Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Acknowledgements:
Prof. Ben Cowling, School of Public Health, University of Hong Kong
Prof. Yugio Li, Dept. of Mechanical Engineering, University of Hong Kong

Edward Joseph Lister Lowbury (1913 - 2007)

A pioneering and innovative English medical bacteriologist and pathologist and also a published poet.

Bacteria That Cause Airborne Nosocomial Infections
- Group A Streptococcus
- Staph. aureus
- Neisseria meningitidis
- Bordetella pertussis
- MTB

Viruses Implicated in Airborne Nosocomial Infections
- Rinoviruses
- Influenza and Parainfluenza viruses
- Respiratory Syncytial Virus
- Adenovirus

A Webber Training Teleclass
www.webbertraining.com

Edward Joseph Lister Lowbury (1913 - 2007)

A pioneering and innovative English medical bacteriologist and pathologist and also a published poet.

Bacteria That Cause Airborne Nosocomial Infections
- Group A Streptococcus
- Staph. aureus
- Neisseria meningitidis
- Bordetella pertussis
- MTB

Viruses Implicated in Airborne Nosocomial Infections
- Rinoviruses
- Influenza and Parainfluenza viruses
- Respiratory Syncytial Virus
- Adenovirus

A Webber Training Teleclass
www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Recent classification for airborne transmission

Obligate airborne: initiate solely through aerosols: TB

Preferential airborne: initiate through multiple routes but predominantly by aerosols: Chicken pox and measles

Opportunistic airborne: typically through other routes but by aerosols in favorable conditions (as high-risk procedures such as intubation): Influenza and SARS
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

A Webber Training Teleclass
www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Is Influenza Airborne?

Reviews
Clinical Trials Comparing N95 and Medical Masks
New Experimental Studies

Two major reviews

Transmission of influenza A in human beings

In principle, influenza viruses can be transmitted by 3 routes: aerosols, large droplets, and direct contact with secretions (or with fomites)

More a systemic review

Artificial generated aerosol can infect man and animals
Artificial aerosols: <10% are larger 8 µm
Natural coughing: 99.9% are larger then 8 µm
“We question whether these studies are relevant to natural route of human transmission”
“No published evidence of human infection resulting from the ambient air”

Search of 2012 citations

Alaskan Airline: Non functional ventilation system 72% infected
(Am J Epidemiol 1979:110:1-6) 2nd instance of passengers

Influenza lower with UV lights in VA hospital (Am Rev Resp Dis 1961:83-36)
Infection related to ventilation systems in 4 buildings (J Am Ger 1996:18:811)

• Many confounders not accounted:
  - eg. number of index patients, bed layout, length of stay, hand hygiene, immunization status;
  - One study even confirmed that lowest rate has more space allocated
  - Air exchange rate is not reported
  - 2nd study even reported equal rates in next season.

Clinical Trials Comparing N95 and Medical Masks.

A Webber Training Teleclass
www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France


WHO guidance for infection prevention and control for H1N1

III, 1.1 - Standard & Droplet Precautions should always be applied
III, 1.2 - performing aerosol-generating procedures
wear a particulate respirator
III, 4. Collection of laboratory specimens
Upper respiratory tract (above larynx)
Standard and Droplet Precaution
Lower respiratory tract specimens
Aerosol-generating procedures IPC measures

Recommendation for 2009 H1N1 Pandemic

"At the start of the 2009 outbreak, there was uncertainty regarding the transmission dynamics of the novel H1N1 virus. While seasonal influenza is spread by large respiratory droplets, a concern at the onset of any potential influenza pandemic is whether the pathogen will have a different dynamics or methods of spread."

13th May – CDC recommends N95 to be used in all situations

But there is a study not considered by IOM showing that surgical masks is as effective as N95.

Surgical Mask vs N95 Respirator for Preventing Influenza Among Health Care Workers: A Randomized Trial
Mark Loeb et al, JAMA, 2009;302(17), October 1 online
A randomized controlled trial of 446 nurses in 8 tertiary care hospitals – Ontario
Surgical masks
N = 225
Influenza infected = 50 (23.6%)
p = 0.086 (meet criteria for non-inferiority)

HICPIC advisory committee
endorse the use of surgical masks for the routine care of patients with confirmed or suspected, novel influenza A (H1N1)"

"It is appropriate at this time to recommend the use of N95 or higher respiratory protection for procedures that are likely to generate small particle aerosols. The procedures are then listed to include bronchoscopy, intubation under controlled or emergent situations, cardiopulmonary resuscitation, open airway suctioning and airway induction."

Comment on Blachere et al: PCR positive is not the same as culture positive

A Webber Training Teleclass
www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Institute of Medicine

HCWs (including non-hospital settings) in close contact with individuals with nH1N1 or ILIs should use fit-tested N95 respirators.

Endorse current CDC guidelines.

