Building Design and Engineering Approaches to Airborne Infection Control
Harvard School of Public Health

Pandemic Influenza

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Disclosures

No conflicts to disclose.

This handout does not contain all of the slides to be presented
Influenza - Infectious

- Virus infects any part of the respiratory tract, from nose to throat to bronchial tract to lungs
- People with influenza **highly infectious**
  - Infectious before symptoms start
  - A lot of virus in secretions
  - Coughing, sneezing, talking
- Time from exposure to symptoms (**incubation period**) can be as short as **2 days**
- **Infectious for 7-10 days**, but drops off after 5 days
- Young children can be infectious for **2-3 weeks**
- Constant mutation (“**drift**”), major genetic change (“**shift**”)
  - Recurrent infection
  - Need to change vaccine
  - Pandemics
Trends in Deaths from Selected Causes, Massachusetts: 1842-1997

1. The category of infectious disease includes Infectious and Parasitic Diseases, ICD-9 codes 001-139, and Pneumonia and Influenza, ICD-9 codes 480-487
2. Heart Disease, ICD-9 codes 390-398, 402, 404-429
3. Cancer, ICD-9 codes 140-208
4. Injuries, ICD-9 codes E800-E999
Pandemic Influenza P&I Mortality

1918

1957

1968
### Case Fatality Ratio

#### Projected Number of Deaths*

**US Population, 2006**

<table>
<thead>
<tr>
<th>Case Fatality Ratio</th>
<th>Category</th>
<th>Number of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2.0%</td>
<td>Category 5</td>
<td>&gt;1,800,000</td>
</tr>
<tr>
<td>1.0 - &lt;2.0%</td>
<td>Category 4</td>
<td>900,000 - &lt;1,800,000</td>
</tr>
<tr>
<td>0.5 - &lt;1.0%</td>
<td>Category 3</td>
<td>450,000 - &lt;900,000</td>
</tr>
<tr>
<td>0.1% - &lt;0.5%</td>
<td>Category 2</td>
<td>90,000 - &lt;450,000</td>
</tr>
<tr>
<td>&lt;0.1%</td>
<td>Category 1</td>
<td>&lt;90,000</td>
</tr>
</tbody>
</table>

*Assumes 30% illness rate and unmitigated pandemic without interventions*

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### Mitigation Strategy by Pandemic Severity

<table>
<thead>
<tr>
<th>Pandemic Severity Index</th>
<th>1</th>
<th>2 and 3</th>
<th>4 and 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interventions</strong> <em>by Setting</em>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Home</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voluntary isolation of ill at home (adults and children); combine with use of antiviral treatment as available and indicated</td>
<td>Recommend*</td>
<td>Recommend*</td>
<td>Recommend*</td>
</tr>
<tr>
<td>Voluntary quarantine of household members in homes with ill persons (adults and children); consider combining with antiviral prophylaxis if effective, feasible, and quantities sufficient</td>
<td>Generally not recommended</td>
<td>Consider**</td>
<td>Recommend**</td>
</tr>
<tr>
<td><strong>School</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child social distancing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dismissal of students from schools and school based activities, and closure of childcare programs</td>
<td>Generally not recommended</td>
<td>Consider: ≤4 weeks††</td>
<td>Recommend: ≤12 weeks§§</td>
</tr>
<tr>
<td>- reduce out-of-school social contacts and community mixing</td>
<td>Generally not recommended</td>
<td>Consider: ≤4 weeks††</td>
<td>Recommend: ≤12 weeks§§</td>
</tr>
<tr>
<td><strong>Workplace / Community</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult social distancing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- decrease number of social contacts (e.g., encourage teleconferences, alternatives to face-to-face meetings)</td>
<td>Generally not recommended</td>
<td>Consider</td>
<td>Recommend</td>
</tr>
<tr>
<td>- increase distance between persons (e.g., reduce density in public transit, workplace)</td>
<td>Generally not recommended</td>
<td>Consider</td>
<td>Recommend</td>
</tr>
<tr>
<td>- modify postpones, or cancel selected public gatherings to promote social distance (e.g., postpone indoor stadium events, theatre performances)</td>
<td>Generally not recommended</td>
<td>Consider</td>
<td>Recommend</td>
</tr>
<tr>
<td>- modify workplace schedules and practices (e.g., telework, staggered shifts)</td>
<td>Generally not recommended</td>
<td>Consider</td>
<td>Recommend</td>
</tr>
</tbody>
</table>
Potential Impact of Next Pandemic

