Research Brief

NCPERRC
North Carolina Preparedness and Emergency Response Research Center

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Simulating a Public Health Emergency: A Case Study of the 2004 North Carolina State Fair E. Coli 0157 outbreak

Since the attacks of September 11, 2001, billions of dollars in federal funding have been invested in emergency preparedness and response systems. Some of this funding has gone into the development of information technology (IT) systems to improve information sharing and decision making. In 2002, North Carolina used new federal funding to improve the public health infrastructure, including creation of the North Carolina Health Alert Network (NC HAN). Over the following years, the state also implemented two capacity building IT systems, the NC Electronic Disease Surveillance System (NC EDSS) and a syndromic surveillance system, the NC Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT). Along with NC HAN, these made up the new NC Public Health Information Network (NC PHIN). However, few details were provided on how their efficacy would be evaluated. Given the complex and dynamic conditions in which emergency preparedness and response systems must perform, it is critical to determine whether NC PHIN has increased the state's ability to efficiently prepare for and respond to events that involve communicable diseases.

While research has modeled many of the tangible aspects of preparedness and response (e.g., spread of disease, number of hospital beds, transit capacity), broadly accepted performance measures for determining the efficacy of less tangible aspects of response systems, such as communication, information sharing and decision making, have not been established. Traditional public health capacity assessments have relied on self-assessments that measure performance and capacity based on checklists of plans, resources and activities and achievement of established benchmarks. Although these assessments provide some guidance for measuring emergency preparedness and response, the literature suggests that the methods are insufficient given the complex and dynamic conditions in which emergency preparedness and response systems must perform (Davis et al. 2007; Jackson 2008). For example, with these measures it is not possible to anticipate response-system performance before actual emergencies. Thus there is a need for prospective assessment of the reliability of response.

It is essential that investments in information technology systems for public health preparedness be evaluated to determine if they increase public health's ability to respond to communicable disease events. In this simulation study, access to syndromic surveillance systems as well as the amount of hospital and laboratory resources available, had the most impact on system performance.

This report describes a means to measure the utility of increasing IT capacity in improving emergency preparedness and response. To address the question of whether NC PHIN has increased the state's ability to efficiently prepare for and respond to events that involve communicable diseases, we developed a simulation model of the response to the 2004 North Carolina State Fair *Escherichia coli* serotype O157:H7 (*E. coli*) outbreak.

Methods

The NC State Fair is an 11-day agricultural and entertainment fair held at the Wake County, NC, fairgrounds. The 2004 *E. coli* outbreak involved 108 confirmed cases, including 15 cases of hemolytic uremic syndrome, a severe, life-threatening complication. The outbreak was one of the largest petting zoo outbreaks of *E. coli* to date and presented a statewide public health threat since the fair attracted visitors from across the state. Three NC Health Alert Network alerts were sent in response to the outbreak, one by the Wake County Department of Health and two by the North Carolina Division of Public Health (DPH).

To simulate the public health emergency response, we developed a model that included the role of the key organizations, resources, and IT support systems of NC PHIN during the process of responding to the threat. The simulation model focused on the flow of information on contamination of petting zoo visitors, the process of identifying these cases, detection of a threat, release of an alert via NC HAN, and alert recipient awareness. The response process was divided into seven steps: susceptibility (exposure), reporting, surveillance, detection, confirmation, notification, and mass dissemination of information and implementation of control measures. Visitors to the petting zoo progressed through the seven steps: each visitor who became infected was defined as a case, with cases further categorized as probable, suspect or confirmed. The cases used resources such as physicians, labs and LHD personnel, and eventually entered the DPH or an LHD queue. Cases waiting in a queue represented state or local health department awareness. They remained in the queue until a signal was sent for them to be released, implying mass awareness of the cases. Decision makers made decisions based on information provided by the number of cases in their queue and the number of cases provided by the NC PHIN components they could access.

The model was parameterized by selecting the distributions of the random input variables based on data provided, and then varying the capacity levels of the resources until the simulation output data matched the real output data from the outbreak. Five experiments were run with different levels of access to the IT components of NC PHIN: 1) NC HAN only; 2) NC HAN and NC DETECT; 3) NC HAN and NC EDSS; 4) NC DETECT and NC EDSS and 5) NC HAN, NC DETECT and NC EDSS. For each of the experiments, seven scenarios were run representing differences in hospital and LHD human resources and laboratory capacities. The scenario data were used to analyze the impact of changes in preparedness capacity on NC PHIN performance metrics. Metrics included total number of outbreak cases, time from first case exposure to implementation of control measures, time from first case exposure to initial detection of a statewide threat, time from detection to implementation of control measures, and alert recipient awareness, or the percentage of cases that the alert recipient was made aware of at the time of the alert.

Our simulation centered on capacity-based performance. Therefore, performance metrics served as indicators of response capacity, defined by the World Health Organization as information, authority, institutions, partnerships and the plans, resources and procedures to activate them. *Information* was represented by access to data from NC HAN, NC EDSS and NC DETECT, phone calls, emails and other means of communication. *Authority* was the ability of the DPH or LHD to issue an alert. *Institutions* were the organizations acting as information providers and decision makers (LHDs, DPH, hospitals, labs), and *partnerships* reflected the communication between these organizations. *Plans* were the seven steps in the process and the flow of information for the monitoring and control of communicable disease threats. Resources were the labs, physicians and LHD personnel, and procedures were the signals activated before certain activities could occur, such as control measures.

