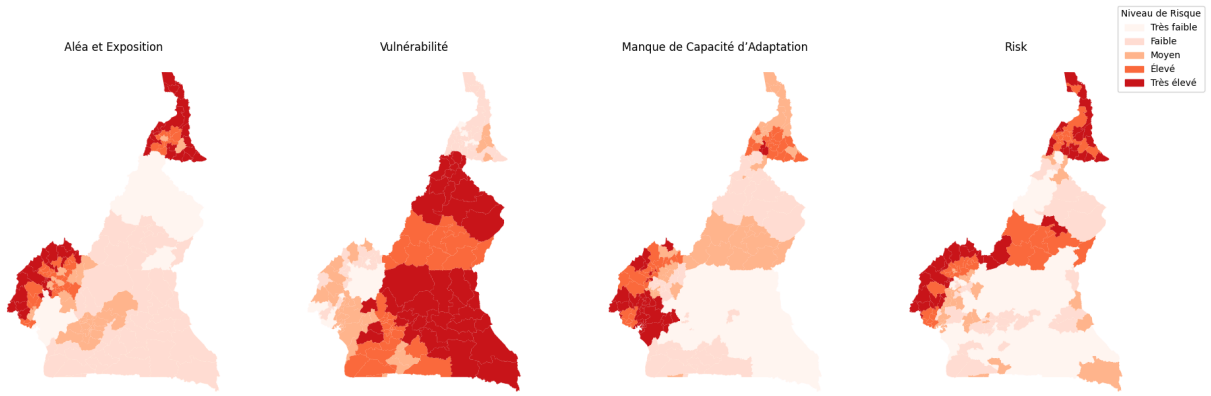


Figure 5: Risk maps using the weighting methodology

The poor performance of the linear regression model suggests that these risk maps generated from the linear regression coefficients may not be reliable.

Choice of final methodology

After a comparative evaluation of the two approaches, the INFORM methodology was chosen for the construction of the maps and the final risk index. This choice was guided by the results of the correlation assessment, which revealed a weak relationship between cholera cases and several indicators identified as significant in the literature. This weak correlation is probably

due to the quality of the available data, which proved insufficient to establish robust and reliable relationships.

In this context, the INFORM methodology was chosen because of its standardised structure and its robustness in the face of data gaps. It enables a coherent integration of multiple dimensions of risk, while compensating for data quality limitations thanks to a more global and systematic approach. This framework thus guarantees a more reliable assessment that is applicable to the realities on the ground.

EAP DETAILS

Trigger model

Early detection and interventions aim to slow the spread of the epidemic and reduce the morbidity and mortality attributable to cholera. Many common hygiene measures, such as water chlorination, latrine use and hand-washing, have helped to reduce the burden of diseases related to faecal peril in "northern" countries. Cholera is a seasonal disease with recognised regional characteristics that can be used to facilitate anticipatory action. There is considerable evidence of seasonal risk factors. The identification of priority areas can facilitate early action interventions in the context of the fight against cholera. In addition, climate change, particularly rising sea temperatures, is likely to favour the appearance or establishment of Vibrio cholerae in coastal ecosystems.

Trigger instruction

Due to the complex risk factors that impact on the likelihood of subsequent cholera transmission, including epidemiological and external factors in most contexts, two consecutive triggers are proposed (Figure 6):

1. **Trigger 1:** A **climatic** trigger that includes hazards that impact WASH infrastructure. Triggered when a district is associated with one or more of the following amplification factors:
    - River or rain **flooding**, with an estimated number of people affected exceeding 2,000, notified by the authorities or CRC volunteers through the community EWS.
    - **Period of heavy rain**, as defined by Cameroon's National Meteorological Department: a period of 4 days with an average daily rainfall of at least 50 mm.

Deadline for completion: 2 months from the start of the flood or period of heavy rainfall.

2. **Trigger 2:** A trigger based on monitoring data. Triggered when a district in which trigger 1 has been activated in the last 3 months is associated with one or more of the following alerts:
    - At least **5 cases of community alert** in the same district notified and validated by a CRC supervisor in the same week.
    - At least **5 suspected cases notified** by the Ministry of Health in the same district in the same week.

- At least 1 **case of** cholera **confirmed** by the Ministry of Health in a neighbouring district in Cameroon and in a border district in another country.

Turnaround time: 5 days

N.B. To activate trigger 2, trigger 1 must already have been activated.

