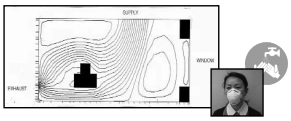
Airborne Transmission and Precaution – Facts and Myths
Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Airborne transmission and precaution – facts and myths



WH Seto,
HK, China

Edward Joseph Lister Lowbury (1913 - 2007)

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

Acknowledgements:

Prof. Ben Cowling, School of Public Health,
University of Hong Kong

Prof. Yugio Li, Dept. of Mechanical Engineering,
University of Hong Kong

Bacteria That Cause Airborne Nosocomial Infections

- Group A Streptococcus
- Staph. aureus
- Neisseria meningitidis
- Bordetella pertusis
- MTB
- Acinetobacter
- Legionellae
- Clostridia
- Pseudomonas
- Nocardia

Viruses Implicated in Airborne Nosocomial Infections

- Rinoviruses
- Influenza and
- Parainfluenza viruses
- Respiratory Syncytial Virus
- Adenovirus
- Varicella Zoster Virus
- Measles
- Rubella
- Smallpox
- Certain enteroviruses

Adapted from Schaal, 1985

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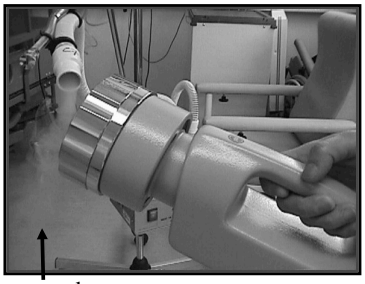
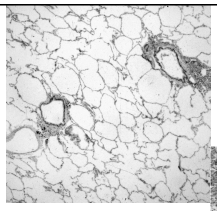
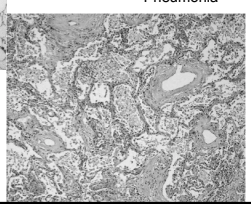



Normal alveolar

Pneumonia



Courtesy: Dr Gavin Chan, Department of Pathology
Queen Mary Hospital

Recent classification for airborne transmission

Obligate airborne: initiate solely through aerosols: TB

Preferential airborne: initiate through multiple routes but predominately 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

2014
WHO ARI
Guideline

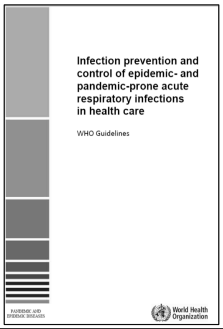


Table 1. IPC precautions for HCWs and caregivers providing care for patients with ARIs according to a sample of pathogens

Precaution	Pathogen							
	No pathogen identified or risk factor for ARI or potential concern (e.g. influenza-like illness without risk factor for ARI or potential concern)	Bacterial ARI[a], including plague	Tuberculosis	Parainfluenza RSV & Adenovirus	Influenza virus with sustained human-to-human transmission (e.g. seasonal influenza, pandemic influenza)	New influenza virus with no sustained human-to-human transmission (e.g. avian influenza)	SARS	Novel ARI[b]
Hand hygiene[c]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gloves	Risk assessment[d]	Risk assessment[d]	Risk assessment[d]	Yes	Risk assessment[d]	Yes	Yes	Yes
Gown[e]	Risk assessment[d]	Risk assessment[d]	Risk assessment[d]	Yes	Risk assessment[d]	Yes	Yes	Yes
Eye protection	Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Yes	Yes	Yes
Medical mask on HCWs and caregivers	Yes	Risk assessment[g]	No	Yes	Yes[g]	Yes[g]	Not routinely[g]	
Particulate respirator on HCWs and caregivers	for room entry	No	No	Yes	No	No	Not routinely[g]	Not routinely[g]	Yes
	within 1 m of patient	No	No	Yes	No	No	Not routinely[g]	Not routinely[g]	Yes
	for aerosol-generating procedures[i]	Yes	Not routinely[j]	Yes	Not routinely[j]	Yes	Yes	Yes	Yes
Medical mask on patient when outside isolation area[k]	Yes	Yes	Yes	Yes[l]	Yes	Yes	Yes	Yes
Adequately ventilated separate room	Yes, if available[m]	No	No	Yes, if available[m]	Yes, if available[m]	Yes	Yes	Not routinely[g]
Airborne precaution room[n]	No	No	Yes, or Cohort	No	No	Not routinely[g]	Not routinely[g]	Yes
Summary of IPC precautions for routine patient care, excluding AEROSOL-GENERATING PROCEDURE	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
	Droplet	--	--	Droplet	Droplet	Droplet	Droplet	--
	--	--	--	Contact	--	Contact	Contact	Contact
	--	--	Airborne	--	--	--	--	Airborne

