A Regional Approach To Preventing Antimicrobial Resistance

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Conceptual Framework for Preventing AR Transmission: Regional Approach to Controlling Healthcare-associated Multidrug-Resistant Organisms

- **Traditional approach to MDRO control**
  - Promotion of prevention efforts independently implemented by individual health care facilities
  - Does not account for inter-facility spread through movement of colonized/infected

- **Regional Approach**
  - Recognizes that individual facilities are components of integrated and dynamic networks connected via patient movement
    - Occurrences in one healthcare facility may affect many other healthcare facilities

Lee et al, JAMIA 2013;20:e139
Is there an advantage to using a regional approach for MDRO prevention across a healthcare network?

- What would happen if health interventions to reduce MDRO transmission were based upon:
  - Better situational awareness (i.e., timely information on incidence of MDROs from all facilities in a network)
  - Understanding of the “connectedness” of facilities within a region in terms of patient sharing
Vital Signs: Estimated Effects of a Coordinated Approach for Action to Reduce Antibiotic-Resistant Infections in Health Care Facilities — United States

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Common Approach *(Not enough)*
- Patients can be transferred back and forth from facilities for treatment without all the communication and necessary infection control actions in place.

Independent Efforts *(Still not enough)*
- Some facilities work independently to enhance infection control but are not often alerted to antibiotic-resistant or *C. difficile* germs coming from other facilities or outbreaks in the area.
- Lack of shared information from other facilities means that necessary infection control actions are not always taken and germs are spread to other patients.

Coordinated Approach *(Needed)*
- Public health departments track and alert health care facilities to antibiotic-resistant or *C. difficile* germs coming from other facilities and outbreaks in the area.
- Facilities and public health authorities share information and implement shared infection control actions to stop spread of germs from facility to facility.

Figure from CDC Vitals Signs:
http://www.cdc.gov/vitalsigns/stop-spread/index.html
Coordinated prevention approaches that take into account patient sharing in a region have the potential to more completely and efficiently address emergence and dissemination of MDROS and in comparison to independent facility based efforts:

- cumulative 55-74% reduction in acquisitions over time
Overview of Social Network Analysis

- Framework in which to describe the relationships among entities in a system (e.g., relationships among individual people)
- Quantifies the connections among entities (i.e., nodes) using mathematical language to describe connections
- Used in many fields including physics, ecology, neurology, computer science, etc.
- Used in public health for understanding transmission of sexually transmitted infections
Generating Social Networks Using Administrative Data

- Administrative claims are filed for reimbursement each time an individual seeks healthcare
  - Payers (i.e., Medicare, private insurance companies, etc.) compile claims in databases
  - Individuals are given a unique person-level identifier which enables longitudinal analyses of healthcare utilization

- Leveraging these existing data, we can quantify the relationships among healthcare facilities through patient sharing
  - Generate a matrix of interfacility patient sharing
The Impact of Healthcare Facility Patient Sharing on the Incidence of \textit{Clostridium difficile} Infections: Rationale for Prioritizing Prevention in Highly Connected Facilities

- Combined NHSN CDI surveillance data from Washington and Oregon data patient sharing networks in those states
- Modeled the association between connectedness measures and incidence of CDI

Slayton et al., submitted for peer review
The Impact of Healthcare Facility Patient Sharing on the Incidence of *Clostridium difficile* Infections: Rationale for Prioritizing Prevention in Highly Connected Facilities

**Findings**
- Hospitals that were most highly connected to other healthcare facilities through patient sharing had significantly higher rates of incident facility-wide CDI, *independent of size, teaching status or CDI test type*.
  - The rate of incident CDI was nearly 3.5 times higher for hospitals in the highest quartile of “connectedness” (weighted overall indegree) compared to the lowest quartile.

**Conclusion**
- Hospitals that are highly connected to other healthcare facilities via patient sharing will have its CDI rate influenced by the sending healthcare facilities.

Slayton et al., submitted for peer review
Hospital Transfers are a Significant Predictor of *Clostridium difficile* Burden

“*Clostridium difficile* burden at a hospital level can be better understood by knowing how a hospital is connected to other hospitals in terms of patient transfers”

Simmering et al, Infect Control Hosp Epidemiol 2015;36:1031-37
So What?
Drivers of Outbreaks Over Time

- Healthcare associated infections characterized by high patient-to-patient transmission (through environmental or healthcare worker intermediaries) rates within hospitals
- Movement of infectious patients from one hospital to another spreads outbreak in a region
- Outbreaks driven by hospitals where each infectious patient is likely to infect at least one susceptible patient, and by patient sharing in a network of hospitals
Modeling an Outbreak in a Network: Patient Sharing
Modeling an Outbreak in a Network: Simulation
Modeling an Outbreak in a Network: Simulation
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Positive CRE lab tests per 10,000 admissions (NHSN 2015)
The potential for interventions in a long-term acute care hospital to reduce transmission of carbapenem-resistant Enterobacteriaceae in affiliated healthcare facilities

- designed an agent-based simulation model of patients in a regional network of 10 healthcare facilities:
  - 1 LTACH
  - 3 short-stay acute care hospitals (ACHs)
  - 6 nursing homes (NHs).
- calibrated to achieve realistic patient flow and CRE transmission and detection rates

Toth et al., Clin Infect Dis. 2017 May 3.[Epub ahead of print]
The potential for interventions in a long-term acute care hospital to reduce transmission of carbapenem-resistant Enterobacteriaceae in affiliated healthcare facilities

- simulated an LTACH-focused intervention in a previously CRE-free region
- Findings: cumulative CRE transmissions over 5 years reduced by 79% compared to no-intervention simulations

Curves represent the no-intervention scenario (circles); intervention initiation triggered at 1 clinical detection in the LTACH (stars); 10 clinical detections (triangles); and 20 clinical detections (squares).

Toth et al., Clin Infect Dis. 2017 May 3.[Epub ahead of print]
Using Patient Transfer and Length of Stay Data to Target Regional Carbapenem-resistant Enterobacteriaceae (CRE) Prevention Efforts

- **Deterministic compartmental disease transmission model**
  - incorporates patient transfer among hospitals in a U.S. state
  - Model parameters for CRE were estimated from CRE prevalence data from hospitals reporting to the National Healthcare Safety Network (NHSN). The model does not include skilled nursing facilities.

- **Hospitals with longer length of stay and that are more connected by patient transfer play a disproportionate role in the spread of CRE in a regional network**

Paul et. al., abstract presentation, SHEA 2017
Putting this information to work: Prevention Demonstration Projects Currently Underway

- Demonstration projects for the regional benefit from a targeted approach
- Use mathematical modeling to guide the design of regional prevention collaboratives for MDROs
  - SHIELD-OC (Shared Healthcare Intervention to Eliminate Life-threatening Dissemination of MDROs in Orange County)
  - Chicago PROTECT (Providing Regional Organizations with TEEchniques to Control MDROs)
Summary

- The problem of healthcare-associated antibiotic resistance must be viewed as a regional problem
  - A regionally coordinated approach is key to success
- Research and demonstration projects are providing information to guide local and state level activities
  - Understanding patient sharing networks is important
- Modeling results support strategy of targeted interventions using local data to maximize regional impact when information and resources are limited
- Strategies should be adapted as additional data and experience accrue