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ABSTRACT

Quantifying the potential benefit of early detection for preventing morbidity and mortality: a simulation study of cryptosporidium outbreak

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Objective
To quantitatively assess the benefit of issuing a boil-water advisory for preventing morbidity and mortality from a waterborne outbreak of cryptosporidiosis.

Introduction
Many studies evaluate the timeliness and accuracy of outbreak detection algorithms used in syndromic surveillance. Of greater interest, however, is defining the outcome associated with improved detection.

In case of a waterborne cryptosporidiosis outbreak, public health interventions are aimed exclusively at preventing new infections, and not at medical treatment of infected individuals. The effectiveness of these interventions in reducing morbidity and mortality will depend on their timeliness, the level of compliance, and the duration of exposure to pathogen.

In this work, we use simulation modeling to examine several scenarios of issuing a boil-water advisory (BWA) as a response to outbreak detection through syndromic surveillance, and quantify the possible benefits of earlier interventions.

Methods
We developed an agent-based model for simulating realistic outbreak signals similar to historical waterborne outbreaks of gastrointestinal disease.[1] The model generates a synthetic population and simulates the spread of pathogenic organisms through water system, individual mobility and water consumption, disease progression in infected individuals, and patterns of healthcare utilization and disease reporting—all within the geographical setting of the Island of Montreal. We also model the effect of BWA on water consumption determined by the rate of compliance with the advisory.

We simulated an outbreak scenario resulting from a 2-week failure of a water treatment plant, similar to that observed in Milwaukee in 1993. We varied the BWA compliance rate, and timing relative to symptom onset (earliest possible time for BWA guided by syndromic surveillance only). Because Milwaukee incident was the largest documented outbreak in terms of duration and pathogen concentration, and might not be the most representative scenario, we also simulated a shorter outbreak with a 72-hour treatment plant failure. In all experiments, we measured the total number of disease cases and deaths.

Results
Figure 1 displays the number of cases prevented by the BWA under a 2-week contamination scenario, as a function of the delay for different compliance levels. There appears to be little benefit in issuing a BWA 5 or more days after the beginning of the outbreak. In the 72-hour scenario, same happens with the delay exceeding 1 day. We can also see that

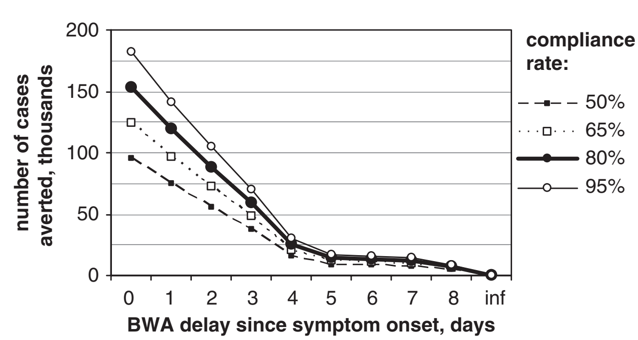

Figure 1 Benefit of BWA as a function of its timeliness and compliance rate.

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the benefits of BWA decline faster with time than with deteriorating compliance: issuing a BWA 1 day later is equivalent to about 20% loss in compliance.

Conclusions

We have shown that even for large outbreaks like the Milwaukee outbreak, the time window for effective intervention can be only 5 days wide if BWA relies on detection through human health surveillance, suggesting that using additional sources of information (for example, water quality surveillance) to enable earlier intervention can be beneficial in preventing morbidity and mortality. This finding, however, depends on some additional factors related to outbreak scenario, like daily infection rate (a function of pathogen concentration) and specifics of the water distribution system, and thus should be generalized with care.

Our results also suggest that timeliness of BWA is more critical than high compliance rates. A good decision about issuing a BWA must take into account its cost and the uncertainty of outbreak detection.

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Reference

1 Okhmatovskaia A, Verma AD, Barbeau B, Carriere A, Pasquet R, Buckeridge DL, *et al*. A simulation model of waterborne gastro-intestinal disease outbreaks: description and initial evaluation. AMIA Annual Symposium, 2010.