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GIS for Health and Human Services

GIS Uncovers Hospital Infection Transmission Clues

Spatial Visualization Reveals Staff-Patient Contact Patterns

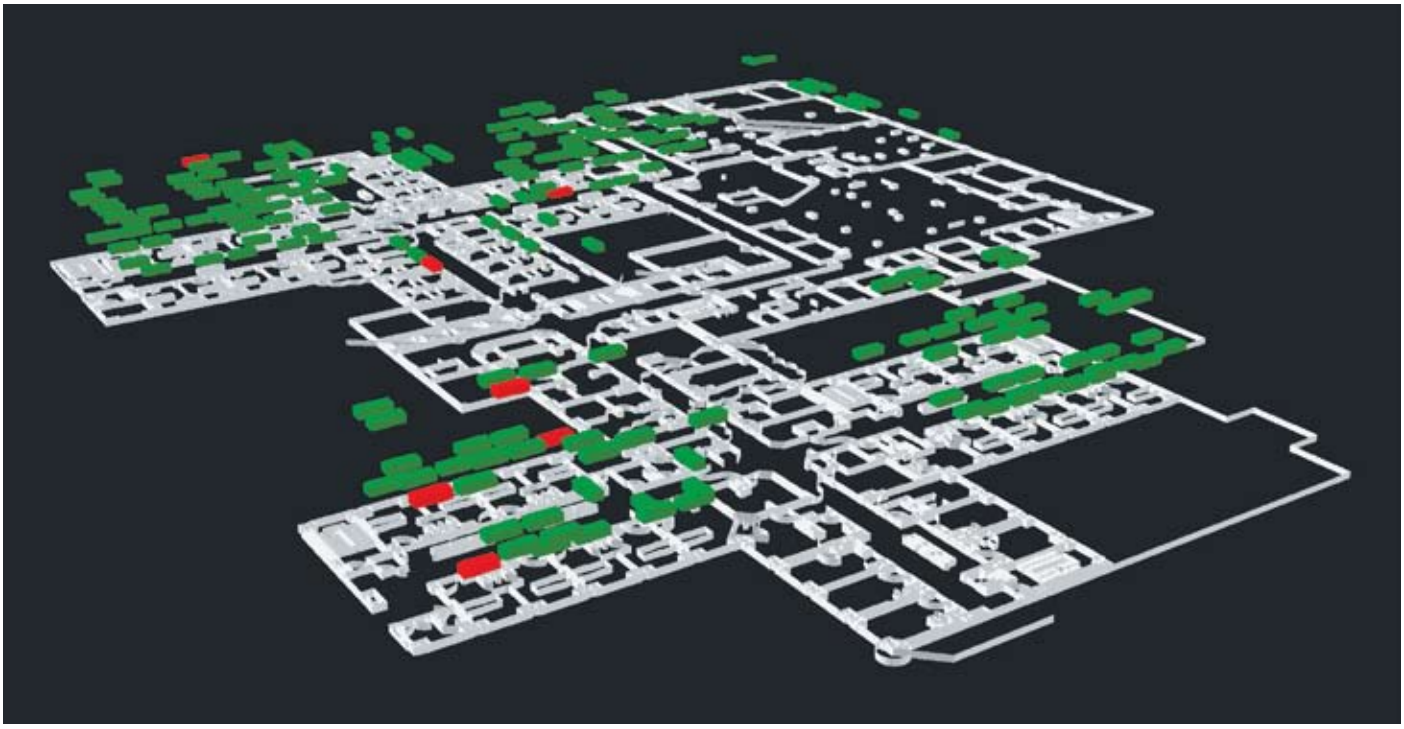
Not many years ago, geographer Jeffrey Wilson watched the painful experience of a family member fighting off secondary infections in the hospital while recovering from a serious accident. Little did Wilson know that he would soon contribute his geographic information system (GIS) skills to efforts to reveal patterns in the occurrence of hospital secondary infections. The resulting GIS analysis of person-to-person contact over space and time provided compelling evidence used to educate hospital workers and improve preventive measures.

Wilson's relative had a nosocomial infection—one caused during his stay in the hospital, not by his initial injury. One such infection, fairly common, is methicillin-resistant *Staphylococcus aureus* (MRSA), which is a bacterium that is resistant to certain antibiotics including methicillin. An estimated 90,000 nosocomial-related deaths are reported in the United States annually. In a hospital, the main mode of infection transmission to other patients is thought to be through human hands, especially health care workers' hands.

"There's still a lot of controversy out there as to what the means are by which bacteria are transmitted within hospitals and the effective ways to stop that transmission," says Abel Kho, M.D., an affiliated scientist at Regenstrief Institute, Inc., in Indianapolis. As a researcher, Kho was concerned with shedding more light on MRSA transmission and developing effective prevention methods.

Kho had read about using GIS for health applications and recognized that his challenge involved tracking the location and movement of patients and staff within a defined space. He contacted Wilson, chair of the Geography Department at Indiana University-Purdue University, for help. The department's GIS group frequently works with the university's School of Medicine on GIS health applications for environmental health risk assessment.

Wilson and then graduate student Kelly Johnston responded by creating a GIS model to visualize the data spatially and over time. Since



A 3D view of the entire hospital layout, imported from architectural drawings, maps one floor and indicates the location of patients infected with methicillin-resistant *Staphylococcus aureus* with the color red.

the information they were tracking occurred inside the hospital, they used ArcGIS Desktop to import the building's computer-aided design (CAD) plans and create a basemap representation of the building.

