Are We Ready for the Next Outbreak?

Hospital Surge Capacity

By **Shobha S. Subhash** and **Lewis J. Radonovich, M.D.**

The threat of a severe infectious disease outbreak resembling the influenza pandemic in 1918 or a large-scale bioterrorist attack on the citizens of the United States compels us to prepare for the unthinkable. Those of us who are hospital engineers and operators are obligated to prepare for a range of scenarios in which large numbers of victims seek health care on an urgent basis.[1]

Outbreaks may be relatively small, straining but not overwhelming our operational capacities. Or, the next pandemic may be unlike anything seen in recent history: an outbreak so severe it greatly stretches and eventually overburdens nearly every aspect of our health-care delivery and public health systems on a national or global scale. We simply don't know which one awaits us in the future.

Preparedness is essential; complacency or inaction is irrational, even reckless, in an era when lethal infectious disease outbreaks have occurred and are anticipated to occur again in the future.[2,3,4] We should be prepared to face new and emerging infectious disease outbreaks. In the cases where our hospitals require additional bed capacity, a rapid and robust response from the health-care engineering community will be required to minimize negative consequences.

Infection Control Limitations

From a public health perspective, one of the most effective ways to limit disease and outbreak progression is to identify, isolate and treat the source (index) patient early in his course of illness. Separating an ill patient from others who are not infected minimizes the chances for person-to-person transmission.

Unfortunately, even with today's sophisticated clinical technology, diseases often remain undiagnosed for days or weeks. It is in the window between the time-of-arrival and time-of-isolation that an airborne contagious illness is most likely to spread from person-to-person. In this scenario, hospital engineers play an essential role, identifying appropriate locations to house individual contagious patients and determining where to put large numbers of patients who may be infected. Whether proper ventilation and airborne infection control precautions are implemented may determine the course of the outbreak among those hospitalized; it could be quickly quelled with no transmission within the hospital or it could cycle out of control with many new cases and a propagating epidemic.

The limitation of administrative infection control measures was evident during the emergence of Severe Acute Respiratory Syndrome (SARS) in 2003, when early in the course of the outbreak an alarming number of health-care workers were infected. A substantial number of these infections occurred, in part, because hospitals did not have enough information to properly handle infected patients, including the type of precautions necessary to prevent transmission.

SARS served as a reality check in some instances, demonstrating the limitations of administrative control measures and the important role of engineering control measures. In the aftermath of SARS, it was common for new and retrofitted negative pressure isolation spaces to be constructed as a means to separate groups of infected patients from the uninfected.[5,6]

Importance of Sound Engineering

Robust engineering plans were equally important during the 2009 H1N1 influenza pandemic. Although the number of total persons infected with 2009 H1N1 influenza was lower than some mathematical models predicted, the number of severe illnesses and deaths experienced among the pediatric age (0–17 years) groups and pregnant women was much higher than usual. A central focus of infection control revolved around the appropriate type of hospital space to use for housing patients.

As information about the nature of the 2009 H1N1 virus became available to the scientific community, the Centers for Disease Control and Prevention (CDC) worked diligently to appropriately match infection control recommendations with known risks. Early on, concerns about the airborne route of transmission led CDC to espouse the use of negative pressure spaces in a variety of scenarios. As the outbreak evolved, the pandemic virus proved to be not easily transmitted via an airborne route, leading CDC to recommend reserving airborne infection isolation rooms (AIIRs) for medical procedures that cause bioaerosols.

But what would hospitals have done if the 2009 H1N1 influenza virus had proven readily transmissible by the airborne route? Even in the absence of airborne transmission, the amount of negative pressure space was stretched and occasionally insufficient. What can be done to accommodate the large surge of patients if we are faced with a public health crisis similar in severity to the 1918 pandemic? The Joint Commission (IC.01.06.01) calls for a hospital surge plan to be prepared by an interdisciplinary team of partners, such as infection control practitioners, hospital plant operators, ventilation engineers, nurses and public health personnel. Somewhere in most of these plans, contemporary practices are typically described to help control the scope of the outbreak, such as timely identification of those infected, separation of the infected from the non-infected, prompt treatment for those who stand to benefit, consistent implementation of infection control measures, careful surveillance for new infections and a robust education and training program for involved staff. But for some or all of these measures to be effective, an environmentally safe place to locate ill patients where air exchange is adequate is a prerequisite.

Important Components of Engineering Infection Control

A number of important engineering issues must be considered when designing a plan for a large infectious disease outbreak. Among the first steps is to conduct a ventilation assessment of the facility to determine the configuration of its HVAC systems. This includes ensuring the availability of as-built drawings, testing, adjusting and balancing results and the ability to manage airflow patterns. Facilities should review their AIIR strategies by assessing design guides, placement of sensors, maintenance plans, conducting measurements for AIIRs operations and evaluating strategies for creating backup AIIRs, if needed.

To optimize surge capacity, locations should be identified where conventional space can be swiftly transformed into "flu/isolation wards" that house many patients suspected to be infected with the same disease. If the causative infectious agent has the potential to be "airborne" (transmitted from person-to-person via an airborne route) the surge space should be equipped with negative pressure relative to adjacent conventional space. To create negative pressure wards, floors or wings of buildings with a dedicated air-handling unit should be identified. Air exhausted from these units should be directly exhausted to the outside, not re-circulated to other areas of the facility. Airflow should always be directed from clean to dirty areas. Patients should be directed though a single entrance, separated from hospital staff and visitors, to avoid unprotected contacts. Triage areas should be set up near this patient entrance, if possible.

HVAC adjustments may be needed to ensure air flows from clean to dirty areas, such as supplying air at the ceiling and returning it near the floor. Ventilation rates in new negative pressure wards should be maintained in accordance with ASHRAE or FGI guidelines. The exhaust airflow from wards should be equipped with high-efficiency (HEPA) filters.

With so many *active* problems facing health care in 2011, it is easy to develop a sense of complacency about *preparing* for an event that may or may not happen in the near future. Some have pointed out that pandemic risks may be exaggerated as well.[7,8] A key problem with this position is that being wrong only one time may portend many unnecessary deaths and suffering. To be sure, some health-care facilities have taken seriously the importance of developing sound surge plans, including ways to transform non-essential hospital spaces to locations where groups of ill victims can be accommodated. Although these plans typically propose practicable ideas, rarely have these ideas been tested with an exercise or demonstration in which people are moved, ventilation systems are modified, barriers are erected and effectiveness is evaluated.

To our knowledge, there are no peer-reviewed publications from the U.S. health-care sector that discuss the empiric results of surge capacity modifications from an engineering perspective. As engineers and hospital operators, we know all too well that sound ideas do not always translate into sound operations. If we are serious about preparedness, we will be certain our plans can be effectively carried-out and we will continue to build strong interdisciplinary partnerships involving public health officials, first responders, doctors, nurses, engineers, industrial hygienists and infection control staff and others. We must work together to be ready.

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