a. Bacterial ARI refers to common bacterial respiratory infections caused by organisms such as *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Chlamydophila* spp., and *Mycoplasma pneumoniae*.
b. When a novel ARI is newly identified, the mode of transmission is usually unknown. Implement the highest available level of IPC precautions, until the situation and mode of transmission is clarified.

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CDC Centers for Disease Control and Prevention — ***Transmission Based Precaution***

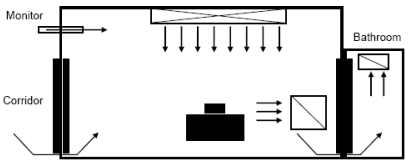
	Type *	Duration †
Measles (rubeola)	A	4 days after onset of rash; DI in immune compromised
Tuberculosis *(M. tuberculosis)*		
Pulmonary or laryngeal disease, confirmed	A	
Pulmonary or laryngeal disease, suspected	A	
Varicella Zoster	A,C	Until lesions dry and crusted

Airborne Precaution

Single room - Negative Pressure
Keep doors closed

N95

Figure 3. Example of negative-pressure room control for airborne infection isolation (AII)* + §¶



* Stacked black boxes represent patient's bed. Long open box with cross-hatch represents supply air. Open boxes with single, diagonal slashes represent air exhaust registers. Arrows indicate direction of air flow.
+ Possible uses include treatment or procedure rooms, bronchoscopy rooms, and autopsy.
§ Negative-pressure room engineering features include
- negative pressure (greater exhaust than supply air volume);
- pressure differential of 2.5 Pa (0.01-in. water gauge);
- air flow volume differential >125-cfm exhaust versus supply;
- sealed room, approximately 0.5-sq. ft. leakage;
- clean to dirty air flow;
- monitoring;
- ≥12 air changes per hour (ACH) new or renovation, 6 ACH existing; and
- exhaust to outside or HEPA-filtered if recirculated.

Figure 3. Example of negative-pressure room control for airborne infection isolation (AII)* + §¶

Airborne infection isolation room (AII):

- **Single room or cohorting**
- **Negative pressure** (-2.5 Pa)
- **12 air changes per hour for new renovations**
- **Exhaust air outside or recirculated by HEPA filters**

- sealed room, approximately 0.5-sq. ft. leakage;
- clean to dirty air flow;
- monitoring;
- ≥12 air changes per hour (ACH) new or renovation, 6 ACH existing; and
- exhaust to outside or HEPA-filtered if recirculated.

General consensus on the N95 Respirator to prevent airborne transmission

A tightly sealed respirator blocked 99.8% of total virus and 99.6% of infectious virus (n = 3).
A tightly fitted (surgical) mask block 94.5% of the total virus and 94.8% of the total infectious virus.

Noti JD, Lindsley WG, Blachere FM. et al: Detection of influenza virus in cough aerosol generated in a simulated patient examination room. Clin Infect Dis 2012; 54 (1 June) 1569-1577

A. Are Most Respiratory Viral Infections Airborne?

Most studies done – Influenza and SARS

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Is Influenza Airborne?

Reviews

Clinical Trials Comparing N95 and Medical Masks

New Experimental Studies

Two major reviews

Transmission of influenza A in human beings

Lancet Infect Dis 2007; 7: 257–65

Gabrielle Brankston, Leah Gitterman, Zahir Hirji, Camille Lemieux, Michael Gardam

However, we are able to conclude that transmission occurs at close range rather than over long distances, suggesting that airborne transmission, as traditionally defined, is unlikely to be of significance in most clinical settings.