- **Outbreaks will occur simultaneously** throughout the US
  - *Overwhelming demand* on the healthcare delivery system
  - *No “outside” help*
- **Up to 40% absenteeism** in all sectors at all levels
  - Public service, public safety
  - Healthcare personnel
  - *Just-in-time economy*
- **Vaccine not available** for several months
- **Antivirals may or may not be available and/or useful**
- **Order and security disrupted** for several months, not just hours or days
- **On multiple news outlets 24/7**
State Preparedness

- Space – planning for additional care sites
- Supplies – working to procure adequate and accessible provisions
- Staff - professional practice issues:
  - altered standards of care
  - licensure
  - liability
  - vaccination
  - family support
- Security - planning and resources
- Systems – surveillance, education, and communication
Prevention for the Public

- Wash hands frequently, and teach children well
- Hand-washing/sanitizing particularly after contact w/ public surfaces (e.g. shopping carts)
- If you get sick, stay home from school/work
- Cover mouth when coughing to avoid exposure to others
- Stay 3 feet from anyone coughing or sneezing
- Get an annual flu shot as indicated
- If a pneumonia vaccine is recommended, get it
Efficacy of Community-Level Interventions on Respiratory Diseases SARS, Hong Kong, 2003

Mitigation

- Social distancing
  - Cancellation of public events
  - Closure of recreational and other facilities
  - Closure of schools
  - Closure of businesses

- Self-shielding – “reverse quarantine” - self-imposed exclusion from infected persons or those perceived to be infected
  - Snow days

- Travel restrictions
Community-Based Interventions

1. Delay outbreak peak
2. Decompress peak burden on hospitals/infrastructure
3. Diminish overall cases and health impacts

Pandemic outbreak:
- No intervention
- With intervention

Days Since First Case

Daily Cases

Pandemic outbreak:
- No intervention
- With intervention
Spacing of people: If homes were like schools

*Based on avg. 2,600 sq. ft. per single family home*
Spacing of people: If homes were like schools

*Based on avg. 2,600 sq. ft. per single family home*
Adherence to Face Mask Use

[Graph showing adherence to face mask use over five days with bars for Surgical and P2 categories]
ILI Reduction With Either Surgical Mask or P2 Respirator Use

Masks in the Community

- Healthy people - masks may prevent transmission of influenza
  - Would have to be worn whenever in contact with other people
- People with respiratory symptoms - consider wearing masks in public
Vaccine Development

surveillance

select strains

prepare reassortants

standardize antigen

assign potency

review/license

formulate/test/package

vaccinate

WHO/CDC

CDC/FDA

FDA

manufacturers

clinic

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
Swine Influenza A (H1N1) Infection in Two Children — Southern California, March–April 2009

On April 21, this report was posted as an MMWR Early Release on the MMWR website (http://www.cdc.gov/mmwr).
Some Pre-2009 H1N1 Planning Assumptions

- Starts in Asia
- H5N1 top candidate
- 0.5-1.0% mortality
- 7 day infectious period
- N-95 respirators
- School closure to decrease spread
- No vaccine available
- Two doses of vaccine for everyone
- Antivirals for treatment and prophylaxis
- Young to middle-age adults heavily affected
Some Realities of N1H1 Influenza

- Starts in North America
- <0.1% mortality
- Increased comfort level with shorter infectious period
- Acted like ordinary influenza – higher level of respiratory protection maybe not needed
- Variable school response – closure for community mitigation abandoned
- Vaccine available earlier than expected, but maybe not early enough
- One dose of vaccine for most people
- Antivirals reserved for treatment
- Children most heavily affected
Genetic Relationships among Human and Relevant Swine Influenza Viruses, 1918-2009
Percentage of Visits for Influenza-like Illness (ILI) Reported by the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet), Weekly National Summary, October 1, 2006 – April 3, 2010
Distribution of Reports of Cases of H1N1 Influenza

Influenza-Like Illness Surveillance
Massachusetts Sentinel Sites

MMWR Reporting Week
% Influenza-Like Illness*
Rate of Confirmed Pandemic H1N1 by Age Massachusetts, through February 10, 2010

