Getting ahead of the curve; using cholera risk information to act earlier

Summary of the Yemen case study

The Early Action for Cholera (EACH) project has explored how cholera risk information and rainfall forecasts were used by UNICEF (and partners) in Yemen to inform cholera response. Analysis of the accuracy of the University of Florida's Cholera Risk Model (CRM) and the Met Office's rainfall forecasts has been undertaken and recommendations are made about how these tools could be more widely used to support planning and preparation and earlier cholera control.

About cholera

Cholera is a highly contagious diarrhetic infection which is transmitted through the consumption of contaminated water or food. If untreated, it can kill within a matter of hours. Regarded as a disease of inequality, cholera presents a major threat to lower income countries with poor quality drinking water and sanitation systems. Natural disasters and conflict also increase susceptibility to outbreaks of the disease.

Cholera in Yemen

Before the war in Yemen, which started in 2016, the country was predisposed to cholera due to its high levels of poverty, frequent droughts, and poor sanitation infrastructure. The widespread displacement of people, food shortages and other conflict-related impacts led to one of the worst cholera epidemics in modern times; between October 2016 and January 2020 over 2.3 million cases and nearly 4,000 deaths were reported.

UNICEF play a key role in cholera prevention and response in Yemen and coordinate water, sanitation, and hygiene (WASH) interventions. These include the provision of safe drinking water and sending teams of volunteers into communities to run hygiene programmes. The International Committee of the Red Cross, World Health Organization (WHO), Oxfam, Medécins San Frontiers and other international and local NGOs are also involved in cholera prevention in Yemen and work with the government's Ministry of Water and Environment (MoWE).

Why cholera risk information was used in Yemen

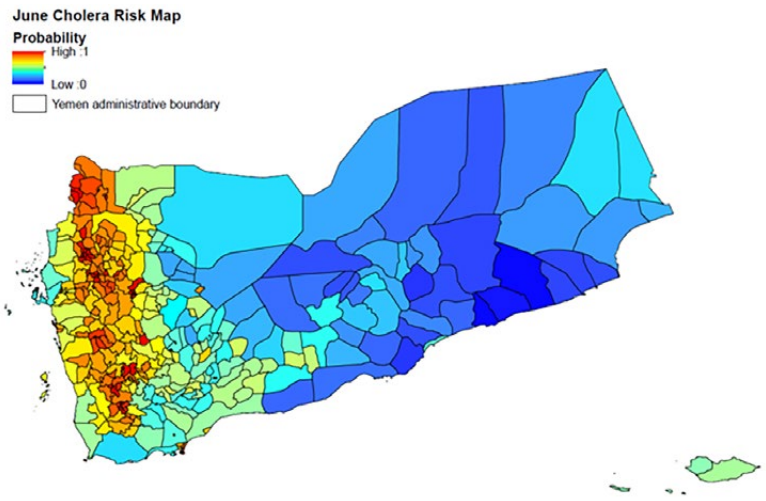
As the association between environmental factors and cholera had been established (Camacho et al 2018, Eisenburg et al, 2013, Hashizume et al, 2008), the use of a tool was proposed to help prioritise cholera interventions to help ensure the response to the outbreak remained dynamic.

Treating cholera in Yemen.

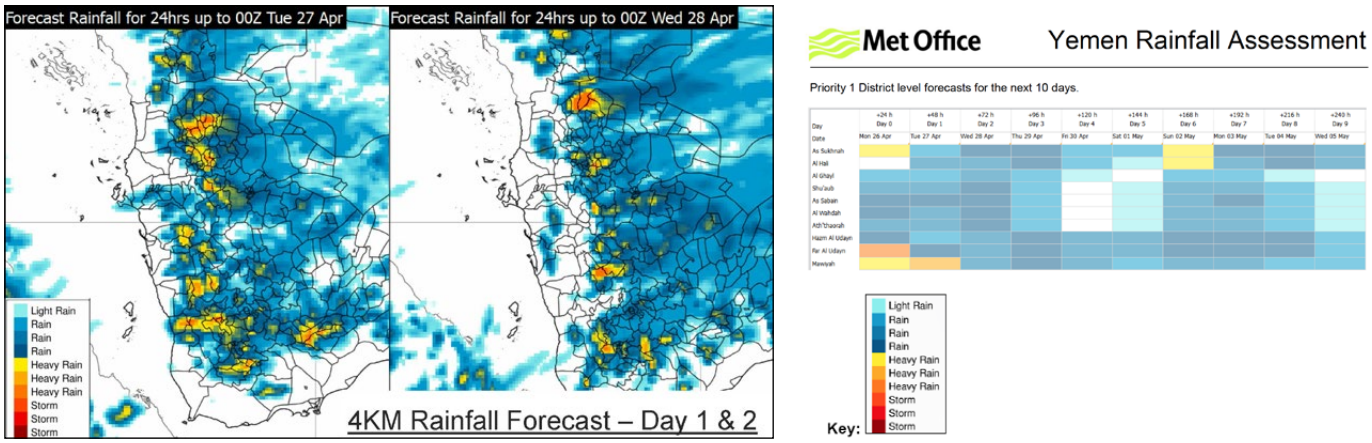
Supported by the UK's Foreign, Commonwealth and Development Office (FCDO), UNICEF began to receive weekly reports from the University of Florida's Cholera Risk Model (CRM) in 2018. They also started receiving weekly rainfall forecasts from the Met Office, the UK's national meteorological service, in 2018.