Review of Aerosol Transmission of Influenza A Virus

Raymond Tellier*†

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 12, No. 11, November 2006

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

Transmission of influenza A in human beings

Brankston et al. **Lancet ID 2007(7):257-65**

More a systemic review

Search of 2012 citations

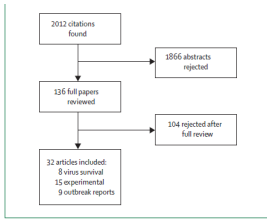

Figure: Flow diagram of the process and results of article selection

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"

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

Naval base aircraft (**Am J Epidemiol 1989:129:341-48)**
Riontz reported outbreaks (56%) in functional ventilation planes.

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.

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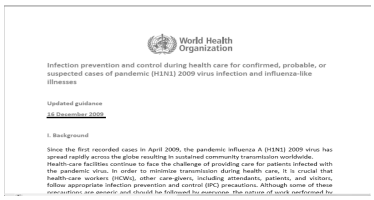
http://www.who.int/csr/resources/publications/cp150_2009_1612_ipc_interim_guidance_h1n1.pdf


World Health Organization

Infection prevention and control during health care for confirmed, probable, or suspected cases of pandemic (H1N1) 2009 virus infection and influenza-like illnesses

Updated guidance

26 December 2009

1. Background

Since the first recorded cases in April 2009, the pandemic influenza A (H1N1) 2009 virus has spread rapidly across the globe resulting in sustained community transmission worldwide. Health-care facilities continue to face the challenge of providing care for patients infected with the pandemic virus. In order to minimize transmission during health care, it is crucial that health-care workers (HCWs), other care-givers, including attendants, patients, and visitors, follow appropriate infection prevention and control (IPC) precautions. Although some of these precautions are generic and should be followed by everyone, the nature of work performed by

This guidance replaces guidance documents issued on 29 April and 25 June 2009 and remains **valid until 30 June 2010,**

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

CDC Centers for Disease Control and Prevention

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 Trail.
Mark Loeb et al, JAMA,, 2009;302(17), October 1 online

A randomized controlled trail of 446 nurses in 8 tertiary care hospitals – Ontario

	Surgical masks	N95
n =	225	221
Influenza infected =	50 (23.6%)	48 (22.9%)

p = 0.086 (meet criteria for non-inferiority)

CDC

HICPIC advisory committee
23rd July 2009 to vote on the latest recommendation
(http://www.cdc.gov/ncidod/dhqp/hicpac_transcript-07-23.html).

"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

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INSTITUTE OF MEDICINE Advising the nation • Improving health
OF THE NATIONAL ACADEMIES

1st September 2009

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"

Blachere et al (CID 2009 48 (4):438)

Also based on the Macinthyre study done in China

But Macintyre group retracted their study

http://abcnews.go.com/Health/SwineFluNews/cdc-flu-mask-decision-based-flawed-study-authors/Story?id=8965858&page=1

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

www.influenzajournal.com

Accepted 3 December 2010. Published Online 27 January 2011.

Chandini Raina MacIntyre,[a] Quanyi Wang,[b] Simon Cauchemez,[c] Holly Seale,[a] Dominic E. Dwyer,[d] Peng Yang,[b] Weixian Shi,[b] Zhanhai Gao,[b] Xinghuo Pang,[b] Yi Zhang,[b] Xiaoli Wang,[b] Wei Duan,[b] Bayzidur Rahman,[a] Neil Ferguson[c]

Table 2. Intention to treat analysis using random effect logistic regression analysis

	CRI		ILI*		Laboratory-confirmed virus**		Influenza	
Arms	*N* (%)	OR (95% CI)***	*N* (%)	OR (95% CI)***	*N* (%)	OR (95% CI)***	*N* (%)	OR (95% CI)***
N95 fit-tested	21/461 (4·6)	0·76 (0·27–2·13) $P_{RE} = 0.607$[†]	1/461 (0·2)	0·35 (0·04–3·42) $P_{RE} = 0.37$[†]	8/461 (1·7)	0·69 (0·24–2·03) $P_{RE} = 0.50$[†]	3/461 (0·7)	0·64 (0·15–2·68) $P_{RE} = 0.54$[†]
N95 non-fit-tested	16/488 (3·3)	0·48 (0·24–0·98) $P_{RE} = 0.045$[†]	2/488 (0·4)	0·67 (0·11–4·03) $P_{RE} = 0.66$[†]	5/488 (1)	0·39 (0·12–1·22) $P_{RE} = 0.11$[†]	0/488 (0)	0
All N95	37/949 (3·9)	0·62 (0·28–1·35) $P_{RE} = 0.23$[†]	3/949 (0·3)	0·52 (0·10–2·57) $P_{RE} = 0.42$	13/949 (1·4)	0·54 (0·21–1·36) $P_{RE} = 0.19$[†]	3/949 (0·3)	0·31 (0·07–1·32) $P_{RE} = 0.113$[†]
Medical mask	33/492 (6·7)		3/492 (0·6)		13/492 (2·6)		5/492 (1)	