Source: Massachusetts Immunization Program MDPH MassCHIP 2005 Population Estimates
Rate of Hospitalization with Pandemic H1N1 Influenza by Age Group, per 100,000 Population
Massachusetts, April 1, 2009 to February 10, 2010

Source: Massachusetts Immunization Program
MDPH MassCHIP 2005 Population Estimates

Preliminary Data
Massachusetts Department of Public Health
February 2010, Do Not Distribute

N = 401
Initial Target Groups For H1N1 Vaccine

- Pregnant women
- HH contacts/caregivers of infants < 6 m/o
- HCP and EMS
- Persons 6 mos – 24 yrs/old
- HR persons 25 - 64 yrs/old

3.4 M in MA
Eligible for H1N1 Vaccine
12/21/09

- Healthy people 25 – 49 y/o
- People ≥ 65 y/o
  - Risk for infection less
- Still target group for:
  - Seasonal flu vaccine
  - Pneumococcal vaccine
H1N1 Vaccine

- 9 formulations of H1N1 vaccine
  - Approved for different age and risk groups
  - Live nasal spray and inactivated injectable
  - No vaccine with adjuvants

- Provided with vaccine:
  - Needles, syringes
  - Alcohol swabs
  - Sharps containers
  - Vaccine record cards
<table>
<thead>
<tr>
<th>IF PATIENT IS...</th>
<th>GIVE SEASONAL INFLUENZA VACCINE?</th>
<th>GIVE PANDEMIC H1N1 VACCINE?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HEALTHY, NO UNDERLYING CONDITION</td>
<td>HEALTHY, NO UNDERLYING CONDITION</td>
</tr>
<tr>
<td>PREGNANT</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>HEALTHCARE WORKER/ EMERGENCY MEDICAL STAFF</td>
<td>Yes</td>
<td>Limit to providers with direct patient contact, if vaccine supply is limited</td>
</tr>
<tr>
<td>HOUSEHOLD CONTACT OF CHILD &lt;6 MONTHS OLD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6 MONTHS TO 4 YEARS OLD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5 TO 18 YEARS OLD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>19 TO 24 YEARS OLD</td>
<td>Provide as desired to prevent influenza</td>
<td>Yes</td>
</tr>
<tr>
<td>25 TO 49 YEARS OLD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>50 TO 64 YEARS OLD</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>65 YEARS OLD AND OLDER</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Depending on availability of vaccine. Chart indicates which groups are prioritized for seasonal influenza and H1N1 influenza and should receive vaccine immediately, and which groups should not be vaccinated if there is a limited supply of vaccine.*
Cumulative Seasonal and H1N1 Flu Vaccination Rates 6 mos – 17 yrs
January 2010, National 2009 H1N1 Flu Survey

<table>
<thead>
<tr>
<th></th>
<th>Seasonal</th>
<th>H1N1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>55%</td>
<td>57%</td>
</tr>
<tr>
<td>NE</td>
<td>51%</td>
<td>52%</td>
</tr>
<tr>
<td>US</td>
<td>40%</td>
<td>33%</td>
</tr>
</tbody>
</table>
Healthcare Worker Influenza Vaccination 2009-2010
Massachusetts, Behavioral Risk factor Surveillance System

- Seasonal Vaccine
- 2009 H1N1 Vaccine

<table>
<thead>
<tr>
<th>Vaccination Type</th>
<th>Healthcare Workers</th>
<th>HCWs - Direct Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal Vaccine</td>
<td>51</td>
<td>55</td>
</tr>
<tr>
<td>2009 H1N1 Vaccine</td>
<td>41</td>
<td>37</td>
</tr>
</tbody>
</table>
Impact in the U.S.
CDC Estimates April – February 13, 2010

- 59 million cases (42-86 million)
- 265,000 hospitalizations (188,000-389,000)
- 12,000 deaths (8,520-17,620)
  - 1,250 – 0-17 y.o. (10.4%)
  - 9,200 – 18-64 y.o. (76.7%)
  - 1,550 – 65+ y.o. (12.9%)

- Compared with 90% >64 y.o. with seasonal influenza
Need

- Flexible planning
- Broad understanding of need to adjust to evolving situation
- Adherence to the evidence-based approach
- More research
- Better public understanding of vaccine efficacy and safety
- Surveillance and situational awareness
- Cooperation
- Attention to just-in-time economy issues
- Credible source of information
Prevention of Influenza

