News and Perspectives

When Old Diseases Return: Cholera, Crisis, and Digital Surveillance in Fragile Settings

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Key Takeaways

- Cholera's re-emergence reflects systemic collapse rather than pathogen novelty. Economic crisis, climate stress, displacement, and infrastructure failure can rapidly reverse infectious disease control.
- Delayed detection has been a core problem in resource-limited situations, due to lack of laboratory capacity and incomplete reporting.
- Digital surveillance plays an important role in early warning and response. Mobile reporting, GISgeographic information systems, and real-time data integration can be used when traditional surveillance fails.
- Integration of digital and genomic information can enhance preparedness and outbreak prevention.

For almost three decades, Lebanon was free of cholera. Its re-emergence in October 2022—the first outbreak in Lebanon since 1993 [1]—marked not simply the return of an old pathogen but the convergence of modern crises: economic collapse, infrastructure failure, population displacement, and environmental stress [2]. Comparable patterns are now playing out across multiple regions globally, where diseases once thought controlled are resurging under these new conditions.

Cholera, an acute waterborne diarrheal disease transmitted primarily through contaminated water and food, remains a preventable disease. Yet the conditions required to prevent it—safe water, sanitation, early detection, and rapid response—are increasingly undermined by conflict and climate-related shocks. In fact, the number of cholera outbreaks and countries affected has increased sharply in recent years, especially in contexts affected by humanitarian emergencies, according to the World Health Organization [3,4].

Flooding, drought, and rising temperatures intensify exposure risks, while health systems weakened by those very influences often fail to recognize outbreaks in time to limit their spread [5,6]. For regions where resources and infrastructure may be pre-existing challenges, digital disease surveillance tools offer not only speed but a decentralized, low-infrastructure means of outbreak detection and mitigation [7]. For example, these tools have been used to monitor cholera outbreaks in regions with minimal laboratory capacity, demonstrating that real-time reporting can remain effective even when traditional health systems are under strain [7].

When Traditional Surveillance Systems Fail

Under stable conditions, cholera outbreaks can be controlled through reporting, confirmation, and response. Under fragile conditions—shortages in health facilities, limited laboratory capacity, and unorganized reporting—this process breaks down [8]. The resulting delayed detection can allow cholera to spread extensively through the population [9].

This was evident in the 2022 outbreak in Lebanon, where traditional surveillance failure contributed to the spread of cholera nationwide in a matter of weeks. The initial cholera outbreaks were identified in the northern governorates of Akkar and Minieh-Danniyeh, near the Syrian border, in areas with ongoing cross-border movements and continued transmission in neighboring Syria [1]. Despite these risk factors, the outbreaks went undetected for several weeks, highlighting gaps in early surveillance. Subsequent investigations revealed *Vibrio cholerae* contamination in water piping systems, irrigation water, and sewage networks, reflecting the long-term degradation of water infrastructure amid the country's ongoing economic crisis [10].

The Lebanese situation—in which climate and other pressures strain already-taxed or limited public health infrastructure, rendering them more vulnerable to outbreaks—is not an isolated one. For example, in Malawi, floods have caused the displacement of people and the contamination of water sources, and this has led to new outbreaks, despite previous success in controlling the disease [8]. In Yemen, in 2017, the world's largest cholera epidemic was facilitated by inadequate water supplies due to conflict and an overwhelmed health care system [2,5]. In Sudan, similar problems have contributed to the spread of the disease and are ongoing [8]. Cholera outbreaks no longer follow predictable seasonal periods, but instead track crises and displacement [6].

In all these cases, digital surveillance platforms, such as mobile case reporting and geographic information system (GIS) mapping, could have mitigated delays, enabling earlier intervention and more effective and efficient use of limited resources.

Digital Advances in Surveillance and Prediction

The challenges in resource-limited environments associated with traditional surveillance methods (often, for example, facility based and involving the use of paper-based forms and delayed aggregation) are increasingly being complemented by the use of digital health technologies. Reporting systems developed using mobile technologies enable the reporting of suspected cases in nearly real time by health workers on the front lines of the response. Particularly in the context of displacement, where populations are highly mobile and not all are registered, these technologies represent viable alternative approaches [11]. However, in fragile settings, internet and cellular network disruptions, power instability, and limited access to reliable technology may hinder digital surveillance systems, making hybrid approaches desirable.

GIS mapping can further help detect outbreaks by tracking distributions of cases and environmental factors simultaneously. Rainfall, floods, temperature changes, and population movement can all be overlaid to help pinpoint potentially high-risk regions before large numbers of cases are seen [5]. In recent cases of cholera, these methods have facilitated vaccination and water and sanitation efforts, as well as the pre-positioning of oral rehydration kits [2]. Development of other predictive models combining data on epidemiology, climate, and mobility also helps health systems move away from reactive responses to predictive preparedness, particularly helpful in areas where testing is slow or inconclusive [5,12,13].

In tandem with syndromic and environmental surveillance, advances in genomic sequencing have added a new layer of early warning for cholera outbreaks. Through whole-genome sequencing of *Vibrio cholerae*, circulating strains can be identified, differentiation can be made between endemic persistence and new introductions, and genetic markers of virulence or antimicrobial resistance can be detected [14]. When integrated into digital surveillance platforms, genomic data can support real-time mapping of transmission routes across regions and borders, linking molecular signatures to epidemiologic, climatic, and mobility data, as demonstrated during the COVID-19 pandemic through platforms such as GISAID and Nextstrain [15,16]. It's particularly useful in fragile settings where laboratory confirmation is delayed and traditional surveillance is fragmented, allowing molecular signals to complement clinical reporting and enhance outbreak prediction and response.

Implications for Policy and Preparedness

Cholera's flare-ups offer several lessons for managing recurring infections in an age of compounding crises.

First, advances in infectious disease control can be swiftly reversed when social, political, and environmental stability breaks down. Second, surveillance is as critical as cure: interventions delayed by gaps in data may be ineffective, no matter their inherent utility. Third, health technology platforms must be regarded as essential infrastructure rather than optional tools, particularly in fragile or conflict-affected contexts [3]. For policymakers, this means investing in interoperable digital surveillance systems as a form of preparedness rather than a reactive measure. For clinicians, it requires maintaining a high index of suspicion for cholera in nontraditional settings. For researchers, these outbreaks underscore the value of an interdisciplinary approach that integrates epidemiology, climate data, and digital surveillance and predictive modeling tools [9].

As climate change, displacement, and conflict continue to redefine risk in global health, cholera is not likely to be the last "old" disease to return. Our ability to preempt outbreaks and resurgences of such diseases will depend largely on our ability to develop, integrate, and rapidly operationalize digital surveillance data and predictive modeling tools [3].

Keywords: cholera; public health surveillance; disease outbreaks; water microbiology; genomics; climate change; epidemiology; vaccines; health policy; population surveillance; war; internally displaced persons

Conflicts of Interest

None declared.

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