Lessons Learnt From Exercise Celestial Navigation: The Application of a Geographic Information System to Inform Legionnaires' Disease Control Activity

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ABSTRACT

Geographic information systems (GIS) have emerged in the past few decades as a technology capable of assisting in the control of infectious disease outbreaks. A Legionnaires' disease cluster investigation in May 2016 in Sydney, New South Wales (NSW), Australia, demonstrated the importance of using GIS to identify at-risk water sources in real-time for field investigation to help control any immediate environmental health risk, as well as the need for more staff trained in the use of this technology. Sydney Local Health District Public Health Unit (PHU) subsequently ran an exercise (based on this investigation) with 11 staff members from 4 PHUs across Sydney to further test staff capability to use GIS across NSW. At least 80% of exercise participants reported that the scenario progression was realistic, assigned tasks were clear, and sufficient data were provided to complete tasks. The exercise highlighted the multitude of geocoding applications and need for inter-operability of systems, as well as the need for trained staff with specific expertise in spatial analysis to help assist in outbreak control activity across NSW. Evaluation data demonstrated the need for a common GIS, regular education and training, and guidelines to support the collaborative use of GIS for infectious disease epidemiology in NSW. (*Disaster Med Public Health Preparedness*. 2019;13:372-374)

Key Words: communicable diseases, outbreaks, emergency preparedness, geographic mapping

BACKGROUND

The use of mapping to identify the source of an infectious disease outbreak is well documented in history.[1] However, geographic information systems (GIS) have only emerged in the past few decades as an important technological aspect of epidemiology in public health[2] and more specifically for surveillance and control of infectious disease outbreaks.[3] Legionnaires' disease is caused by inhalation of aerosolized *Legionella* bacteria from an environmental water source. The use of GIS to identify the location of higher-risk water sources during outbreaks is becoming more common.[4]

Despite the growing use of GIS globally,[3] there is no common system, process, or guideline that Public Health Unit (PHU) staff in New South Wales (NSW), Australia, can use to inform Legionnaires' disease control activity. In May 2016, the Sydney Local Health District (SLHD) initiated a Legionnaires' disease cluster investigation,[5] and one of the key lessons from this investigation was the need to train staff and develop and implement standard processes for use of GIS in the control of infectious disease outbreaks.[6] SLHD PHU developed a desktop exercise to test the capability of NSW PHU staff in using GIS to inform an outbreak investigation (using the SLHD *Legionella* cluster as the example). Eleven staff members from 4 PHUs in metropolitan Sydney, NSW, participated in the exercise, held over 2 half-days on April 27 and 28, 2017. The exercise was evaluated to capture any key lessons for future use of GIS within NSW.

EXERCISE PLAN

Exercise Objectives

The objectives of the exercise were as follows:

1. To gather feedback on the use of different GIS across several PHUs in Sydney;
2. To test staff capability in:
   a. geocoding data;
   b. producing multi-layered maps—that is, including disease exposure locations, case residence, and location of cooling towers, with buffer zones around common exposure areas; and
   c. reporting GIS data in a situational report with a map and list of high-risk water sources, to inform environmental health control measures.
3. To document lessons learnt regarding the use of GIS in NSW.

Exercise Scope and Scenario

At least 1 staff member from each PHU was invited to participate and was required to have skills in mapping and producing situational reports. In preparation, 2 teleconferences were held and an exercise outline was shared with participants. The scenario mimicked the

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SLHD PHU Legionnaires' disease cluster investigation,[5] but fitted into 2 half-days (3 hours per day) with action to identify a cluster (ie, one or more Legionnaires' disease cases reporting a common exposure within 100 m over a 3-month period) and high-risk water sources for sampling as per NSW Health guidelines.[7] The desktop exercise was conducted with time-limited components to reflect the urgency and need for timely GIS data to inform the investigation; however, recommended field actions were nominal only.

EXERCISE EVALUATION

Evaluation tools included an *audit checklist of PHU exercise outputs*, with outputs for each assigned task assessed as fully achieved, partially achieved, or not completed. A *hot debrief meeting* collected feedback around (1) what went well? (2) what didn't go so well? and (3) what could we improve for next time? An online *semi-structured survey* developed using REDCap[8] was used to collect information on the level of agreement on the effectiveness of the design and operations of the exercise (Likert scale from strongly agree to strongly disagree), as well as the level of difficulty regarding the assigned tasks (Likert scale from very easy to very difficult).

Of the 11 participants, 10 completed the online survey (91% response rate). At least 8/10 participants agreed that sufficient pre-exercise information was provided, assigned tasks were clear, sufficient data were provided to complete tasks, and the scenario progression was realistic. Participants reported that existing skill deficits in the use of GIS for required tasks meant that completion of the exercise took longer than they had anticipated. Participants suggested that pre-exercise webinars would be helpful for preparedness—for example, including an overview of mapping tasks. In addition, real-life work issues took precedence over the exercise, highlighting the need to ensure that participants have agreement on their own protected time to complete the exercise.