- Vaccine
- Standard precautions
- Droplet precautions
- Airborne precautions
- Respiratory hygiene/cough etiquette
- Social distancing
- Isolation
- Antiviral treatment
- Quarantine
Transmission of Influenza

- Droplet (wet droplets, 3-6 feet)
- Contact
  - Direct (person-to-person)
  - Indirect (fomites)
- Airborne (droplet nuclei)
  - “Short-range aerosol transmission”
Controversy

- How much transmission by each route?
- Nature of precautions
- Context
Influenza, Livermore V.A., 1957

- Upper room UVGI installed in main building for tuberculosis control
- 1957 pandemic influenza A H2N2, 2 outbreaks

- Attack rates (clinical and serologic)
  - 2% of 209 patients in irradiated ward
  - 19% of 396 patients in unirradiated buildings

- No information on exposures and patient mix.
An Outbreak of Influenza Aboard a Commercial Airliner
Ventilation and Influenza in a LTCF

<table>
<thead>
<tr>
<th>Building</th>
<th>Population</th>
<th>% Outside Air</th>
<th>Culture Confirmed Influenza A H3N2*</th>
<th>Attack Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A**</td>
<td>184</td>
<td>100</td>
<td>3</td>
<td>1.6%</td>
</tr>
<tr>
<td>B</td>
<td>196</td>
<td>70</td>
<td>31</td>
<td>15.8%</td>
</tr>
<tr>
<td>C</td>
<td>194</td>
<td>70</td>
<td>18</td>
<td>9.3%</td>
</tr>
<tr>
<td>D</td>
<td>116</td>
<td>30</td>
<td>16</td>
<td>13.8%</td>
</tr>
</tbody>
</table>

* 15 non-confirmed, but ill, 8 from building A
** More square feet per person

Attack rates in the next season essentially the same among buildings.
7/20 (35%) vaccinated staff with symptoms
8/13 (62%) unvaccinated staff with symptoms
Overall attack rate for illness = 30/62 (48%)

No single room cases
Occupational Exposure to a Hospitalized Influenza A Index Case

- First culture confirmed case in region
- Primary care provider acquires influenza
- None of 28 unvaccinated health care workers, with median unprotected exposure of 4 hours developed influenza (clinically or serologically)
Naval Base/Airplane Outbreak of Influenza A H1N1, 1986

October 17-28, deployed in Puerto Rico

October 28, two DC-9’s to Key West
Doors closed 2.5 hours

Barracks in Puerto Rico, re-circulated AC air

DC-9
Complete air exchange every 4 min., above to below
Non-Inferiority of Surgical Masks Versus N95 Respirators, Nurses, Ontario, Seasonal Influenza
Loeb, et al. JAMA 2009; 302:1865-71

Table 2. Comparison of Laboratory-Confirmed Influenza Between the Surgical Mask and N95 Respirator Groups

<table>
<thead>
<tr>
<th></th>
<th>Surgical Mask (n = 212)</th>
<th>N95 Respirator (n = 210)</th>
<th>Absolute Risk Difference, % (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory-confirmed influenza(^a)</td>
<td>50 (23.6)</td>
<td>48 (22.9)</td>
<td>-0.73 (-8.8 to 7.3)</td>
<td>.86</td>
</tr>
<tr>
<td>RT-PCR influenza A</td>
<td>5 (2.4)</td>
<td>1 (0.5)</td>
<td>-1.88 (-4.13 to 0.36)</td>
<td>.22</td>
</tr>
<tr>
<td>RT-PCR influenza B</td>
<td>1 (0.5)</td>
<td>3 (1.4)</td>
<td>0.96 (-0.89 to 2.81)</td>
<td>.37</td>
</tr>
<tr>
<td>≥4-Fold rise in serum titers A/Brisbane/59/2007 (H1N1)(^b)</td>
<td>25 (11.8)</td>
<td>21 (10)</td>
<td>-1.79 (-7.73 to 4.15)</td>
<td>.55</td>
</tr>
<tr>
<td>≥4-Fold rise in serum titers A/Brisbane/10/2007 (H3N2)(^b)</td>
<td>42 (19.8)</td>
<td>49 (23.3)</td>
<td>3.52 (-4.32 to 11.36)</td>
<td>.38</td>
</tr>
<tr>
<td>≥4-Fold rise in serum titers B/Florida/4/2006(^b)</td>
<td>15 (7.1)</td>
<td>19 (9.0)</td>
<td>2.0 (-3.0 to 7.17)</td>
<td>.46</td>
</tr>
<tr>
<td>≥4-Fold rise in serum titers A/TN/1560/09 (H1N1)(^b)</td>
<td>17 (8.0)</td>
<td>25 (11.9)</td>
<td>3.89 (-1.82 to 9.59)</td>
<td>.18</td>
</tr>
</tbody>
</table>