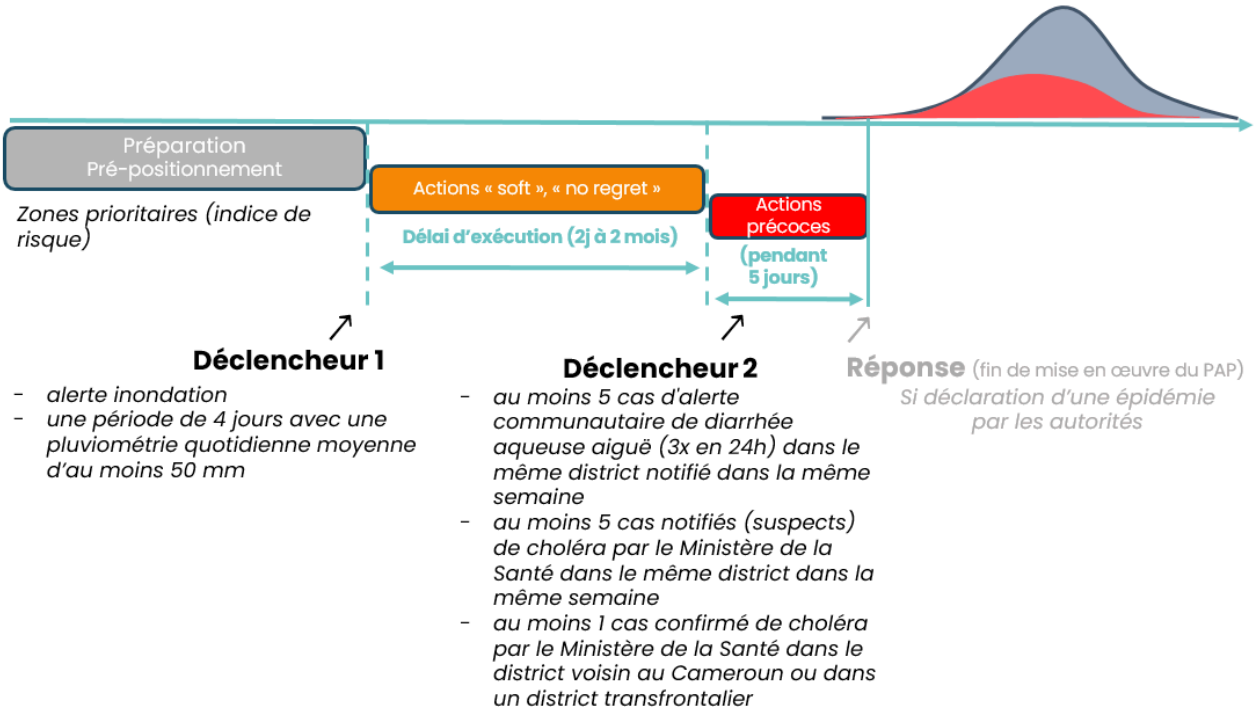


Figure 6: Trigger model

Important definitions of surveillance methodology :

- **Community alert cases** of acute watery diarrhoea (AWD) - defined as anyone presenting three or more watery stools in the last 24 hours - are notified to the Ministry of Health by the CRC's community surveillance.
- There is talk of a **suspected case of** cholera:
    - In areas where a cholera epidemic has not been declared, any person aged two and over with AWD and severe dehydration, or dying from AWD, is notified to the Ministry of Health by its representatives or other state partners.
    - In areas where a cholera epidemic is declared, any person presenting with or dying from AWD is notified to the Ministry of Health.
- **A confirmed case of** cholera occurs when a suspected case of Vibrio cholerae O1 or O139 is confirmed by culture or gene amplification by the Ministry of Health, according to the surveillance process defined below.
- Action is taken before a **cholera epidemic** is defined by the occurrence of at least one confirmed case of cholera and evidence of local transmission. Confirmation of a cholera epidemic in district X triggers an alert and a rapid response in neighbouring districts W, Y, Z or other areas linked by main roads and a communication axis or neighbouring countries.

Forecast selection

Cholera epidemics typically begin with the first case "imported" into the area (usually from a cholera-affected area). Cholera transmission is weak and can spread from one place to another until one or more serious cases result in hospitalisation or death, and the epidemic is investigated and confirmed (biological confirmation).

Often, at the start of a cholera epidemic, local people tend to wait too long before going to the health centre or starting oral rehydration at home. As a result, the majority of deaths occur at the start of an epidemic in an area, demonstrating the importance of early action to prevent widespread mortality. After a few cases and/or deaths in a community, awareness and risk perception of the severity of the disease increases, and people who fall ill are more likely to go directly to the nearest health centre, thereby reducing mortality.

Therefore, given that the national cholera attack rate is estimated at between 2 and 3% (SitReps Ministry of Health), a single case as described above should trigger a response to immediately reduce the number of lives lost. Early action and response activities to prevent further transmission are essential to ensure that cholera does not spread and cause the same consequences in neighbouring communities. This is also why preparedness activities are essential when a case is detected in neighbouring communities. The diagram below demonstrates the impact that early action can have on the overall reduction of potential cholera cases compared to a response after traditional delayed action. It also ensures that resources can be used as effectively as possible to reduce the burden of cholera in high-risk areas.

Trigger 1 uses amplification factors to implement long-term impact actions that the SN will not regret if trigger 2 is not reached or if there are no cholera cases. This trigger should allow for a lead time of two to three months before the planned date of the high-risk period. Trigger 2 uses data on cases of diarrhoea or cholera to implement rapid actions to prevent the occurrence of a confirmed case of cholera and a possible epidemic in the district at risk.

Table 4 shows the forecast data analysed for cholera and how the final forecasts are chosen. For the selected forecasts, **they all have false alarm rates of 0** as they are based on observed data and not forecast modelling data.

Forecast name	Relevant for Cameroon	Turnaround time	Source of justification	Data source
Period of heavy rain	Yes, heavy rains have an impact on the operation of WASH infrastructures	2 months	Climate-Health Bulletin of the National Meteorological Department of Cameroon, scientific literature and humanitarian experience	GPM or National Meteorology of Cameroon
Droughts	No, the inter-institutional group of experts at the EAP design workshops determined that this was not relevant to Cameroon, as it is a tropical country and droughts do not cause cholera epidemics.			