*ILI definition using fever >38 – note, this is less sensitive than laboratory-confirmed infection.
**Any respiratory virus.
***Odds Ratio – Medical group as reference. A random effect logistic model accounting for clustering was used to compute odd ratios.
†P_{RE}: *P* value adjusted for clustering of hospitals using random effect logistic regression model.[24]
CRI, Clinical respiratory illness; ILI, influenza-like illness.

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

C. Raina MacIntyre[1], Quanyi Wang[2], Holly Seale[1], Peng Yang[2], Weixian Shi[2], Zhanhai Gao[1], Bayzid Rahman[1], Yi Zhang[2], Xiaoli Wang[2], Anthony T. Newall[1], Anita Heywood[1], and Dominic E. Dwyer[3]

Am J Respir Crit Care Med Vol 187, Iss. 9, pp 960-966, May 1, 2013

TABLE 2. NUMBER AND PROPORTION OF PARTICIPANTS REPORTING PRIMARY OUTCOMES, BY RANDOMIZATION ARM AND INTENTION-TO-TREAT ANALYSIS

	Medical Mask Arm	Targeted N95 Arm		N95 Arm	
Variable	N (%)	N (%)	*P* Value (ICC)*	N (%)	*P* Value (ICC)†
CRI	98/572 (17.1)	61/516 (11.8)	0.280 (0.1166)	42/581 (7.2)	0.0238 (0.1194)
ILI	4/572 (0.7)	2/516 (0.4)	0.4882 (<0.0001)	6/581 (1.0)	0.5416 (<0.001)
Virus	19/572 (3.3)	17/516 (3.3)	0.985 (0.0206)	13/581 (2.2)	0.4394 (0.0311)
Bacteria + CRI	84/572 (14.7)	52/516 (10.1)	0.27 (0.091)	36/581 (6.2)	0.019 (0.086)
Bacteria (any symptoms)[J]	120/572 (21.0)	75/516 (14.5)	0.2448 (0.1279)	52/581 (9.0)	0.0163 (0.1338)
Virus or bacteria + CRI	91/572 (15.9)	56/516 (10.8)	0.260 (0.100)	39/581 (6.7)	0.022 (0.102)
Virus or bacteria (any symptoms)	123/572 (21.5)	77/516 (14.9)	0.2484 (0.1339)	52/581 (9.0)	0.016 (0.1442)
Influenza A or B + CRI	1/572 (0.2)	2/516 (0.4)	0.5898 (0.145)	3/581 (0.5)	0.3241 (<0.001)

Conclusions: Continuous use of N95 respirators was more efficacious against CRI than intermittent use of N95 or medical masks. Most geted N95 respirator use. Continuous use of N95s resulted in significantly lower rates of bacterial colonization, a novel finding that

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

(http://clinicaltrials.gov/ct2/show/NCT01249625).

Clinical and Nonclinical Health Care Workers Faced a Similar Risk of Acquiring 2009 Pandemic H1N1 Infection

Wing-Hong Seto,[1] Benjamin J. Cowling,[2] Hung-Suet Lam,[1] Patricia T. Y. Ching,[1] Mei-Lan To,[1] and Didier Pittet[3,4]

CID 2011:53 (1 August) • BRIEF REPORT

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 (0.63%)	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%)	

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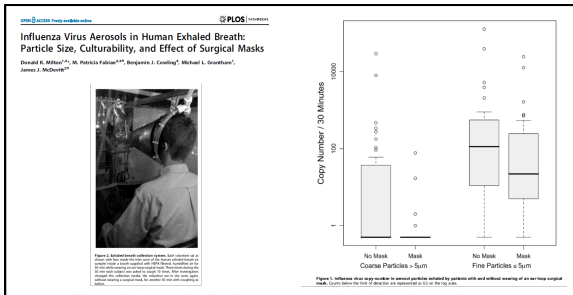
New Experimental Studies.

