From: Kathy Harriman
Sent: 04 March 2006 05:40
To: Hodges, Rebecca; Edwards, Simon
Subject: Pandemic influenza study

Attachments: PandemicInfluenzaTransmission.doc

I am writing to submit information to the Royal Society and the Academy of Sciences for review as they study the extent to which scientific evidence is being incorporated into preparedness for a pandemic. I am attaching a literature review that I wrote relating to influenza transmission and respiratory protection. Please let me know if you have any questions about this document. Based on an assessment of the literature, the Minnesota Department of Health is making the following recommendations for infection control for avian and pandemic influenza. Thank you.

Minnesota Department of Health (MDH) recommendations
The Minnesota Department of Health recommends airborne and contact precautions, plus eye protection, in addition to standard precautions ("full barrier precautions") for all known and suspect avian and pandemic influenza patients. Personal protective equipment (PPE) for full barrier precautions, includes:

- **respirator at least as protective as a NIOSH-certified N95 respirator;**
- **gown;**
- **gloves; and**
- **eye protection (faceshield/goggles)**

In making this recommendation, MDH acknowledges that supplies of PPE necessary to implement full barrier precautions, particularly respirators, may be limited during a pandemic. The Institute of Medicine is currently formulating recommendations for the reuse of disposable particulate respirators. MDH will provide guidance on prioritization and possible reuse of PPE when supplies are limited.

Influenza transmission and respiratory protection

Infectious respiratory aerosols

- Coughing, sneezing, and talking can generate respiratory aerosols of varying sizes.[1]
- A cough can contain up to 100,000 particles and a sneeze can generate 20 times more particles than a cough.[2]
- The greater the force and pressure involved in aerosol generation, the smaller the expelled particles will be.
- The smallest particles evaporate quickly and the dried residues that remain (droplet nuclei), are so small that they can be carried on air currents a considerable distance from the source and remain suspended in the air for substantial lengths of time and infect people at some distance from the source.[1]
- Particle size also determines where particles are deposited in the respiratory tract of the host. Where the particles are deposited can determine whether or not infection will occur, e.g., smaller particles may be deposited lower in the respiratory tract than larger particles.[3]

Current infection control recommendations for respiratory diseases

- Infectious particles are typically measured in microns; there are 25,400 microns in one inch.
- Infection control guidelines cite a particle size of 5 microns (μm) as a break point that distinguishes between diseases spread by "droplet transmission" (particles $\geq$ 5 μm) and diseases spread by "airborne transmission" (particles < 5 μm).[4]
- Larger droplets are thought to typically travel no more than 3 feet and small particle aerosols have the ability to travel longer distances.
- Larger droplets are thought to be deposited mainly in the mucous membranes of the nose, eyes, and mouth; small particle aerosols are more likely to be deposited in the lower respiratory tract.
- Communicable diseases are classified by their presumed route of transmission and infection control recommendations are based on this classification.
- Infection control guidelines recommend that healthcare workers wear a surgical mask when working within 3 feet of patients with an infection spread via the droplet route and that they wear a respirator when in the same room with a patient with an infection spread by the airborne route.

Transmission of respiratory aerosols

- Existing infection control recommendations do not reflect current knowledge of respiratory aerosols.
- There is no clear delineation between droplet and airborne transmission and the distances that particles travel can vary (e.g., particles $\geq$ 5 μm can travel more than three feet).[5]
- The length of time particles remain airborne varies and is determined by particle size, settling velocity, and airflow in the area.
- There is no predictable size for droplet nuclei; the final size depends on the nature of the fluid that contained the organism, the initial size of the aerosol, environmental conditions (e.g., temperature, relative humidity, airflow), the time spent airborne, and the size of the organism within a droplet.

Human influenza transmission

- Using current infection control terminology, there is evidence that influenza is transmitted between humans via small particle aerosols (airborne transmission), larger droplets (droplet transmission), as well as by direct and indirect contact (contact transmission).[3, 4, 6, 7]
- The relative importance of each route of transmission is unclear.

Evidence for airborne transmission of influenza

The explosive spread of influenza after introduction into a community has long suggested the possibility of airborne transmission.