Flooding	Yes, flooding has an impact on the operation of WASH infrastructures	2 months	Scientific literature and humanitarian experiences	Competent authorities or CRC volunteers trained in SCAP
High temperatures	No			
Population movement/relocation	Yes, but there's no data source with the right update frequency to trigger a EAP			
Overcrowding, inadequate water and sanitation, poor nutrition	Yes, but there's no data source with the right update frequency to trigger a EAP			
Community alerts	Yes, ACD is a condition at risk of cholera	5 days	WHO and Ministry of Health	CRC volunteers trained in SBC
Suspected cases of cholera	Yes, by definition	5 days	WHO and Ministry of Health	Ministry of Health or representatives
Confirmed cases of cholera in a neighbouring district	Yes, by definition	5 days	WHO and Ministry of Health	Ministry of Health or representatives

Table 4: Justification for forecast selection

Flooding

With the incidence data available in the cholera management situation reports (SitRep Ministry of Health) published online it was possible to extract case and death data by health district. Unfortunately, due to the poor quality of these data, it was not possible to extract a significant relationship between the incidence of cholera and climatic factors. A qualitative analysis was therefore carried out between the floods[21] and the cases of cholera notified in the SitReps. However, we are certain that this relationship exists, based on the literature, other humanitarian partners[22] , the experience of the Ministry of Health and the experience of the national society.

[21] The floods identified for this analysis have been taken out of this article inventory: https://floodlist.com/tag/cameroon

[22] UNICEF Cholera Factsheet Cameroon Cholera Factsheet_Cameroon_2017_FINAL.pdf

In August 2022, the Littoral, North-West and South-West regions experienced heavy rain and flooding. From 1 October onwards, we have seen an increase in cholera cases caused by these floods. Figure 7 shows the occurrence of cholera cases in 2022 (extracted from SitReps) with an increase in marked cases across several health districts in the Littoral (focused around Douala where flooding was most reported). In the South-West, the SitReps do not include a quantified increase in cases in this period, but the situation maps in Figure 8 (Image 1 and 2) show a change in most of the South-West into an epidemic zone. This includes the Mamfe health district where flooding was reported.

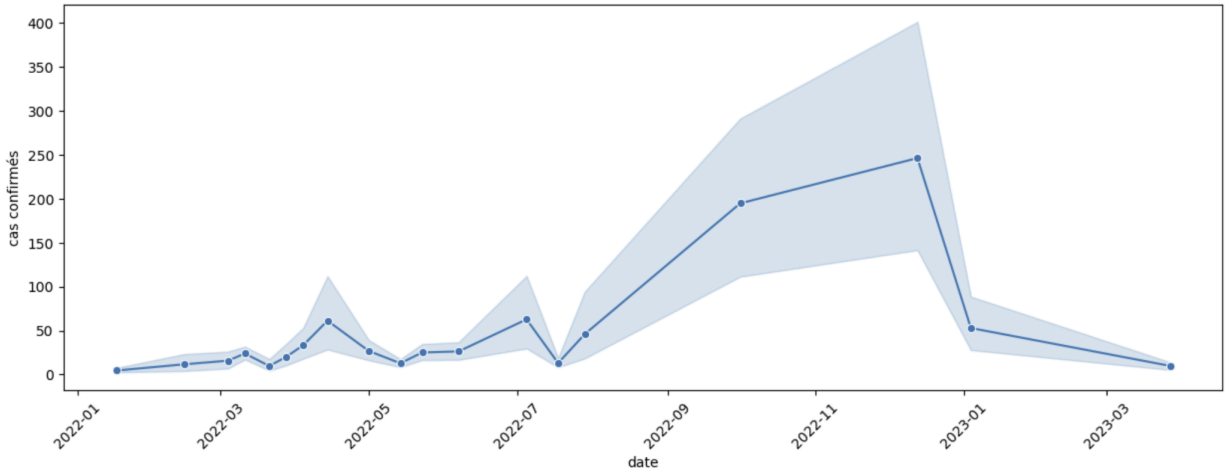


Fig.7 Cholera cases in the Littoral region between 01-01-2022 and 01-04-2023 (source: SitRep); the shaded area corresponds to the confidence interval given the variation within health districts.

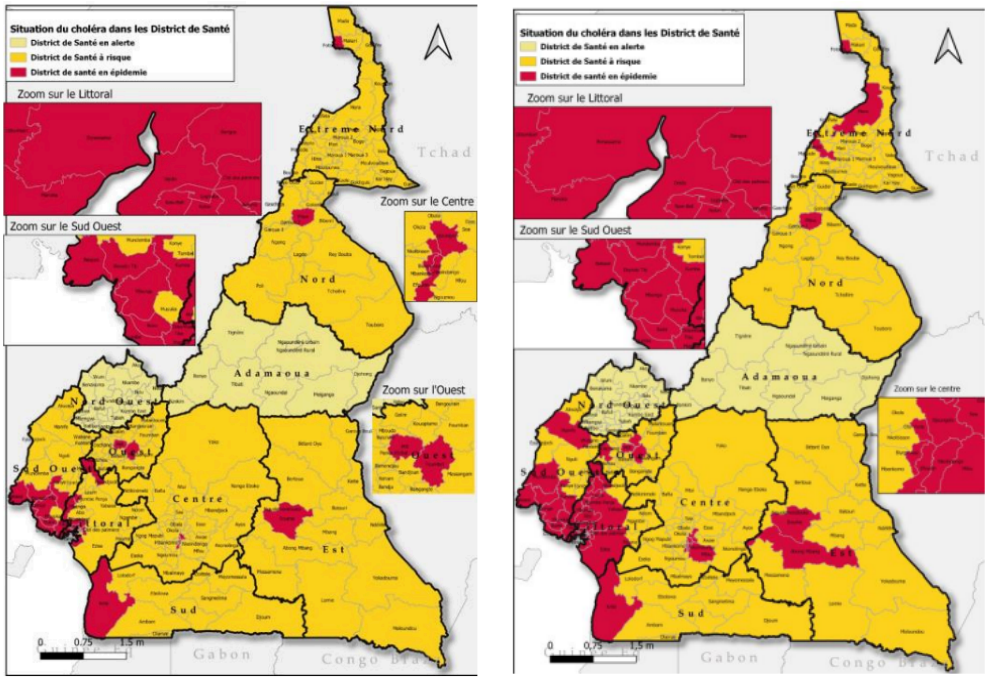


Fig. 8 Left: map of health districts affected by cholera published in the SitRep of 10-08-2022. Right: Map of health districts affected by cholera published in the SitRep of 01-10-2022.