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.

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

Presence of viable viral aerosols in the exhaled breathe

1. Milton KD, Fabian P, Cowling JB. et al: Influenza virus aerosols in human exhaled breath: particle size, culturability and effect of surgical mask. PLOS Pathogen March 2013 Vol 9, Iss 3 e1003205
2. Fabian P, McDevitt, DeHaan HW. et al: Influenza virus in human exhaled breath: an observational study. PLOS ONE July 2008, Vol 3, Iss 7 e2691


Influenza Virus Aerosols in Human Exhaled Breath: Particle Size, Culturability, and Effect of Surgical Masks

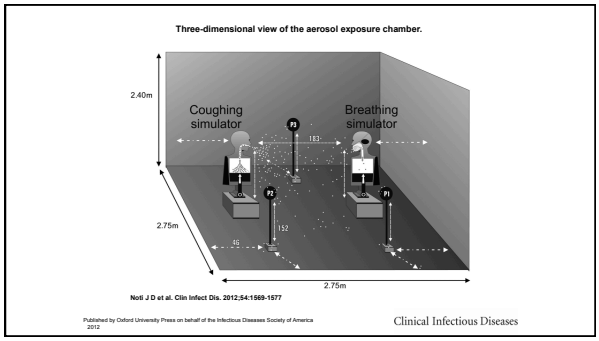
Donald K. Milton[1,2*], M. Patricia Fabian[1,3¤], Benjamin J. Cowling[4], Michael L. Grantham[1], James J. McDevitt[1¤]

We only detected infectious virus in exhaled breath samples with high (10^4 to 10^5) copy numbers by quantitative RT-PCR.

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

1. Noti JD, Lindsley WG, Blachere FM. et al: Detection of influenza virus in cough aerosol generated in a simulated patient examination room. Clin Infect Dis 2012; 54 (1 June) 1569-1577
2. Bischoff EW, Reid T, Russell BG, Peters T: Transocular entry of seasonal influenza-attenuated virus aerosol and the efficacy of N95 respirators, surgical masks and eye protection in human. JID 2011:204 (15 July) 193-199

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.

Tang J, Gao CX, Cowling BJ, et al: Absence of detectable influenza RNA transmitted via aerosol during various human respiratory activities – experiments from Singapore and Hong kong. PLOS ONE September 2014 Vol 9, Iss 9 e107338 1-9

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.

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Tang J, Gao CX, Cowling BJ, et al: Absence of detectable influenza RNA transmitted via aerosol during various human respiratory activities – experiments from Singapore and Hong kong. PLOS ONE September 2014 Vol 9, Iss 9 e107338 1-9

Results

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

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

Subject code no.	Influenza A/B	Age (yrs)	Sex (M/F)	Days post-onset of illness	Air sampling method	Test distance (m)	Patient 'source' activities	Influenza RNA detected in filter/sampler (cop/mL)	Influenza RNA cop/mL in source diagnostic swab
00302	A	47	M	3	PTFE filter + SKC BioSampler	0.1	Count 1–20; Cough 10 times	None	9.50×10^{7}
01402	A	42	M	3	PTFE filter + SKC BioSampler	0.1	Count 1–100; Cough 10 times	None	1.39×10^{7}
01702	A	14	F	2	PTFE filter + SKC BioSampler	0.1	Breath 1 min; Count 1–20; Cough 20 times	None	1.67×10^{8}
02602	A	17	F	3	PTFE filter + SKC BioSampler	0.1	Talk 10 min; Count 1–100; Cough 20 times	None	4.19×10^{5}
02702	A	22	F	2	PTFE filter + SKC BioSampler	0.1	Talk 10 min; Count 1–100; Cough 20 times	None	8.67×10^{6}
03802	A	49	F	3	PTFE filter + SKC BioSampler	0.1	Talk 10 min; Count 1 to 100; Cough 20 times	None	7.40×10^{6}
04102	A	57	F	2	PTFE filter + SKC BioSampler	0.1	Talk 10 min; Count 1 to 100; Cough 20 times	None	3.01×10^{8}
05602	A	62	F	2	SKC BioSampler	0.1, 0.5	Talk 10 min; Count 1 to 100; Cough 20 times	None	5.38×10^{5}
00203	B	not given	M	3	SKC BioSampler	0.1, 0.5	Talk 10 min; Count 1 to 100; Cough 20 times	None	3.70×10^{8}