Table 4. Clinical Outcomes Between the Surgical Mask and N95 Respirator Groups

<table>
<thead>
<tr>
<th></th>
<th>Surgical Mask (n = 212)</th>
<th>N95 Respirator (n = 210)</th>
<th>Absolute Risk Difference, % (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician visits for respiratory illness</td>
<td>13 (6.1)</td>
<td>13 (6.2)</td>
<td>-0.06 (-4.53 to 4.65)</td>
<td>.98</td>
</tr>
<tr>
<td>Influenza-like illness(^a)</td>
<td>9 (4.2)</td>
<td>2 (1.0)</td>
<td>-3.29 (-6.31 to 0.28)</td>
<td>.06</td>
</tr>
<tr>
<td>Work-related absenteeism</td>
<td>42 (19.8)</td>
<td>39 (18.6)</td>
<td>-1.24 (-8.75 to 6.27)</td>
<td>.75</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.
\(^a\) Influenza-like illness was defined as the presence of both cough and temperature ≥38°C or greater.
Surgical Masks Versus N95
MacIntyre, ICAAC, 9/15/09; IDSA, 10/31/10

- Randomized, community trial of 24 hospitals and 1936 HCWs in Beijing
- 4 weeks in winter, respiratory illness, ILI and laboratory confirmed respiratory virus
- No efficacy of surgical masks
- N95s same efficacy fit-tested or not
  - 60% for clinical respiratory illness
  - 75% for ILI
  - 56% for viral respiratory infection
  - 75% for influenza
- Re-analysis reveals no statistical difference between surgical masks and N95 respirators
Lack of Airborne Transmission during Outbreak of Pandemic (H1N1) 2009 among Tour Group Members, China, June 2009

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Total no. persons</th>
<th>No. cases</th>
<th>Secondary attack rate, %</th>
<th>Rate ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat proximity to index case-patient during flight CZ6659, Chengdu–Jiuzhaigou, June 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;2 rows</td>
<td>19</td>
<td>5</td>
<td>26</td>
<td>Referent</td>
</tr>
<tr>
<td>≤2 rows</td>
<td>4</td>
<td>2</td>
<td>50</td>
<td>1.9 (0.35–5.7)</td>
</tr>
<tr>
<td>Seat proximity to index case-patient during bus rides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never ≤2 rows</td>
<td>8</td>
<td>2</td>
<td>25</td>
<td>Referent</td>
</tr>
<tr>
<td>Ever ≤2 rows</td>
<td>22</td>
<td>7</td>
<td>32</td>
<td>1.3 (0.39–6.0)</td>
</tr>
<tr>
<td>Talked with index case-patient from &lt;2 m for ≥2 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
<td>9</td>
<td>56</td>
<td>∞ (2.4–∞)</td>
</tr>
<tr>
<td>No</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>Referent</td>
</tr>
<tr>
<td>Length of conversation with index case-patient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥10 min</td>
<td>10</td>
<td>8</td>
<td>80</td>
<td>4.8 (1.2–70)</td>
</tr>
<tr>
<td>2–9 min</td>
<td>6</td>
<td>1</td>
<td>17</td>
<td>Referent</td>
</tr>
</tbody>
</table>

*Cl, confidence interval.
Household Transmission of Pandemic 2009 Influenza A (H1N1)

- **New York** (Cauchemez, et al. NEJM 2009; 361: 2619)
  - Less transmission than previous pandemics
  - 9-28%
- **Texas** (Morgan et al. EID 2010; 16: 631)
  - Children <5 – 8-19%
  - Adults ≥50 – 4-12%
Roy & Milton Classification

- Airborne transmission of disease:
  - Obligate
  - Preferential
  - Opportunistic
Parameters of Influenza Transmission/Acquisition