The results of this analysis indicate a correlation between the onset of flooding and cases of cholera, with a delay of 2 months before the incidence of cases is seen.

Community-based surveillance (CBS)

Often, the community is aware of a health risk, but those in a position to mobilise intervention resources receive this information too late to halt the spread of the disease and save as many lives as possible. Community-based surveillance (CBS) aims to remedy this problem and improve the rapid detection of disease. The purpose of CBS is the systematic detection and reporting, by members of a community, of significant public health events within that community.

The CRC has been running CBS in 23 districts* for around a year and plans to extend it to other districts** in the near future. Cholera is already one of the diseases monitored: cases of Acute Watery Diarrhoea (AWD) (see definition below) are collected by CRC volunteers at community level, verified by trained CRC supervisors and reported to the Ministry of Health.

**Northern Region: Garoua I, Garoua II, Guider, Bibemi, Tchollire, Figuil, Gashiga, Golombé, Lagdo, Mayo Oulo, Ngong, Pitoa, Reu Bouba, Touboro; Littoral Region: New Bell, Nkongsamba; Southern Region: Ambam, Sangmélima; Central Region: Mfou, Bafia, Ndikinimeki; South West Region: Buéa, Limbé.*

***Far North region: Makary, Mada, Kousseri, Maroua 3, Moutourwa, Vélé; East region: Bertoua, Yokadouma, Batouri, Abong Mbang.*

The CRC does not yet receive feedback from the Ministry of Health on cases notified via the SBC, so we do not have a direct measure from the government on the veracity of community alert cases, i.e. whether the occurrence of a health risk reported by a CRC volunteer is confirmed by a health professional. However, in other contexts, there is a good concordance between alerts of community cases of acute diarrhoea reported by volunteers through the SBC and suspected cases of cholera. For example, in the Democratic Republic of Congo (DRC), where the Red Cross receives feedback from the Ministry of Health on a case-by-case basis, 100% of community alert cases were "validated as real cases", and treated as suspected cholera cases after investigation by health workers (source: DRC Red Cross, 304 suspected cholera cases in 13 health areas in the Uvira health zone over approximately two years).

Trigger execution time based on monitoring data.

Health experts at the SN say that it takes an average of 5 days or more from the notification of cases to the health district to the end of the Ministry of Health's field investigation, including laboratory tests. Only then is the epidemic declared and the response can begin.

Definition and justification of impact levels

Table 5 justifies the definitions of the impact levels of the selected forecasts.

Forecast name	Impact level	Potential alerts	Source and justification
Period of heavy rain	Average 50 mm/day for 4 days	Every 2 years	Historical data ECMWF Reanalysis v5 (ERA5)[23] , multi-risk bulletin from the National Meteorological Directorate of Cameroon[24]
Flooding	2,000 people affected	Every 2 years	DREF floods delivered by the CRC in the last 17 years
Community alerts	5	Conditional on trigger 1 frequency	Given an average rate of positive tests, i.e. the ratio of culture-confirmed cases to suspected cases, of 40±23% over the period 2022-2023 (source: SitReps Ministry of Health[25]), this corresponds to an 80% chance of having at least one confirmed case, and therefore of an epidemic breaking out.
Suspected cases	5	Conditional on trigger 1 frequency	
Confirmed cases (in a neighbouring or border district)	1	Conditional on trigger 1 frequency	A confirmed case triggers an epidemic, so action is taken in the neighbouring district to prevent the epidemic spreading.

Table 5: Justification of impact levels

In addition to the evidence in Table 2, historical data over the last 2 years has been analysed to determine the number of potential alerts for this EAP. The first trigger of 50 mm mean daily rainfall for 4 days was exceeded 39 times, of which 5 were PAMIs. Then there were 6 exceedances of the second trigger of 5 suspected cases (this analysis did not include the community case and confirmed case thresholds due to a lack of data). Of the 6 exceedances, all were on the Littoral and on 01-10-2022, and 2 were PAMIs. This analysis therefore shows that, with these trigger thresholds, the full EAP would have been activated 1 time between 2021 and 2023, in two districts at the same time, Japoma and Njombe Penja.

[23] https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5

[24] Multirisk Meteorological Bulletin: https://meteocameroon.gov.cm/download-category/bulletins-santes-multirisques/

[25] Situation Report: https://www.ccousp.cm/urgences-sanitaires/cholera/situation-cholera-cameroun/

Selection of early actions

The actions proposed under this EAP aim to prevent the occurrence of a cholera epidemic following a flood or to reduce the morbidity and mortality linked to this disease should an epidemic occur despite the implementation of early actions. Early actions were selected using a participatory approach based on a step-by-step process.

Preliminary work carried out by the Cholera and WASH focal points of the Cameroon Red Cross, based on actions with convincing results on the occurrence of diarrhoeal diseases in general and cholera in particular, and the operational capacities of the CRC.

In a second phase, thematic groups were set up to discuss these actions during two workshops (the first in March 2024 and the second in October 2024) in Yaoundé with representatives of the State's technical services (Ministry of Health through the Directorate of Disease Control; Ministry of Water and the National Institute of Statistics), as well as representatives of international organisations (WHO, UNICEF, MSF, ACF, etc.) and community representatives through the local branches of the Cameroon Red Cross. All these stakeholders have proven experience in managing the prevention, preparation and response to cholera epidemics.

