March 3, 2008

Executive Summary:

Multiscale Analysis of Care Facility Infection Control and Policy Interventions

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Reported to:

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We have conducted a multiscale analysis of system behavior for improvement of infection control in and among hospitals, other care facilities and their relationships to community settings. Our analysis identifies key leverage points for intervention to improve the quality of healthcare systems. In particular, it reveals intervention points that are not currently being addressed. While today the target of essentially all interventions is the immediate patient environment and contacts with care providers, we have identified suppression of the transport of infectious agents through the system as providing key high leverage opportunities for interventions to dramatically impact on infection control.

The key finding of our analysis is a new perspective on the flow of infectious agents through the care provider system. While a patient focus is important for understanding individual care, infectious agents can originate either from microorganisms already present in a patient or from transfer of microorganisms from one patent to another mediated by multiple contacts. In considering the flow of pathogens through the system we identify the following: (1) The number and extent of physical contacts in a care facility is very large compared to that in most other professional or personal contexts, (2) these contacts extend throughout the care system with high frequency due to care provider contact with multiple patients within and among various domains of the care facility.

Our analysis suggests that the flow of pathogens and the number of contact points are very large. In considering the transmission of pathogens, as is relevant particularly to highly resistant strains that are not commonly found in patient flora upon admission but are acquired within the system, a focus on individual patient contact misses the key scaling of the behavior and the impact of interventions.

We compare the effect of interventions at the individual patient level with interventions at higher levels of care system organization. The number of patient contacts is large, but the impact of each contact is small on the flow of pathogens through the system. Thus the great effort to improve the patient contact is a low leverage, high-effort and high-cost intervention. By contrast, establishing checkpoints ("airlocks") between domains of the care system, i.e. between the care facility and the community, between buildings, floors or units of the hospital or other care facility would have considerably greater effect toward reducing the resistant pathogen flows. As a policy intervention, each transit across a domain boundary should be designed to reduce the potential of pathogen transfer from one domain to another. This process has high leverage for dramatically reducing the flow of pathogens, as there are relatively few such events and therefore a dramatically lower effort and cost.

Focusing on high leverage interventions is essential to achieve sustainable change where individuals are under pressure to achieve many different objectives and cannot focus on one for prolonged periods. The indirect effect of reducing infectious agent flows can improve individual patient outcomes more than additional attention focused directly on individual patient contacts.

We have further developed a data gathering, modeling, implementation testing and adoption plan including identifying: (1) data collection methodologies to quantify the flow of infectious agents in and between settings, and thus to calibrate the quantitative assessment of the impact of interventions at patient, unit, floor, building, facility and community levels; (2) which simulations should be performed to demonstrate the effect of interventions and thus characterize the specific gains that can be made by performing specific interventions (this is important to provide guidance to policy makers so that they can realize the significant gains to be achieved by interventions); (3) a set of preliminary scenarios for interventions and how they could be implemented in the real world, and (4) potential partners for data collection, intervention planning and implementation for observation research on the impact that is achieved. Observational validation of major impacts of interventions is key to widespread adoption.