Lessons Learnt: The Application of GIS to Inform *Legionella* Control Activity

No common system: the multitude of geocoding software and GIS

Four different geocoding programs were used by participants. Three were open-source software products and 1 was an application designed and managed by NSW Health. In contrast, the majority of participants used only 1 GIS application, ArcGIS explorer. An array of GIS platforms are available, and the functionality and inter-operability of software is critical.[9] Several authors[2,9] have argued that different software is needed to produce, map, and analyze geographic data. Each of these data manipulation processes have resource implications in terms of cost of software and training required.[9]

Specific skills required to use GIS for Legionnaires' disease control activity

Over half of the exercise participants reported some level of difficulty with producing multi-layered maps and producing lists of water sources for inspection to inform field investigations according to guidelines.[7] Participants reported issues with the following skills: (1) mapping lines (ie, mapping the travel routes of cases), (2) creating buffer zones, and (3) systematically identifying and extracting data on points lying within overlapping zones, which allows the water sources of concern to be identified. These particular GIS skills are essential for Legionnaires' disease control activity,[4] as per NSW Health guidelines,[7] but require practice for timely outbreak response.[10]

In addition, participants mapped the buffer zones differently (eg, mapping concentric buffer zones around every single exposure location vs maps with buffer zones around only the most common exposure locations across all cases) and hence produced slightly different lists of water sources to inform field investigations, indicating the need for a common protocol to guide geospatial analysis of data during outbreaks in NSW. Although most participants had some experience with GIS, none had applied GIS in a real-time outbreak scenario and therefore not anticipated the level of technical skill required to complete tasks, reinforcing the importance of regular exercises like this one.

The growing need and interest to develop staff capability to use the GIS in NSW, Australia

All participants agreed in the online survey that the exercise was useful in testing their capabilities in utilizing GIS in an outbreak scenario. Given the growing evidence of the utility of GIS in outbreak surveillance and control,[3,9] there is great scope and interest in developing a skilled workforce to routinely use GIS for real-time outbreak control activity in NSW.

Improving staff capability through education and training

Some participants reported logistical constraints during the exercise, such as only having 1 computer set up with the GIS software and geocoding applications and only 1 staff member in their PHU with skills or experience in using GIS. Clearly, having sufficient IT infrastructure and number of staff members trained with a minimum skill level in the use of GIS is critical for resilient and rapid responses to disease outbreaks.[9,11]

DISCUSSION

This exercise demonstrated that training in the use of GIS by running a real-life outbreak scenario is critical to the development of capacity within a public health network to use the technology for infectious disease control. The exercise evaluation pointed toward the need for a common GIS and associated tools, regular education and training, and guidelines to support the consistent and collaborative use of GIS for infectious disease epidemiology in NSW.

Despite growing evidence of the use of GIS for infectious disease outbreak epidemiology[3] and in particular for Legionnaires'

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disease outbreak control,[4] there is no widespread uptake and translation of this technology and knowledge into public heath practice across NSW. Globally, authors[3,9] have reported the need for (i) easily accessible and reliable geographic data (eg, up-to-date geocoded lists of cooling towers); (ii) a web-accessible, secure, and inter-operable GIS that can provide the functionality users desire; and (iii) usability evaluation and exercises that promote system evolution and resilience for sustained effective use.

State-wide access and use of geospatial data is expected to improve in NSW as the NSW Location and Intelligence Strategy is implemented.[12] NSW Health is also planning to pilot the state-wide use of an ArcGIS server platform for health protection purposes, including infectious disease epidemiology, to enable secure, coordinated access to a single GIS for public health staff in NSW. The pilot will include a package of user needs evaluation, education and training materials, and exercises to promote user-based development of the system.[13,14]

This exercise was limited in scope and hence in testing the technical capability of staff members to perform any statistical cluster detection or other methods for spatial analysis of data. However, authors have identified a limited uptake and lack of consistency in the approach to spatial analysis with regard to infectious disease outbreaks.[3,4] Therefore, guidelines on the use of GIS in the spatial analysis of infectious disease outbreaks,[3] in particular Legionnaires' disease,[4,15] would enable the consistent identification and risk assessment of the time, place, and person characteristics of outbreaks in NSW. Furthermore, the critical interpretation of spatial data to inform field investigations was only tested indirectly through submission of a situational report during the exercise, with 3 of 4 PHUs fully meeting this task.

CONCLUSIONS

This exercise identified an interest and potential gap in the use of GIS for infectious disease outbreak control in NSW. It highlighted that introduction of any new IT system and process across a network of people must be accompanied by ongoing education, training, exercises, and the establishment of standard guidelines for spatial analysis, in NSW and perhaps Australia, if the technology is to be used successfully and consistently for outbreak control activity.

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