During the final workshop, all these proposed actions were discussed in group work and a prioritisation of actions was made, based on those that would have the greatest effect on these impacts. The selection criteria were :

- Understanding the local epidemiology of cholera - including identifying geographical and temporal patterns, as well as at-risk populations and specific risk factors
- The effectiveness of the action in preventing the occurrence of a cholera epidemic or reducing the impact should one occur
- The financial feasibility of the project
- Temporal feasibility, i.e. feasibility within the execution window, i.e. between the threshold being exceeded (and therefore the alert) and the event occurring.
- The CRC's organisational and operational capacity to implement them
- The existence and/or functionality of a community-based surveillance system
- Improved and agile control capacity to limit the spread of cholera thanks to rapid control teams (including WASH, OCV and Community Engagement).

These criteria have been used to prioritise the actions below.

	WASH	HEALTH	CREC/PGI	COORDINATION

Preparation and pre-positioning actions	• Training volunteers and supervisors in various responses: disinfection, awareness-raising, sanitising water points, using water purifiers, preparing and setting up oral rehydration points, etc. • Setting up/revitalising hygiene committees in high-risk areas • Acquisition and pre-positioning of water purifiers • Acquisition and pre-positioning of inputs for chlorine production by CRC teams for disinfection • Acquisition of hand washing devices	• Training healthcare staff in ICP and case management • EPIC training (including ERP modules) for volunteers • Implementation of surveillance and case notification (SBC) • Cholera hot-spot risk analysis (dashboard observation, SBC, hospital survival, etc.) • Acquisition and pre-positioning of Oral Rehydration Salts (ORS) to support the management of the first cases • Purchase, provision and prepositioning of ICP kits (chlorine, soap, gowns, gloves, etc.) for CRC health facilities and other health facilities (public and private). • Raising awareness of the EAP among CRC staff • Regular EAP monitoring meetings	• CREC and PGI training for volunteers and healthcare staff • Lifeline training for press representatives • Workshop to adapt, produce and validate tools for different channels of communication with communities on cholera (posters, leaflets, picture boxes, audio messages, etc.): ensure community participation in drafting key messages and adapt communication tools according to community needs and risk mapping (ensure products are translated into local languages). • Acquisition of communication tools (posters, leaflets, image boxes, etc.) • Dissemination of tools	• Participate in coordination meetings to discuss surveillance and preparatory details (led by the MoH) • Organisation of EAP monitoring meetings with local players and preparation stakeholders

			• CEA and community awareness-raising on cholera: informing the population about modes of transmission, cholera symptoms and preventive measures (mobile cinema, interactive radio programmes, focus groups, posters, leaflets, picture boxes, town criers, door-to-door, etc.).	

Trigger 1 actions	• Carrying out a rapid vulnerability assessment (including ERP aspects)	• If CBS is not yet active in the district: train volunteers and supervisors in SBC, and set up • If the SBC is already active in the district: reminder of the SBC training with the volunteers (complement the training in the preparation plan with just-in-time training and briefings) - refresher before intervention • Intensified surveillance and case notification (SBC)	• Stepping up community awareness-raising in public places (schools, markets, etc.): Informing the population about how water-borne diseases are transmitted and about preventive measures (mobile cinema, interactive radio programmes, focus groups, posters, leaflets, picture boxes, town criers, etc.). • Hand-washing and water purification demonstrations • Implementing/strengthening the CRC's community feedback system and transparent community feedback mechanism, taking into account the gender and inclusion aspect. • Encourage women and young people (girls and boys) to play a leading role in early action (water management, domestic hygiene, etc.).	• Participate in coordination meetings with all actors and stakeholders once the EAP has been launched and the epidemic is underway (led by the Ministry of Health) • Supervision of EAP implementation activities
Trigger 2 actions	• Distribution of water purifiers (for domestic use) • Analysis of water quality (spot-checking chlorination) in homes • WASH disinfection of households (patients' beds, toilets and kitchens) where one or more suspected cases have been reported. • WASH disinfection (households, schools, markets, public services, etc.) where one or more suspected cases have been reported. • Cleaning up water points	• Distribution of Oral Rehydration Salts (ORS) to notified alert cases (then referral to care structures).		

Indicators	• *# of volunteers and supervisors trained in various WASH responses (targets: 150 volunteers, 10 supervisors)* • *# of sites capable of producing chlorine at CRC branches for disinfection as part of the cholera EAP (target: 5)* • *% of public places having benefited from disinfection (households, schools, markets, public services, etc.) after the launch of the EAP (target: 100%)* • *% of early WASH actions carried out according to the EAP timetable after trigger 1 and/or 2 (target: ≥ 90%)* • *Percentage of households identified having benefited from a distribution of water purifiers, aquatabs/emergency tablets after the launch (1 and/or 2) of early actions (target: 80%)*	• *# of healthcare workers trained in ICP and management of cholera cases (target: 20)* • *# of CRC volunteers and supervisors who have received EPIC training (targets: 150 volunteers, 10 supervisors)* • *# of ICP kits (chlorine, soap, gowns, gloves, etc.) for health facilities (Target: 20)* • *% of CRC volunteers who are active in DBS as part of the implementation of the EAP after trigger 1 and/or 2 (target: ≥ 95%)* • *% of early health actions carried out according to the EAP timetable after trigger 1 and/or 2 (target: ≥ 90%)*		• *% participation in various coordination meetings with local players and stakeholders to discuss epidemiological surveillance and epidemic preparedness and response (led by the Ministry of Health) (target: 100%)*

Recommendations made by the committee to prioritise early action.