Cholera Risk Model

The CRM provides an indication of cholera risk which is valid for 4 weeks (from issue date). Based upon rainfall and temperature data, information on population density and movement and, where available, WASH data, the model's algorithm then calculates a risk score for cholera. This is presented in a series of maps along with a brief description on how to interpret the risk values.



Example of CRM output for Yemen.



Example of rainfall forecasts provided to UNICEF Yemen.

Rainfall forecasts

The Met Office provides rainfall information to users in Yemen on a weekly basis. This includes a 7-day hindcast, a 7-day forecast, a 4-week forward outlook, and a summary highlighting high-impact weather. It also includes maps showing the spatial distribution of rainfall and tables giving forecast rainfall, by category, for specific locations around the country.

How the information was used by cholera responders in Yemen

Cholera monitoring and response is coordinated by an Emergency Operations Centre. The centre prepares a table of the administrative districts most affected by cholera. The CRM risk scores and rainfall forecasts are considered alongside this data and the districts are then ranked into low-high risk categories according to where there are cases already and where predictions suggest these will increase. The most appropriate action to take in high-risk districts is then identified, based on local contexts.

A significant drop in cholera cases was observed in Yemen during 2018. For example, during one week in 2018, there were 2,500 cases, compared to 50,000 during the same week in 2017. The drop in cases was attributed anecdotally by UNICEF to the forecast based early intervention actions they had been taking, using the information from the University of Florida and the Met Office.

The approach taken by UNICEF and partners in Yemen represents a novel way of tackling infectious diseases by bringing interventions forward, using predictive tools. Whilst well established in humanitarian contexts, the concept of 'anticipatory / early action' is nascent in the field of cholera control.

Validation: How reliable were the CRM and rainfall forecasts provided in Yemen?

To understand whether the continued use of these tools in Yemen is appropriate, and to explore the scalability of the approach to other countries, the validity of the CRM and rainfall forecasts in Yemen was assessed.

To validate the CRM, its predictions in 2017, 2018 and 2019 were compared to recorded cases of cholera in Yemen. In the most populous governorates (comprising about 80% of the Yemeni population), the CRM's predictions were accurate 60% of the time. Assessments of the CRM's performance in other countries also supports these findings. Analysis of sensitivity, specificity, accuracy and precision, and negative predictive value, indicate changes in model risk scores predict change in number of cholera cases locally in Yemen. The CRM had the highest accuracy in 2017, followed by 2019 and 2018. Cholera has occurred consistently in Yemen each week from 2017 to 2019 and this suggests cholera is becoming endemic.

The precipitation from the Met Office forecast models used in the weekly rainfall assessments was validated against observation data. As there was an absence of in-situ rainfall observations in Yemen, satellite derived rainfall observations were used to investigate model accuracy. The forecast rainfall was given one of five categories, from light rain to storm, each with a specific threshold. The analysis showed that light rain was typically forecast to be within 11 km of the observation, whereas for heavy rain, the location accuracy was at least 160 km. The accuracy of the Met Office Global Model is higher, or similar, to models from other National Weather Centres.

Getting ahead of the curve: using cholera risk information to act earlier

(in contexts where cholera prevention activity is already underway)