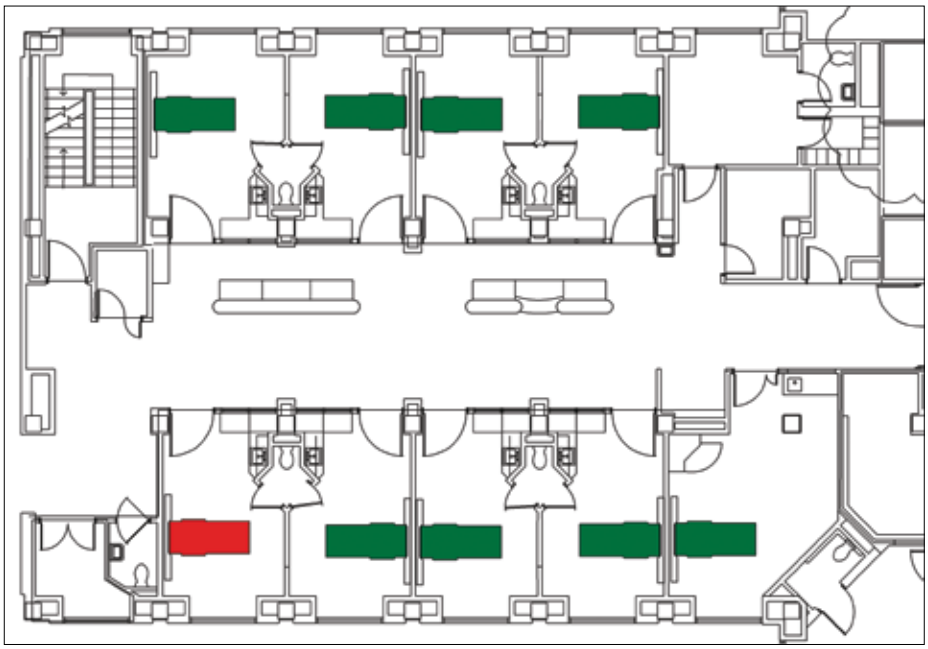
Kho pulled together a number of disparate data sources, thanks in part to the close working relationship between Regenstrief Institute and Wishard Memorial Hospital in Indianapolis. Kho extracted microbiology and laboratory data along with admission/discharge/transfer (ADT) data commonly used to identify where patients are in the hospital at any given time. But the pivotal data was from the automated vital signs system, a bedside system used by nurses and nurse's aides to log in their identification and date/time stamps whenever they check a patient's vital signs. "That was the key point to allow us to reconstruct movement patterns of staff through different patient care areas," says Kho.

To ensure anonymity of both patients and staff, Kho deidentified the data to protect patient and staff privacy and then passed it on to Wilson and Johnston for geocoding. The sample spanned activity over a three-month period and provided a large volume of data to work with (44,485 logins). Using ArcGIS Desktop and the ArcGIS Tracking Analyst extension, they superimposed patient bed assignment, contact isolation status, MRSA status, and nursing staff movements onto the floor plans to create time sequence animations. ESRI's ArcGIS 3D Analyst extension served as a visualization tool to look at infection data across multiple floors of the hospital and to animate changes in infection over time. This helped the team look for time intervals of staff-patient contact that were too short for staff to practice adequate hand hygiene while moving between patients.

The results revealed staff-patient contact patterns that could contribute to infection transmission. It also revealed incidences of placing MRSA patients in a shared, instead of isolation, room.

"Seeing is believing," says Kho, adding, "We used GIS to demonstrate what was hidden under the surface, and it became a very effective educational tool to allow us to change the behavior of staff."

As a result of this research, Infection Control was able to educate staff to improve hand hygiene between patients. Kho also instituted a computerized reminder for physicians to place patients with known MRSA into contact isolation, which improved appropriate contact isolation rates for patients with MRSA from about a third to almost 100 percent. Over the past two years, there has been an almost 50 percent decrease in the rate of hospital-associated MRSA infections at Wishard Hospital.



A mapped hospital ward linked with patient information allows doctors to confirm that a patient infected with *Staphylococcus aureus* is placed in a single-occupancy room (red bed).

"We'd like to think that some of that has to do with our work," says Kho, but warns that it is very hard to prove true statistical cause and effect, adding, "All you can usually show is a high correlation." Nevertheless, their work is now being implemented as part of a citywide project. Kho sees a potential to apply this model in outbreak investigations, hospital design, and bed management.

Extending this work, Kho has developed, with Agency for Healthcare Research and Quality funding, an electronic network to track known MRSA patients whenever they are admitted to a hospital within Indianapolis and track some of the environmental factors that might be leading to infections and the frequency of the patients' visits to health centers.

Kho currently holds dual posts as an assistant professor at Northwestern University in Chicago and affiliated scientist at Regenstrief Institute in Indianapolis. For more information, contact him by e-mail at abel.kho@nmff.org.

About Regenstrief Institute, Inc.

Regenstrief Institute, Inc., is an internationally recognized informatics and health care research organization dedicated to the improvement of health through research that enhances the quality and cost-effectiveness of health care.

For 30 years, Regenstrief's research scientists have developed the Regenstrief Medical Records System (RMRS), one of the nation's first electronic medical record systems and the keystone of many institute activities. RMRS serves as the day-to-day electronic medical records system at Indianapolis Wishard Memorial Hospital, among others.

In fall 2007, the U.S. Department of Health and Human Services awarded the Indiana University School of Medicine a contract to begin, through Regenstrief Institute, a trial implementation of a Nationwide Health Information Network (NHIN) in collaboration with eight other organizations. For more information, visit www.regenstrief.org.

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