LESSONS LEARNED FROM THE DEVELOPMENT OF AN EARLY ACTION PROTOCOL (EAP) FOR EPIDEMICS

Step 1: Assess feasibility and commit to FbF

Objective: To identify whether the epidemiological context, data systems and institutional capacities are suitable for implementing an FbF mechanism.

Key actions :

- Analysing available data: collecting climatic, epidemiological and demographic data.
- Assess disease-specific risks: nature of target epidemics and their potential climatic triggers.

Lessons learned from the cholera EAP in Cameroon :

- **Data sharing**: It is imperative that the National Society (NS) establishes robust agreements with the Ministry of Health and other sectors to access relevant epidemiological and climate data. The absence of such agreements can considerably delay, or even prevent, the design of the EAP, as the data on which the feasibility analysis is based is fundamental to understanding epidemic trends and defining relevant triggers.

- **Targeting climate-influenced epidemics**: It makes sense to target epidemics that are significantly affected by local climatic factors. This reinforces the commitment of local stakeholders to the importance of developing an EAP for this epidemic. In addition, the inclusion of these climatic factors allows for a longer forecasting time, thus facilitating the feasibility and effectiveness of anticipated actions.

Step 2: Involve stakeholders

Objective: Create cross-sector coordination between stakeholders.

Key actions :

- Map the stakeholders involved: ministries, NGOs, technical partners, communities.
- Conduct inclusive consultations to define priorities, such as the epidemic to be targeted in the EAP
- Assess existing capabilities, strategies and plans
- Establish clear roles and responsibilities.

Lessons learned from the cholera EAP in Cameroon :

- **National integration**: Before developing a EAP, it is essential to understand and assess the state of existing anticipatory action initiatives in the country, whether these are local or national projects. This assessment should include collaboration with the Ministry of Health and other sectors as necessary to ensure that the EAP complements and integrates seamlessly with existing disease control strategies, such as priority disease elimination or control plans.

- **Clarification of financial roles**: When drawing up a EAP, it is essential to explain to partners that this mechanism provides exclusive funding for the NS and the IFRC regional cluster, and that any external partner wishing to participate will have to mobilise its own resources. This point is often misunderstood and has sometimes led to unrealistic expectations on the part of stakeholders. The example of the Philippines, where common triggers are used but funded independently by OCHA and the local Red Cross, is a model to follow if stakeholders want to collaborate on anticipatory actions.

Step 3: Setting up an FbF programme

Objective: To create the infrastructure needed to activate the EAP in a timely manner.

Key actions :

- Train operational teams in the use of predictive tools and trigger thresholds.
- Train all stakeholders involved in the FbF

Lessons learned from the cholera EAP in Cameroon :

- **Time availability**: The process of designing an EAP is time intensive and requires a prolonged commitment from the NS. Identifying a focal point within the NS and the Ministry of Health from the outset is crucial to coordinate the process effectively and minimise delays due to organisational constraints.

- **Local capacity building**: If the NS has limited capacity for community-based surveillance, it is important to build this capacity upstream. Community-based surveillance plays a central role in collecting the data needed to develop a robust EAP, especially in contexts where national surveillance systems are limited.

Step 4: Develop an Early Action Protocol (EAP)

4.1. Defining the trigger

Objective: Identify precise thresholds to trigger action.

Key actions :

- Develop centralised databases for climate and health data.
- Analyse correlations between climatic and epidemiological data.

- Set measurable indicators (e.g. increase in cases, temperature/humidity thresholds).
- Define and justify your level of impact

Lessons learned from the cholera EAP in Cameroon :

- **Use of community-based surveillance data:** For epidemics that are not influenced by climatic hazards, community-based surveillance data becomes essential for establishing trigger thresholds. This approach enables the early detection of cases that could lead to the outbreak of an epidemic by eliminating dependence on data on suspected cases notified by the Ministry of Health. However, this method relies on the collection capacity and reliability of community surveillance systems, which can vary depending on the context. Often the CBS exists where there are projects funding them, so that coverage of the whole country is insufficient to predict all epidemics and function as a surveillance system for a EAP. So setting up the DBS as an action after an initial climatic trigger is essential to supplement the insufficient coverage.

- **Complexity of predicting epidemics:** Unlike climatic hazards such as floods, for which thresholds can be defined on the basis of historical data and return time probabilities, epidemics pose unique challenges due to their unpredictable spread. One of the key criteria in the development of a EAP is that triggers should not lead to frequent activations, but only once every five years according to the rules in force (trigger frequency currently under discussion within the IFRC Validation Committee). This considerably limits the scope for identifying reliable thresholds that require precise calibration of epidemiological models.

- **Problems linked to insufficient data :** In many cases, robust quantitative data correlating climatic hazards and disease are lacking. In this context, a qualitative approach is often necessary, albeit less robust. In Cameroon, the EAP team had to rely on discussions with local experts to establish trigger levels for cholera, based on their expertise and experience of local epidemiological and climatic conditions.

- **Crucial role of government technical services:** Meteorological and hydrometeorological services play a key role in defining the trigger thresholds. These services often have historical data and tools that they already use for their own warning systems. In Cameroon, for example, cholera alert thresholds are defined in the meteorological services' climate-health bulletin. The existence of these thresholds has reinforced the relevance and feasibility of the EAP. Collaboration with government technical services makes it possible to use pre-existing alert thresholds as a starting point, while adjusting them to the specific needs of the EAP.