An additional component of the simulation was awareness on the part of decision makers and alert recipients, represented as a percentage based on the number of cases people were aware of relative to the number of cases that actually existed. Once the threat alert was released, alert recipients were able to make decisions based on their awareness. Awareness of alert recipients served as an indicator of the accuracy and timeliness of the information being delivered.

Results

The simulation experiments showed that IT access, human resources and lab resources all had significant impacts on alert recipient awareness. Of the NC PHIN components, access to NC DETECT had the greatest impact. Variation in human resource levels in hospitals and in lab resources, however, had the most significant impact on alert recipient awareness over time (Figure 1 on next page). Interestingly, increasing and decreasing capacities by the same percentage did not have equivalent impacts on alert recipient awareness. There was a significant decrease in awareness when lab resources were decreased but only a slight improvement when these resources were increased by the same percentage. Thus, while increases in capacity (resources) and alert recipient awareness levels would be expected to be positively correlated, our simulations did not find this. We hypothesize that bottlenecks in the system might have been responsible for the lack of improvement in alert recipient awareness despite increases in certain resources. We found long queue times in some stages of the process followed by shorter queue times in subsequent stages. The bottleneck was primarily associated with lab capacity and the long wait times associated with lab resources. This bottleneck limited the effectiveness of other resources.

Discussion

Our findings suggest that investments in IT capacity may not have the biggest impact on the performance of an information system such as NC PHIN. The limited capacity of other, more tangible resources such as laboratories can have a major impact on the system. Our findings suggest that investments in improving overall system performance of NC PHIN should focus on improving lab capacity. The findings also highlight the fact that the existence of capacity does not mean that the capacity is fully used. Bottlenecks in the upstream stages of a process limit the use or realized capacity of resources later in the process. By identifying these bottlenecks, an analysis such as the simulation we conducted can give public health stakeholders a better understanding of where potential opportunities for improvement lie.

Authors & Acknowledgements

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References

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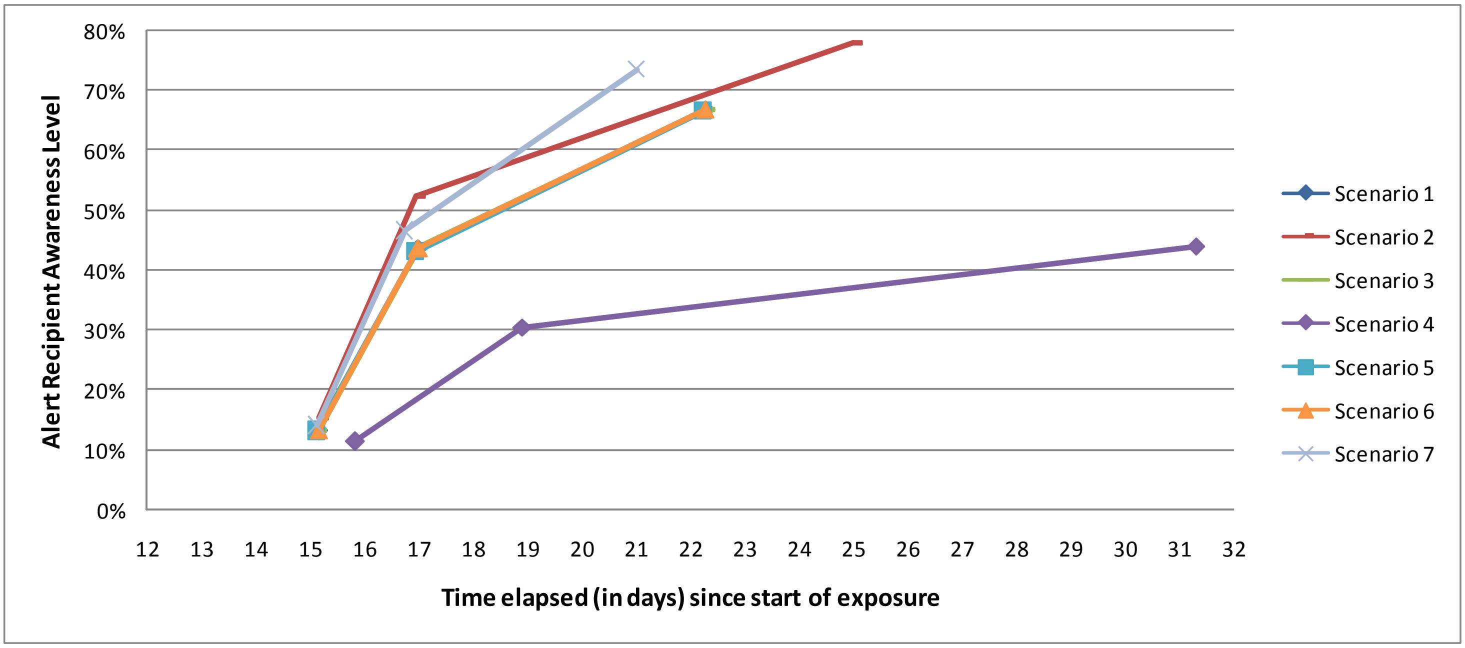
Figure 1: Alert Recipient Awareness Level Over Time for Experiment



Scenario 1: Base Case
Scenario 2: Decrease HR Levels in Hospitals by 50%
Scenario 3: Decrease HR Levels in LHDs by 50%
Scenario 4: Decrease Lab Resources by 50%
Scenario 5: Increase HR Levels in Hospitals by 50%
Scenario 6: Increase HR Levels in LHDs by 50%
Scenario 7: Increase Lab Resources by 50%

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