Page 17: “confirm the presence of airborne influenza virus in various clinic locations”

Also based on the Macintyre study done in China

A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers

A Randomized Clinical Trial of Three Options for N95 Respirators and Medical Masks in Health Workers

Comparison of Non-clinical and Clinical Staff Infected by pH1N1

Non-clinical

Clinical

Statistical significance (p)

Total number of staff (n)

18759

40511

Number infected

A. During mandatory reporting for all staff

119

249 (0.62%)

0.82

RR: 0.98 (95% CI 0.78-1.2)

B. Data during the entire pandemic period

NA

1039 (2.6%)

Large ongoing trial however conducted by John Hopkins which is yet to be published


But Macintyre group retracted their study

Also based on the Macintyre study done in China

A Webber Training Teleclass

www.webbertraining.com
New Experimental Studies.

Experimental studies in which only PCR was used in diagnosis could not be considered conclusive because it would not be possible to ascertain whether such particles had viable virus that could result in transmission.

Presence of viable viral aerosols in the exhaled breath


Must demonstrate both production of infectious virus and inoculation of live viruses on to patients

There were at least two studies showing that viable virus may be transmitted to the host


Sources were by artificially generated aerosols by simulators - difficult to be certain whether the situation was similar in real life.

Finally a study - the sources were naturally infected influenza volunteers. Claims to be the first "end-point host-exposure and sampling study" where special manikins were exposed to these volunteers.


Methods

The two studies had an identical aim, to test transmission of influenza from a naturally influenza-infected human to a life-like human manikin ‘recipient’ through real-life respiratory activities.

The HK study used a shop display manikin, customized for ‘mouth-inhaling’, to examine the quantity of influenza virus inhaled. This study only examined the inhalation phase of a potential recipient.

The Singapore study used a commercial thermal, breathing manikin with a full breathing cycle to quantify the amount of influenza virus landing on facial skin sites.
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Finally a study - the sources were naturally infected influenza volunteers. Claims to be the first “end-point host-exposure and sampling study” where special manikins were exposed to these volunteers.

Table 1. Results for the Hong Kong experiments (n = 9).

Table 2. Results for Singaporean experiments (n = 6).

Results
No influenza RNA was detected from any of these swabs with either team’s in-house diagnostic influenza assays.

"The outcomes of these two studies are presented together due to the similar and largely unexpected results"

Majority of droplets are from 10-100 µm.

Expiratory droplet exposure between individuals in a ventilated room

A Webber Training Teleclass
www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Factors affecting droplets evaporation:
- initial size, composition, humidity, temperature, velocity, exhalation airflow, turbulence and ambience airflow.

Can Influenza be transmitted by air? …the risk is probably low

A. Are Most Respiratory Viral Infections Airborne?
Most studies done – Influenza and SARS
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Table 1: WHO Recommendations for Infection control and Prevention of Acute Respiratory Viral Infections


B. Can we define the aerosols generating procedures?

Ten WHO Recommendations for Infection control and Prevention of Acute Respiratory Viral Infections


<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Overall Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Personal protective equipment (PPE) including the use of gloves, long-sleeved gowns, eye protection (goggles or face shields) and facial mask (surgical/procedure mask or particulate respirators) should be used by HCWs during aerosol generating procedures that have been consistently associated with an increased risk of transmission of ARI pathogens. The available evidence suggests performing or being exposed to aerosolized medications either by itself or combined with other procedures (e.g. cardiopulmonary resuscitation, bronchoscopy) was consistently associated with increased risk of transmission.</td>
<td>Conditional</td>
</tr>
</tbody>
</table>
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

WHO meta-analysis

The most consistent statistically significant association of an increased risk of SARS transmission to HCW was found to be healthcare worker (HCW) contact (see Table 1 and 2) with no other risk factors for transmission. Improper ventilation of ICUs, infection control of studies, and manual ventilation before intubation of studies were also found to have a statistically significant association with transmission.

3 studies all together
One NIV and manual ventilation before intubation is the same study
One study on NIV with OR > 1
One study on tracheostomy

Poor infection control practices

HCW present during intubation is a factor but no factor related to NIV or manual ventilation

A Webber Training Teleclass
www.webbertraining.com
About Sputum Induction
Sputum induction is used to obtain sputum for diagnostic purposes when patients are unable to spontaneously expectorate a specimen. The procedure uses sterile water or hypertonic saline to irritate the airway, increase secretions, promote coughing, and produce a specimen. The CDC and OSHA both classify sputum induction as a high-risk procedure when performed on a person with suspected or known infectious TB.
Nebulizers

Emerging Infectious Diseases • www.cdc.gov • Vol. 10, No. 2, February 2004

Cluster of SARS among Medical Students Exposed to Single Patient, Hong Kong

Teresa Wong, Chui-Leung Lau, Wai-Fai Ho, Jau-Wai Tsang,喵 Mui,和 Yiu-Chu Kwan
Post-R.S.C. Chan, Vivian L.L. Leung and Ti Sung
S.J. Kwong, and Charles D. Panthee
For the Outbreak Study Group

At the time this investigation was begun, jet nebulizer therapy given to the index patient was widely believed to have facilitated transmission. However, our findings demonstrated efficient transmission even before nebulizer therapy was begun on the afternoon of March 6.