- **Importance of involving national stakeholders:** Involving national technical services in the process of defining thresholds ensures that the EAP benefits from a local knowledge base and alignment with existing warning systems. This also contributes to strengthening the legitimacy of the EAP among national stakeholders and facilitates its implementation in the event of a trigger.

- **Valorisation of existing PAMIs for a cholera EAP:** It is essential to recognise that the identification of PAMIs (priority areas for multisectoral interventions) is already a reference method widely used and accepted by ministries of health in countries affected by cholera. Adopting new methodologies can prove complex, as there is a certain institutional inertia towards established approaches. The use of PAMIs, which are already integrated into national cholera control planning processes, has an

important advantage: it is recognised and supported by national authorities and is aligned with the Global Taskforce for Cholera Control (GTFCC) roadmap for cholera elimination, which facilitates the collaboration and commitment of local stakeholders. In this context, it is more appropriate to build on this proven methodology rather than attempt to introduce new risk analysis methods that may be perceived as redundant or difficult to integrate. In order to guarantee the effectiveness of interventions and maximise their impact, priority should be given to the use of PAMIs and results from this approach, while ensuring that they are regularly updated to reflect epidemiological and contextual developments.

4.2. Selecting early actions

Objective: Determine targeted actions to limit the impact.

Key actions :

- Identifying potential early action
- Tighten the list of early actions and prioritise them.
- Developing theories of change

Lessons learned from the cholera EAP in Cameroon :

- **Cross-sectoral consultation**: Identifying and budgeting for early actions required lengthy consultations with CRC focal points in sectors such as CEA, WASH, PGI and Health, due to the dispersal of responsibilities between these sectors. This process, although time-consuming, ensures that all stakeholders feel invested in the priorities and that budgets are balanced to maximise the impact of the actions.

- **Limitations on the role of the NS**: Certain key actions, such as immunisation, are primarily the responsibility of the Ministry of Health, which limits the possibility for the NS to integrate these actions directly into the EAP. This is due to the central role of the Ministry in the management of immunisation campaigns, which often exceeds the operational and legal capacities of the Red Cross. As a result, the EAP must focus on interventions where the National Society has direct expertise and a clear implementation role.

- **Support the Ministry of Health**: To help collaboration with the Ministry of Health, the EAP can include measures to support the Ministry of Health during the preparatory phase. For example, allocating a budget for the training of health personnel or the pre-positioning of essential inputs, such as vaccines and medical equipment, can improve the effectiveness and speed of the response to epidemics. Although these measures are not activated immediately before an epidemic is declared but afterwards, they strengthen institutional preparedness and consolidate collaboration between the Red Cross and the health authorities, while affirming the National Society's auxiliary role with the public authorities.

- **Theories of change:** In developing a theory of change for a EAP, it is imperative to carry out a cause and effect analysis based on existing evidence in order to select early actions, but also to take into account the expertise and the organisational and operational capacity of the NS to implement the recommended interventions. In addition, it is also important to consider the roles and responsibilities delegated to the SN as an auxiliary of the State, and to identify the possibilities for complementarities

and synergies between key players. The link between these different aspects is the basis for the relevance, effectiveness and sustainability of the actions planned under the EAP.

- **Choice of early actions:** The selection of appropriate early actions within the framework of an epidemic EAP is the subject of much technical discussion, especially as it involves two types of early action. The first is preventive early action (taken upstream of the epidemic when climatic or meteorological triggers exist and are reached), the aim of which is to avoid the occurrence of an epidemic or to reduce its scale when it does occur. The second group of early actions, which are implemented when cases are detected (i.e. downstream of the epidemic), can be likened to response actions, the aim of which is to break the chain of transmission in order to rapidly control the epidemic by reducing incidence (i.e. modifying the natural evolution of the epidemic curve) or reducing mortality. As part of the development of Cameroon's cholera EAP, the latter were the subject of long and intense discussions in a small group as to whether they belonged to anticipatory actions. In order to better manage the discussions, preliminary work was carried out by the Cameroon Red Cross Cholera and WASH focal points and reviewed by a small group prior to the validation workshops with stakeholders. This upstream work facilitated discussions within the thematic groups on the relevance of the early actions chosen and the addition or deletion of some through two workshops at central level with representatives of the State's technical services and those of certain organisations with proven experience in epidemic preparedness and response. In the light of the discussions, it was deemed essential to retain certain early actions that could be assimilated to response actions capable of reducing the scale of the epidemic when it occurs despite the implementation of early prevention actions once the threshold of climatic or meteorological triggers has been reached.

4.3. Drawing up a monitoring and evaluation (M&E) plan

Objective: To assess the effectiveness of anticipatory actions.

Key actions :

- Define indicators to measure results (response time, case reduction).
- Set up tools to collect post-intervention data.

Lessons learned from the cholera EAP in Cameroon :

- **Choice of indicators**: The design and proposal of indicators must take into account effectiveness indicators for the EAP's actions, but also those that can evaluate the EAP's deployment process. The latter were omitted from the Cameroon cholera EAP because the actions and indicators were initially proposed for each sector without any real interaction between these sectors. As a result, discussions on taking process indicators into account were marginalised and took place in the final hours of EAP finalisation. As the last few hours were marked by a rush to finalise, joint reflection on indicators (process, effectiveness, effects and impacts) should be initiated when the early actions are selected. This approach would enable an in-depth and participatory analysis to be carried out, so as to have a set of SMART indicators and draw up an optimal and effective monitoring and evaluation plan.

- **Setting up data collection tools:** An early warning system that manages data from an EAP can also function as a source of data for verifying post-intervention indicators. A digital tool can provide a space for managing activities, as for cholera EAPs, the early warning system contains a module for managing activities and their impact.