- Infectivity of the virus
  - “Viability”
  - Receptor recognition
- Access to susceptible host/tissue
- Inoculum size/dose
- Immunity
  - Local
  - Systemic
- Symptoms
Precautions for a Novel Influenza Virus

- Isolation of sick
- Negative pressure room
- Respiratory protection at N-95 level or higher
- Re-evaluate periodically
Day post inoculation with A/Texas/91 (H1N1) virus

2009 – HICPAC Recommendation for Pandemic H1N1 Influenza Precautions

- Standard and droplet precautions
- Respiratory protection for invasive procedures generating respiratory droplet aerosols
CDC Guideline - 2009

- Promote and administer the 2009 H1N1 influenza and seasonal influenza vaccines
- Enforce respiratory hygiene and cough etiquette
- Establish facility access control measures and triage procedures
- Manage visitor access and movement within the facility
- Establish policies and procedures for patient placement and transport
- Apply isolation precautions
  - Close contact = working within 6 feet of the patient or entering into a small enclosed airspace shared with the patient
  - Standard precautions
    - Respiratory protection at the level of fitted N95 respirator or higher with all close contact
- Monitor and manage ill healthcare personnel
- Routine cleaning and disinfection strategies
Specifically charged with not taking economic and logistical considerations into account.

Healthcare workers in close contact with individuals with nH1N1 influenza or influenza-like illnesses should use fit-tested N95 respirators or respirators that are demonstrably more effective as one measure in the continuum of safety and infection control efforts to reduce the risk of infection.

Increase research on influenza transmission and personal respiratory protection.
Issues Related to Precautions for Influenza

- What is necessary?
- Practical aspects
  - Health care delivery overwhelmed, limited staff
    - Never would be enough negative pressure rooms
    - Patient care compromise related to isolation
  - Application of precautions over time
    - Intolerance of procedures and PPE over time
    - Disregard of other measures that may be more important
    - Sustainability of respirator availability and prolonged use, multiple products
    - Safe handling, reuse of respirators
  - Cost
- In epidemic and pandemic situation infection is ubiquitous
  - Exposure in home and outside clinical areas
# Impact of Isolation for Infection Control


<table>
<thead>
<tr>
<th></th>
<th>Isolated for MRSA</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adverse events per 1000 days</strong></td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td><strong>Preventable</strong></td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td><strong>Nonpreventable</strong></td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td><strong>Complain about care</strong></td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>VSs not recorded</strong></td>
<td>51%</td>
<td>31%</td>
</tr>
<tr>
<td><strong>No progress note</strong></td>
<td>26%</td>
<td>13%</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td>17%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Infection Control – In Flux

- Droplet precautions recommended for seasonal influenza
  - 30-year track record
- CDC has recommended N-95 respirator or higher respiratory protection with suspect and confirmed H1N1 cases, but not negative pressure isolation
- MDPH and others recommended droplet precautions, except with aerosol-generating procedures, after initial experience with H1N1
- Official recommendations for H1N1:
  - HICPAC – droplet precautions
  - SHEA, IDSA and APIC – droplet precautions
  - IOM letter – keep current CDC guideline until further research
- Awaiting CDC decision on respiratory protection and 7 day exclusion of HCWs (versus 5 days for seasonal influenza)
CDC Proposed Guidance – 06/22/10

- Promote influenza vaccines
- Enforce respiratory hygiene and cough etiquette
- Establish facility access control measures and triage procedures
- Manage visitor access and movement within the facility
- Establish policies and procedures for patient placement and transport
- Apply isolation precautions
  - Close contact = working within 6 feet of the patient or entering into a small enclosed airspace shared with the patient
  - Standard and droplet precautions
  - Respiratory protection at the level of fitted N95 respirator or higher, and engineering controls during aerosol-generating procedures
- Monitor and manage ill healthcare personnel
- Routine cleaning and disinfection strategies
Standard Precautions

- Universal – every patient, regardless of diagnosis
- Hand hygiene - always
- Gloves – with fluid contact
- Gowns – as needed
- Masks/eye protection – as needed
- Shoe covers – as needed
Standard Precautions

- **Use:**
  - Gloves: When you’re going to touch someone or objects in their environment
  - Gowns: When there is a risk of your clothing or exposed skin coming in contact with anything wet or weeping
  - Mask and goggles or a face shield: When there is a risk of being splashed or sprayed with blood or body fluids