<table>
<thead>
<tr>
<th>Time</th>
<th>SARS infection of the medical students</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 March</td>
<td>11:00-11:00 pm  0.3</td>
</tr>
<tr>
<td>4 March</td>
<td>11:00-11:00 pm  1.0</td>
</tr>
<tr>
<td>5 March</td>
<td>11:00-11:00 pm  0.3</td>
</tr>
</tbody>
</table>

Is N95 Fit Testing Required?

- Most elements of the NIOSH respirator program (i.e., fit factor, protection estimates, etc.) are theoretical using mathematical models and have not been confirmed in practical work situations.

- In one NIOSH study, fit testing respirator assignment errors were as high as 20%.

From Bill Jarvis, CDC

Quantitative Fit Testing Does Not Ensure Health Care Worker Respiratory Protection

M. Lee, S. Takaya, R. Long, M. Joffe
SHEA Abstract – Apr 2005

- 58 HCW never fit-tested
- 25/58 (43%) passed initial fit-test
  - 19 passed with instruction = 76% total passes
- 3 months later, 49/58 re-tested
  - 47% recalled respirator type and passed fit-test
  - Passing at 3 months did not correlate with passing at initial fit-test or receipt of instruction

No, fit testing is not needed.

- No added value to adequate training.


A Webber Training Teleclass

www.webbertraining.com
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Seal check
- A method for determining whether a respirator has been put on and adjusted to fit properly
- Perform every time when a respirator is worn

However, we disagree with the next sentence, which is inherently contradictory, "However, HCWs should undergo initial and periodic fit testing." There is no sound evidence to support initial and periodic fit testing.

Infectious Diseases Society of America (IDSA) letter to CDC
February 4, 2005

D. Is negative-pressure room an absolute necessity?

"The most important part of tuberculosis infection control is getting the patient into the isolation room."
Wurtz, 1996, ICHE

A Webber Training Teleclass
www.webbertraining.com
**Airborne Transmission and Precaution – Facts and Myths**  
Prof. W.H. Seto, Hong Kong

Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

---

**Airborne transmission isolation room:**
- Single room or cohorting
- Negative pressure (2.5 Pa or .01 in water)
- 6 - 12 air changes per hour - now it is ≥12
- Exhaust air outside or recirculated HEPA filters

- Anteroom may enhance effects
- Upper-room UVC only as adjunct
- Avoid within room circulation (eg. fans)

---

Graphs constructed by Wells-Riley equation to express the relationship between infection risk over ventilation rate, quanta generation rate and exposure time.

(a) 5 minutes exposure time  
(b) 10 minutes exposure time  
(c) 15 minutes exposure time

---

AR Escombe et al:  
Supervise by Imperial College and John Hopkins

65 rooms in 8 hospitals in Lima, Peru

Old Facilities: Median 37 ACH  
Modern Facilities: Median 18 ACH

---

Measurements in Grantham Chest Hospital Hong Kong tests in 4 rooms:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>ACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows open (100%), Doors open (100%)</td>
<td>40.4</td>
</tr>
<tr>
<td>Windows open (100%), doors close</td>
<td>20.2</td>
</tr>
<tr>
<td>Windows open (50%), doors close</td>
<td>18.5</td>
</tr>
<tr>
<td>Windows closed, doors closed</td>
<td>0.6</td>
</tr>
<tr>
<td>Windows closed, doors open</td>
<td>3.4</td>
</tr>
</tbody>
</table>

---

A Webber Training Teleclass  
www.webbertraining.com
What is natural ventilation?

Natural ventilation: Use of natural forces to introduce and distribute outdoor air into or out of a building. These natural forces can be wind pressure or pressure generated by the density difference between indoor and outdoor air.

3.1 The association between ventilation and infection
3.2 Ventilation requirements relating to airborne infection control
3.3 World Health Organization recommendations relating to natural ventilation requirements
3.4 Summary

TB incidence in Grantham and HA hospitals 1996-2005

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Incidence (per 100,000 pat year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA hospitals</td>
<td>(257 cases) 60.4</td>
</tr>
<tr>
<td>GH</td>
<td>(5 cases) 65.2</td>
</tr>
</tbody>
</table>

p = 0.9

Dr Seto,

I really enjoyed your insightful presentation yesterday... I am sorry you had to skip through so many of the slides in the interests of time.

I did my infectious disease training in Australia at Fairfield hospital... a stand-alone infectious diseases hospital that saw/treated most of the TB patients in Victoria-- we had single rooms, jail of which opened up to a private balcony... we used lots of open air ventilation, high ACH and none of our staff converted their TSTs.

A Webber Training Teleclass
www.webbertraining.com
Opening your windows,
The key to natural ventilation..