Spatial Analysis Supports Successful Infection Control Policies for Ontario Hospital

Understanding and control of patient secondary infections are high on any hospital administrator’s list of priorities. Low secondary infection rates contribute to a hospital’s good standing in the community, protect patients from undue suffering or even death, and reduce the costs associated with patient infection and recovery. In Canada, the Sault Ste. Marie Innovation Centre (SSMIC) and ESRI business partner Infonaut Inc. are collaborating on the use of GIS technology to understand how patient and equipment movement influences the spread of secondary infections.

Their solution helps administrators and infection control professionals make better decisions about policies for the containment and immediate outbreak management response to secondary infections. Results have already been used to influence policies that resulted in reduced infection rates. Currently, an innovative tracking program to collect precise data is being tested to further improve the commercial solution and provide real-time information for decision making.

“Algoma Public Health found great value in the ability of GIS mapping of patient transfers within the hospital environment and the reflec-
tion of such movements in a spatial and time-linked analysis, which yielded valuable interpretations of the transmission of communicable disease in a closed system," says Jonathon Bouma, director of infection control, Algoma Public Health (APH), the region's local health unit.

In Fall 2006, in a single example of a global phenomenon, the Sault Area Hospital (SAH) in the city of Sault Ste. Marie, Ontario, Canada, had a serious outbreak of patient secondary infections caused by the bacterium *C. difficile*. APH asked for help in applying a spatial analysis of the problem from the Community Geomatics Centre (CGC), a local group that specializes in GIS solutions. CGC is part of SSMIC, a nonprofit organization that promotes economic activity in the community. The regional health unit had successfully worked with CGC before to apply GIS to health-related problems and turned to them again.

"So many people are involved in hospitals, and they work in shifts around the clock, so it is hard to see the big picture because of this complexity," says Paul Beach, CGC manager, about the challenge. He explains, "I have seen hospital staff try to manage infection control using whiteboards to draw isolation plans, but it is just too complex visually. GIS gives you a view to help overcome that complexity and help make the right decisions."

Working with hospital and health unit personnel, SSMIC technicians built an application for analyzing six months of historical information collected during a previous outbreak. SAH infection control practitioners collected data related to the *C. difficile* outbreak including data related to patient movement. APH inspectors then proceeded to input the SAH data, as well as the date of infection onset, hospital assets, and room and bed numbers, using SSMIC's electronic data collection form. To ensure patient privacy, unique codes were assigned to individual patients before inputting the data so that each could be uniquely identified but were not personally identifiable. SSMIC then imported the data and a data relationship structure into ESRI ArcGIS software to conduct spatial analysis.

Orthophotography (digital aerial photography in which distortions due to camera tilt and topography have been removed) and blueprints of both SAH's General and Plummer hospital sites were used to map the real-world coordinates of all rooms using ArcGIS. Other work graphically depicted the General site and a portion of the Plummer site in three dimensions. The spatially captured data was queried and analyzed to provide additional information for examining factors that contribute to the spread of disease. SSMIC took further steps to graphically depict patient flow over space and time to ensure capture of historical patient movement throughout the hospital.

Application development was accomplished using ESRI's ArcGIS Engine and Microsoft .NET Framework. The application runs on ArcGIS Desktop and uses ESRI's ArcGIS Spatial Analyst and 3D Analyst extensions to analyze spatial relationships.

For example, explains Beach, the application can run an analysis to identify whether "hot rooms" of contamination exist, whether patient movement within the hospital is a factor, and if and when patients with active *C. difficile associated disease* (CDAD) have been admitted or released. The health unit took these results and made recommendations to the hospital, which, combined with other internal hospital policy changes, resulted in a number of positive changes.

Based on the successful outcomes, the group received additional funding from the Ontario provincial government's Northern Ontario Heritage Fund Corporation (NOHFC) to add real-time tracking data to the GIS layers and further develop the solution as a Web-based application. CGC partnered with Infonaut, which specializes in location-based business intelligence for the health industry, to complete the project.

The next stage of development involves the incorporation of infection control best practices with GIS, real-time data tracking systems, and risk exposure metrics and alerts to create a final Intelligent Infection Control (IIC) application. This application will be used as a tool to calculate a hospital's unique risk exposure; continued on page 6
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test, monitor, and refine infection control policy; and improve operational and outbreak response. It is a dynamic drill-down hospital risk profile assessment and operational management application.

The IIC application identifies physical variables that directly impact the likelihood of CDAD. Tracking may be conducted on patients, objects, and discrete locations within the hospital. Risk factors for each category are weighted and used to create an overall risk profile for every tracked object within the hospital. The application then applies GIS technology to determine the spatial relationships and contacts between the risk-profiled people, places, and things. The risk profile is dynamically generated: as people and assets interact with each other, associated risks change to reflect new inputs.

The IIC tracking system uses Real-Time Location System (RTLS) tag technology. Existing hospital systems provide baseline patient and asset data, which is linked to the RTLS tags. The tags broadcast to local receivers that, in turn, transmit the tag’s unique identifier, time, and specific location to the GIS for calculating movement and spatial intersections. By layering risk attributes on top of object tracking, the IIC system is capable of continual improvement as understanding of CDAD control grows.

For more information, contact Hugh Williams at hwilliams@infonaut.ca or Paul Beach at pbeach@ssmic.com. You can also learn more about Infonaut at www.infonaut.ca and SSMIC at www.ssmic.com.

About the Sault Ste. Marie Innovation Centre and Community Geomatics Centre

The Sault Ste. Marie Innovation Centre (SSMIC) is a nonprofit organization formed in 1999 to stimulate economic development in the Sault Ste. Marie community in Ontario, Canada. SSMIC’s Community Geomatics Centre (CGC) promotes geospatial technologies and local partnerships to efficiently share GIS data and knowledge. CGC successfully built a community-wide GIS by first partnering with city and public utility companies, then expanding partnership to other local businesses and organizations. The community GIS includes utilities, wastewater, transportation, building, administrative, and land base datasets.

Benefits of the CGC business model include the elimination of duplicate efforts and the cumulative value of creating an integrated information system. From an initial investment of $1 million, SSMIC attracted $10 million in new revenues to the region through GIS projects.

The added value of information integration was evident when the local power company began a GIS project to review assets that might pose potential tripping hazards for pedestrians. It was discovered that one potential hazard, underground boxes that house power transformer equipment, also provided a perfect breeding environment for mosquitoes carrying West Nile virus. As a result, the public health department used the utility’s GIS to quickly locate all existing boxes and send out mosquito eradication crews.

For more information, visit the SSMIC Web site at www.ssmic.com.