4.4. Simulate

Objective: To test the feasibility and effectiveness of the protocol.

Key actions :

- Run simulations to test triggers and coordination.
- Adapt the protocol according to the results of the simulations.

Lessons learned from the cholera EAP in Cameroon :

- **Small-scale simulation before a full-scale simulation:** A simulation in the form of a table-top exercise may prove to be more than sufficient to draw valuable lessons on how coordination around the EAP works within the National Society. Therefore, if a full-scale simulation, including the implementation of certain planned early actions, is envisaged as part of the development of the EAP, it is strongly recommended to start with this simulation on a reduced scale. This will allow the coordination aspects of the EAP to be worked on in advance and the necessary improvements to be made before moving on to a more complex simulation, thereby increasing the chances of success of the full-scale exercise.

- **Planning strategic roles**: During simulations, the absence of key figures such as the General Secretary (GS) or his assistant can lead to unforeseen debates and disrupt the smooth running of exercises. This situation underlines the importance of planning ahead and designating a clearly identified replacement who is accepted by all stakeholders. This ensures the continuity of strategic discussions and the effectiveness of the exercises, by avoiding interruptions or disagreements linked to an unanticipated absence.

- **Timing and organisation of activities**: To optimise the value of tabletop exercises, it is essential to organise them in such a way as to maximise the active participation of the key players involved in the EAP. This prevents certain players from finding themselves without a relevant role, making the simulation less productive. Furthermore, as the afternoons of the workshops are often marked by a decline in the dynamism and interactivity of the participants, critical activities, such as the simulation of trigger or coordination meetings, should be planned in the morning. This approach capitalises on the energy and attention of the participants to obtain usable results and reinforces the quality of the exercise.

CONCLUSION

Response capacities of the health system and the Cameroon Red Cross

The evaluation of the capacities of the Cameroonian health system and the Cameroon Red Cross (CRC) highlights strengths and limitations in the anticipatory response to cholera epidemics. On the one hand, the Ministry of Health (MinSan) has a structured surveillance system, supported by networks for collecting and analysing epidemiological data. This system enables the rapid identification of high-risk outbreaks, although it is hampered by challenges relating to the accessibility of remote areas, limited human resources and manual reporting of cases.

On the other hand, the CRC has a solid organisational structure, supported by trained volunteers who can be mobilised throughout the country. However, shortcomings in stock management, limited data sharing with the MinSan, and the absence of certain planning tools, reduce its effectiveness in anticipatory actions.

The strategic recommendations presented aim to strengthen collaboration between the various players involved in managing cholera in Cameroon. The alignment of objectives, integration into existing mechanisms, the creation of simple protocols and the use of a shared information system are key elements in improving the effectiveness of the health response. These analyses highlight the need for greater coordination between the MinSan and the CRC to optimise existing resources and capacities. A collaborative and integrated approach, combining the strengths of both entities, could significantly improve preparedness, anticipation and response to cholera epidemics, by proactively and effectively anticipating risks.

Cholera Risk Analysis in Cameroon

Data limitations and analysis risks

Interpretation of the results of this risk assessment must be approached with caution due to the inherent limitations of the available data. One of the main challenges has been the lack of high-resolution data. Unlike climate data, which is often available at precise scales, socio-economic data is generally limited to regional and district levels, making it difficult to identify very localised trends.

Key indicators, such as population movements and vaccination coverage, could not be included in the analysis due to insufficient or non-existent data. These shortcomings reduced the precision of the assessment and limited the scope of the results obtained. However, the use of open-access data enhanced the feasibility of this research, underlining the importance of such sources in overcoming constraints in the construction of epidemic risk indices.

Final result and integration into the EAP

Identifying priority areas for multisectoral interventions (PAMIs, sometimes called "hot spots") for cholera control is one of the first steps in developing or revising a national cholera control

plan (NCP) in a cholera-affected country. The methodology, advised and guided by the GTFCC (Global taskforce for cholera control) and was identified as part of Cameroon's cholera elimination plan to 2030. The PAMIs were identified by the Ministry of Health with the support of several partners (e.g. WHO, CRC, and MSF) and the first draft of the PAMIs was finalised in January 2024.

As part of the risk assessment for this EAP, it was decided to rely primarily on the PAMIs because of the confidence they inspire among stakeholders and their institutional recognition in Cameroon. This preference for PAMIs reflects a desire to use a well-established methodology that has already been integrated into national cholera control processes, and to avoid introducing a new risk index that is perceived as redundant or too complex to integrate.

However, the additional analysis described in this document was carried out to enrich the PAMIs. This analysis involved incorporating additional quantitative data and weighting the indicators according to their relevance to cholera risk. Although this collaborative approach did not result in the creation of a new independent risk index, it did help to refine the priorities set out in the PAMIs by providing insights based on additional data.

This combination of methodologies highlights the importance of striking a balance between analytical innovation and institutional acceptability. It also shows that it is essential to continue to promote collaborations that combine analytical rigour, local expertise and institutional anchoring, in order to improve the planning and effectiveness of responses to cholera.

Lessons learned from the development of an Early Action Protocol (EAP) for epidemics

In conclusion, this section has presented a structured guide for the development of an Early Action Protocol (EAP) for a specific epidemic, based on the principles of Forecast Based Financing (FbF) and the key resources available within the International Red Cross and Red Crescent Movement. The lessons learned from the innovative experience of the Cholera EAP in Cameroon have enriched the FbF principles, providing concrete guidance for the writing of an FbF manual specific to epidemics. This framework aims to strengthen the preparedness and responsiveness of National Societies to epidemics, maximising their humanitarian impact through better coordination, planning and use of forecast data.

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