- **Practice:**
  - Hand hygiene as a regular part of Standard Precautions
Expanded Precautions

- **Droplet Precautions**
  - Wear a surgical mask within 3-6 feet of client

- **Airborne Infection Isolation**
  - Single room
  - Negative pressure
  - Wear a particulate respirator when entering patient’s environment
“Universal” Approach to Respiratory Infection Control

- “Respiratory Hygiene” (source control) – health care facility and transport
  - Triage, respiratory complaints/fever – mask
  - Triage, respiratory complaints/fever, with rash or question SARS, TB, measles, etc. – private room, AII room, PPE for staff
  - Waiting room, masks for respiratory complaints/fever, mask availability for all others
  - Can’t wear mask – private room, treatment
  - Expanded PPE recommendations for HCWs
“Cough Etiquette”

- Patients with respiratory tract infection/cough
  - Mouth/nose covered with cough/sneezing, tissues, “no-touch” receptacles
  - Hand hygiene
  - Masks offered at waiting areas
  - Three-foot spacing for suspected respiratory tract infection
SARS: Outstanding Infection Control Issues

- Accurate risk assessment for health care workers
- Role of inanimate objects and surfaces in transmission and coronavirus hardness
- Re-use of N-95 and other respirators
- Safe respiratory care and therapy – avoid nebulizers, non-invasive positive pressure; use of in-line filters and closed suction
- Coronavirus respiratory and gastrointestinal persistence
- Management of SARS patients in the home setting
- Specimen handling and processing in the clinical laboratory
- Applicability and utility of quarantine
- SARS and public places
- Travel policies
Emerging Infection and Bioterrorism Response
Syndromes

- Pneumonia and pneumonia-like
  - Anthrax
  - Plague
  - Tularemia
  - Q fever
  - Staph. enterotoxin B

- Sepsis/systemic illness
  - Brucellosis
  - Hemorrhagic fevers
  - Ricin
  - Nicotine

- Skin lesions
  - Smallpox
  - Anthrax
  - Tularemia
  - Hemorrhagic fevers

- Neurological
  - Botulism
  - Encephalitis
  - Tetrodotoxin

- Gastrointestinal
  - Staph. enterotoxin B
  - Cholera exotoxin
  - Nicotine
Precautions

- **Standard**
  - anthrax
  - brucellosis
  - Q fever
  - tularemia
  - viral encephalitis
  - botulism
  - Staph. enterotoxin B

- **Standard plus Contact**
  - brucellosis (draining)

- **Standard plus Droplet**
  - plague

- **Standard plus Droplet plus Airborne**
  - smallpox
  - viral hemorrhagic fever
From terminally infected animal, or carcass after death

- Cutaneous
- Biting fly

Z1

- Germination & multiplication in lymphatics & spleen.
- Vegetative forms released in massive numbers into blood in final hours of life

Z2

- Pulmonary (spore-laden dust)
- Gastrointestinal (infected meat, contaminated water?)
- Cutaneous (via lesion)

Y

- Sporulate on exposure to O₂

- Ingested (grazing, browsing, drinking). Inhaled sometimes? (spore-laden dust)

- Vegetative forms (shed at death in haemorrhagic exudate from nose, mouth or anus or in spilt blood)
Inhalational Anthrax

- **Infective dose:** 8,000-50,000 spores
- **Incubation period:** 1-7 days (up to 60)
- **Prodrome:** fever, malaise and fatigue, non-productive cough, vague chest discomfort, ± 2-3 day improvement
Onsets: 9-44 days, median 20 days

The Sverdlovsk Anthrax Outbreak of 1979

Matthew Meselson, Jeanne Guillemin, Martin Hugh-Jones, Alexander Langmuir, Ilona Popova, Alexis Shalokh, Oiga Yampolskaya

In April and May 1979, an unusual anthrax epidemic occurred in Sverdlovsk, Union of Soviet Socialist Republics. Soviet officials attributed it to consumption of contaminated meat. U.S. agencies attributed it to inhalation of spores accidentally released at a military microbiology facility in the city. Epidemiological data show that most victims worked or lived in a narrow zone extending from the military facility to the southern city limit. Farther south, livestock died of anthrax along the zone’s extended axis. The zone paralleled the northerly wind that prevailed shortly before the outbreak. It is concluded that the escape of an aerosol of anthrax pathogen at the military facility caused the outbreak.