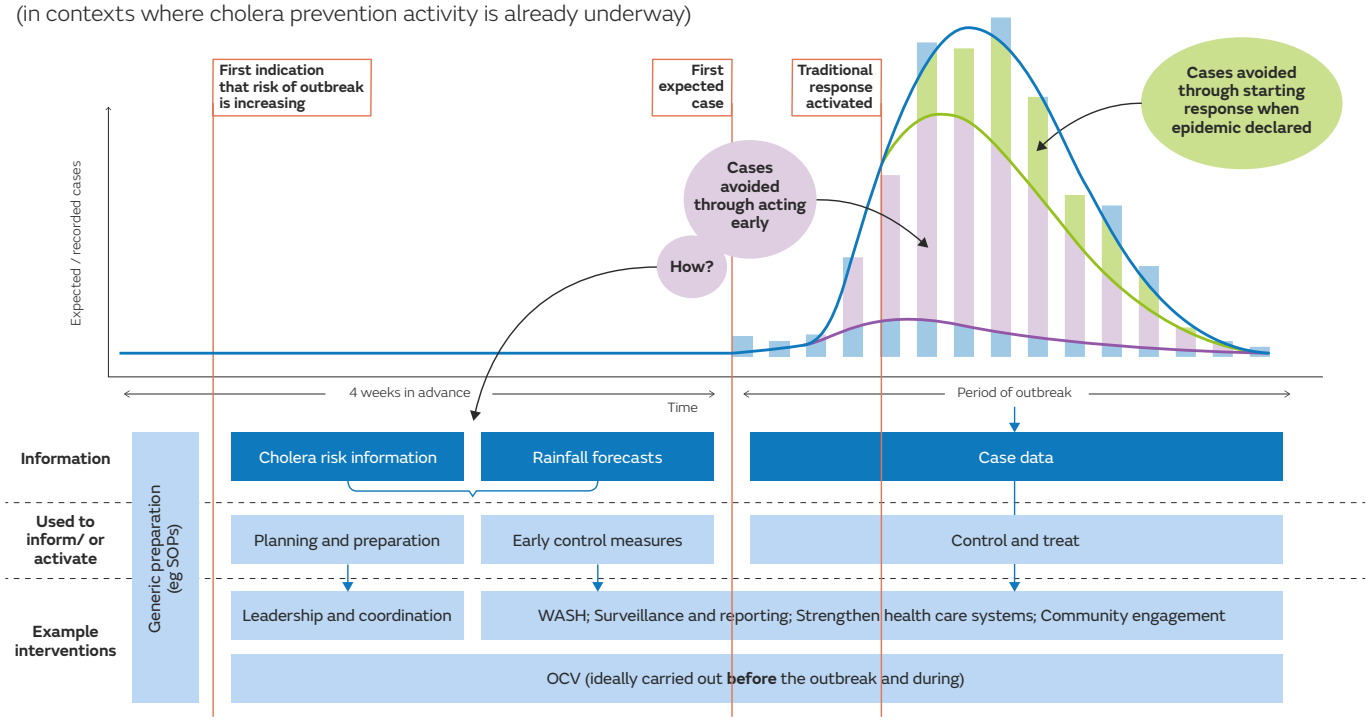


Figure 1 illustrates how using the CRM and rainfall forecasts could influence the epidemic curve of a hypothetical cholera outbreak.

Looking Forward: Recommendations on how the CRM and rainfall forecasts could continue to be used in Yemen and elsewhere

It can be argued that the use of forecasts and cholera risk information in Yemen represents one of the first pilots/trials of their use and that the general concept of using risk information to inform cholera response is in its infancy.

The results of the validation work undertaken through the EACH project are encouraging and indicate that the CRM and rainfall forecasts can add value to cholera decision making when used in the right context. Based on this analysis and understanding on how the CRM and forecasts are used in practice, a set of recommendations on how these tools can be applied in Yemen and elsewhere have been developed covering a wide range of aspects. Key overarching recommendations are as follows:

- In areas where epidemic cholera is expected, preventative measures will most likely already be underway in anticipation of outbreaks. In these contexts, the CRM and rainfall forecasts should be used to inform planning and preparation activities and to intensify early control measures such as surveillance and reporting, strengthening healthcare systems and community engagement. This is illustrated in figure 1.
- Specific actions that can be informed by the CRM and rainfall forecasts will vary by context/use case and should be identified with cholera response stakeholders and providers of the CRM and rainfall forecasts through a process of co-design.
- As Yemen represents the only pilot in which the CRM and rainfall forecasts are used in an operational context, further pilots are needed to test and inform the development of this approach. Sharing insight and learnings from these pilots, with the wider anticipatory action sphere and cholera response community, will be key in enabling the concept of early action in the cholera domain, which is in its infancy, to develop.
- Recommendations to enhance the CRM itself include ingesting real-time forecast data to offer a one week lead time on its four week validity period, and to increase confidence in the tool by coupling its predictions with water sampling to test for the presence of cholera bacteria in high risk-areas.
- Development of communications materials would describe the evidence base and evolution of the CRM to potential users and would provide guidance in how to understand and interpret its outputs. Access to the tool could be improved through the development of a web-based platform.
- The rainfall forecasts to inform cholera response could be enhanced through understanding the relationship between rainfall and cholera at local levels in order to determine where forecasts are most relevant.
- Understanding the impacts of inter-annual events such as El Niño and other seasonal patterns on cholera could provide even earlier indications of cholera risk.

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