- Observational evidence of airborne transmission of influenza in humans:
    - Tuberculosis patients housed in a building with ceiling ultraviolet radiation (which is known inactivate influenza virus and to reduce airborne disease transmission)[8] during the 1957-58 pandemic were less likely to become infected with influenza than tuberculosis patients housed in a building without ultraviolet radiation.[9]
    - In 1979, aircraft passengers, including a passenger who became acutely ill with influenza within 15 minutes of boarding the plane, were detained on a runway for 4.5 hours during which time the ventilation system was turned off for 2-3 hours. The ill passenger stayed on the plane the entire time and the other passengers and crew were free to come and go. Within 72 hours, 72% of the passengers and crew subsequently developed influenza-like-illness (91% with confirmed influenza). The risk of illness was dependent on the amount of time spent on board.[10]
- Experimental evidence of airborne transmission of influenza in humans:
    - The infectious dose of influenza is 10-100 fold lower when small particle aerosols are delivered to the lower respiratory tract (mimicking airborne transmission), rather than when delivered as intranasal drops (mimicking droplet transmission).[11]

    - Influenza virus administered intranasally typically does not cause cough or lower respiratory tract symptoms, whereas early onset of cough and protracted cough are associated with natural influenza infection.[3]
- Experimental evidence of airborne transmission of influenza in animals:
    - Infected and uninfected mice were placed in a closed chamber in which the airflow could be manipulated. As the rate of airflow increased, the rate of influenza transmission decreased proportionately.
    - In a setting of constant airflow, some uninfected mice were separated from infected mice by a screen while other uninfected mice were on the same side of the screen as the infected mice. The infection rates in both groups of initially uninfected mice were similar.[12]
    - Uninfected mice placed in an unventilated room with constantly agitated air and low relative humidity became infected with influenza as late as 24 hours after virus was aerosolized into the room. As relative humidity levels were increased, the virus was infective for shorter periods of time. The possibility of reaerosolisation of influenza virus is supported by increased infectivity of the air after the floor of the room was vigorously swept.[13]
    - A highly transmissible influenza strain could be recovered easily from the air surrounding infected mice during the period when they were most infectious, but there was no recoverable virus in the air surrounding mice infected with a less transmissible influenza strain during the same period.[14]
    - Efficient transmission of influenza from infected to uninfected ferrets was demonstrated whether or not the ferrets were separated by a long straight air duct or by air ducts in the shape of an "s" or a "u."[15]

Influenza transmission in health care facilities

- During the 1957-1958 influenza pandemic, an acutely ill patient was admitted to a four-person hospital room with no precautions. Subsequently, roommates, health care workers, and other ward patients became ill. The epidemic curve suggested a point source outbreak with additional droplet or contact spread, rather than a single source outbreak, which would be more likely to be associated with airborne transmission.[16]

- More recent influenza experiences at two U.S. hospitals have been described:
    - In one hospital transmission of influenza was rarely noted; most rooms were private, but had positive pressure. [3]
    - In the other hospital, transmission of influenza in paediatric patients was most often observed among patients in the same room, particularly those in adjacent cribs. Patients in other rooms in the same ward were less likely to become infected, even though room doors were open and influenza patients were not housed in negative pressure rooms.[6]
    - These two studies suggest that the predominant mode of transmission in these facilities was either through large droplets or by direct or indirect contact. However, it should be noted that paediatric patients do not typically have a forceful cough and are known to be less likely to transmit airborne diseases such as tuberculosis.[17]

Respiratory protection

- Respirators are designed to protect the wearer from respiratory aerosols expelled by others.
- Surgical masks are designed to protect the sterile field from respiratory aerosols expelled by the wearer and are not designed to offer respiratory protection to the wearer.
- Although there are no data on the efficacy of respirators vs. surgical or procedure masks in preventing transmission of influenza to healthcare workers, there are data demonstrating the poor filtration and fit capacity of single or even multiple surgical masks worn at one time.[18-20]

- Surgical masks are not evaluated for fit and cannot be properly fitted to the face or tested for fit and do not prevent leakage around the edge of the mask when the user inhales.
- There are no minimum standards for surgical mask filter efficiency and there are a wide variety of filter efficiencies among available masks; most surgical masks do not effectively filter small particles from the air.

Conclusions

- To minimize exposure of healthcare workers to pandemic influenza virus, healthcare workers should use respirators, if available, rather than surgical masks when working with infected patients.
- Providing appropriate respiratory protection to healthcare workers during a pandemic is critical because:
  - vaccine for the pandemic influenza strain is unlikely to be available in the initial stages of a pandemic;
  - antiviral supplies are likely to be limited; and
  - pandemic influenza may cause disproportionate morbidity and mortality in younger, healthier people, e.g., healthcare workers, as it did in the 1918 pandemic.

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