Anthrax is an acute disease that primarily affects domesticated and wild herbivores and is caused by the spore-forming bacterium *Bacillus anthracis*. Human anthrax results from cutaneous infection or, more rarely, from ingestion or inhalation of the pathogen from contaminated animal products (1). Anthrax has also caused concern as a possible agent of biological warfare (2). Early in 1980, reports appeared in the Western press of an anthrax epidemic in Sverdlovsk, a city of 1.2 million people 1400 km east of Moscow (3, 4). Later that year, articles in Soviet medical, veterinary, and legal journals reported an anthrax outbreak among livestock south of the city in the spring of 1979 and stated that people developed gastrointestinal anthrax after eating contaminated meat and cutaneous anthrax after contact with diseased animals (5-7). The epidemic has occasioned intense international debate and speculation as to whether it was natural or accidental and, if accidental, whether it resulted from activities prohibited by the Biological Weapons Convention of 1972 (8).

In 1986, one of the present authors (M.M.) renewed previously unsuccessful re-
FIGURE 1. Diagram of Brentwood Mail Processing and Distribution Center and location of positive identification of *Bacillus anthracis* spores — District of Columbia, October 2001

- Positive Wipe Locations
- Positive Vacuum Locations

A  Postal Vehicle Transportation Office
B  Express Mail Room
C  Customer Service Area
D  Government Mail

[Scale indicator: 25, 50, 100 Ft]
Estimated Attack Rate of Inhalational Anthrax by \( \text{LD}_{50} \) and Dose

Meselson, ASA Newsletter, 1995; 95-3

\[
\text{LD}_{50} = \begin{cases} 
8,000 \text{ spores} \\
45,000 \text{ spores}
\end{cases}
\]
## Delays in Notification in Smallpox Importations, Europe, 1959-1973

Wharton, CDC

<table>
<thead>
<tr>
<th>Time lag* (days)</th>
<th>Number of Importations</th>
<th>Total number of cases</th>
<th>Avg. number of cases per importation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7</td>
<td>16</td>
<td>87</td>
<td>5.4</td>
</tr>
<tr>
<td>8-14</td>
<td>5</td>
<td>44</td>
<td>8.8</td>
</tr>
<tr>
<td>15-21</td>
<td>4</td>
<td>63</td>
<td>15.8</td>
</tr>
<tr>
<td>&gt;22</td>
<td>5</td>
<td>339</td>
<td>67.8</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>533</td>
<td>17.7</td>
</tr>
</tbody>
</table>

* Interval between date of onset of fever in the first case and date of notification to the health service

Massachusetts Department of Public Health
Source and Place of Infection of 174 Smallpox Patients, Yugoslavia, 1972
Wharton, CDC

<table>
<thead>
<tr>
<th>Source of acquisition</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital-acquired</td>
<td>73</td>
</tr>
<tr>
<td>Community-acquired</td>
<td>99</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
</tr>
</tbody>
</table>

All but 1 of the hospital-acquired cases had face-to-face contact with a case.
Meschede, Germany, 1970
CFR by Vaccination Status
Europe, 1950-1971
Atkinson, CDC

Age-Related Impact of Vaccination in Infancy on Mortality From Smallpox
Liverpool, 1902-1903
Hanna, 1913, cited by Fenner
Search and Containment Strategy
Orenstein, CDC

• Principal global eradication strategy was search for cases and containment of spread by locating and vaccinating contacts

• Search and containment continues to be the most efficient strategy
Number of deaths

Health staff began using VHF Isolation Precautions

Date of onset of symptoms

<table>
<thead>
<tr>
<th>Health care workers</th>
<th>Non health care workers</th>
</tr>
</thead>
</table>

Legend:
Infection Control

- Communicable from person to person
- Single room with adjoining anteroom as only entrance
  - Hand washing facility with decontamination solution
- Negative air pressure if possible
- Strict barrier precautions
  - Gloves, gown, mask. Shoe covers, protective eyewear/faceshield
  - Consider HEPA respirator for prominent hemorrhage, vomiting, diarrhea, cough
- Patient remains
  - Decontamination, embalming, transportation in hermetically sealed containers
Infection Control for Viral Haemorrhagic Fevers in the African Health Care Setting