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Contact Patterns for HCWs: Not Everyone is the "Average"

T. Hornbeck[1] , D. Curtis[1], T. Herman[1], A. Segre[1], G. Thomas[2], D. Naylor[1], P. Polgreen[3]

Departments of Computer Science[1], Engineering[2] and Internal Medicine[3], The University of Iowa, Iowa City, IA

The University of Iowa

Background

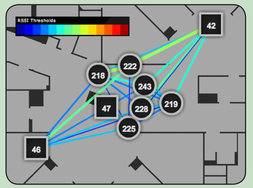
To understand how infections spread within hospitals one must have an understanding of how healthcare workers move and interact.

Contact-network epidemiology models populations as networks of potentially disease-spreading interactions between individuals. The challenge in contact network epidemiology is to obtain *realistic data* from which to generate accurate contact networks.

Objective

We piloted a method for measuring contacts between health-care workers (HCW) using lightweight, non-RFID devices (i.e., motes) that record radio transmissions from other devices in onboard memory. Using this data we characterize the contact patterns of HCWs in a 20-bed intensive care unit.

Motes
Lightweight, low-cost, battery-operated devices containing a small microprocessor, non-RFID radio, and antenna housed in a pager case (for durability).



Mote-to-Mote Contacts
Motes transmit messages to one another. Signal strength (RSSI) can be used to roughly approximate physical proximity.

Research Methods

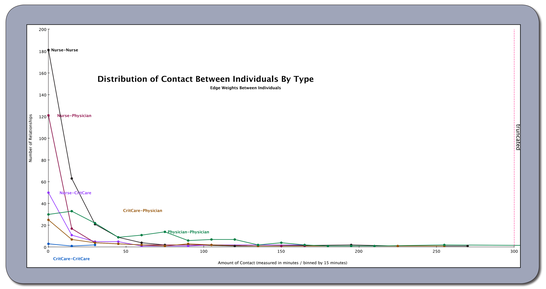
For one week we collected mote-to-mote communication data from devices worn by nearly all HCWs assigned to the Medical Intensive Care Unit at the University of Iowa Hospitals and Clinics.

Three HCW job categories:

- Nurses
- Physicians
- Critical care support personnel (pharmacists, respiratory techs, etc.)

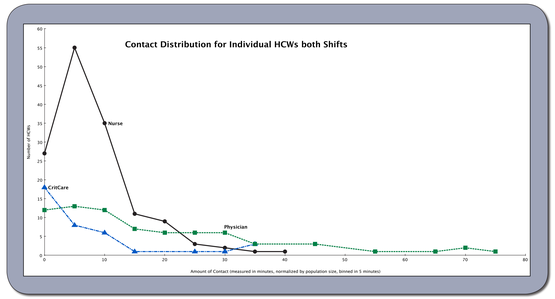
Motes were distributed in shifts (days from 7am until 7pm, and nights from 7pm until 7am). To protect privacy, motes were randomly assigned within job roles each shift, thus we examine each shift independently of the others. Messages between motes contain a timestamp, transmitting mote id, receiving mote id, and signal strength. The signal strength of messages transmitted from one mote to another was used as a proxy for distance; all messages below a minimum signal strength corresponding to a distance greater than 6 feet (determined by calibration with ground truth data) are discarded.

We define a continuous contact between two motes to be a time interval where both motes receive at least one message from the other mote once every 30 seconds. Contacts of duration less than five minutes were also discarded. All results reported here use t-tests to compare sets of values, with the usual significance threshold of $p<0.05$.



Results

The length of contacts between pairs of HCWs is not exponentially bounded (i.e. is heavy-tailed), with most contacts being of relatively short duration and a few being of much longer duration. The amount of contact a HCW has in a given shift, measured by total time in contact with another HCW, is also heavy-tailed. This property is conserved even when limited to HCWs of the same job type. For example, during the night shift, nurses have more contact with other nurses than during the day, with almost five times more contact with other nurses than with physicians, while physicians in the day shift have more than ten times more contact with other physicians than nurses.

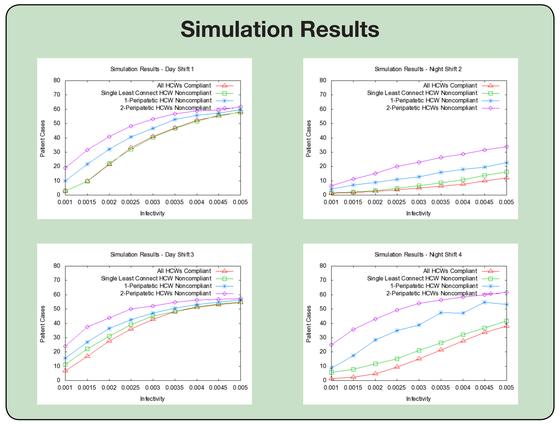


Conclusions

Our results suggest that while HCWs of different job types have different patterns of contact, the contact patterns also vary substantially by individual. This emphasizes the need for fine-grained contact data for the purpose of modeling disease spread and estimating the effects of infection control interventions in healthcare settings.

Related Work: Simulated Disease Spread

Using this same hospital contact data we ran an agent based simulator to assess the impact of one *peripatetic superspreader* (a single HCW who is in contact with many people) on the spread of MRSA in our intensive care unit. Since hand-hygiene control measures have proven to be effective in reducing infection rates, in our simulations we chose either the single most connected (peripatetic) or single least connected HCW to be non-compliant. We ran the simulation over 1000 iterations using contact data from a single shift. Note, these simulations were based on the parameters described in Temime L, Opatowski L, Pannet Y, Brun-Buisson C, Boëlle PY, Guillemot D. Peripatetic health-care workers as potential superspreaders. Proc Natl Acad Sci U S A. 2009 Oct 27;106(43):18420-5.



In the figures above, the result of each simulation is reported as the average number of patients infected over 1000 repetitions. Simulations from each shift show the average number of infected patients was significantly higher when the single most-connected HCW failed to comply with hand hygiene policies compared to when the single least-connected HCW was noncompliant. Our results use real contact data gathered in an ICU and seem to support earlier mathematical studies that heterogeneity in HCW behavior may be an important factor in pathogen transmission.

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