doi:10.1371/journal.pone.0107338.t001

Tang JW, Gao CX, Cowling BJ, Koh GC, et al. (2014) Absence of Detectable Influenza RNA Transmitted via Aerosol during Various Human Respiratory Activities – Experiments from Singapore and Hong Kong. PLoS ONE 9(9): e107338. doi:10.1371/journal.pone.0107338
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0107338

PLOS | ONE

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

Subject code no.	Influenza A/subtype, or B	Age (yrs)	Sex (M/F)	Days post-onset of illness	[a]Test distance (m) – see footnote	[b]Patient 'source' activities – see footnote	Influenza RNA detected in manikin facial swabs (cop/mL)	Influenza RNA cop/mL in source diagnostic swab
1	A/H3	22	M	3	1, 1/10	See	None	1.29×10^{5}
2	A/H1N1/pdm	22	M	2	(a)0.1/10.1/1r 0.1 for additional close-up cough	footnote*	None	2.88×10^{4}
3	B	23	F	6	0.1/1		None	2.14×10^{4}
4	A/H3	25	M	2			None	3.55×10^{3}
5	B	21	M	1			None	4.57×10^{6}
6	B	50	F	3			None	6.76×10^{6}

[a]0.1 m and 1 m.
[b]Nasal breathing (for 20 seconds), mouth breathing (20 s), counting slowly from one to ten in English (43 s), counting slowly from one to ten in a second language (e.g. Mandarin, German, 43 s), laughing (10 s) and coughing (10 s). Coughing was performed at both far (about ~1 m) and near (~0.1 m) distances from the manikin's face.
doi:10.1371/journal.pone.0107338.t002

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

Tang JW, Gao CX, Cowling BJ, Koh GC, et al. (2014) Absence of Detectable Influenza RNA Transmitted via Aerosol during Various Human Respiratory Activities – Experiments from Singapore and Hong Kong. PLoS ONE 9(9): e107338. doi:10.1371/journal.pone.0107338
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0107338

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Indoor Air 2007; 17: 211–225
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INDOOR AIR
doi:10.1111/j.1600-0668.2006.00469.x

How far droplets can move in indoor environments – revisiting the Wells evaporation–falling curve

X. Xie[1], Y. Li[1], A. T. Y. Chwang[1], P. L. Ho[2], W. H. Seto[3]
[1]Department of Mechanical Engineering, The University of Hong Kong, Hong Kong, China, [2]Department of Microbiology, The University of Hong Kong, Hong Kong, China, [3]Department of Microbiology, Queen Mary Hospital, Hong Kong, China

Expiratory droplet exposure between individuals in a ventilated room

Submitted by

LIU, Li

For the Degree of Doctor of Philosophy
Department of Mechanical Engineering
at The University of Hong Kong
in July 2011

Majority of droplets are from 10-100 µm.

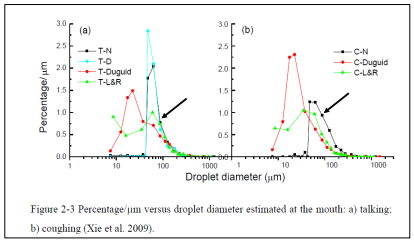

Figure 2-3 Percentage/µm versus droplet diameter estimated at the mouth: a) talking; b) coughing (Xie et al. 2009).

N = Nicas et al (2005), D = Morawska (2006), Duguid (1946), L&R = Louden and Rpberts (1967)

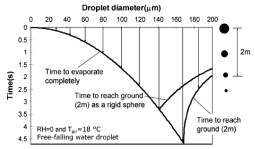

Fig. 1 The Wells evaporation–falling curve of droplets [reproduced and modified from Wells (1934)]

depending on the size of the infected droplet. According to Wells (1934), droplet infection is transmitted by droplets larger than 100 µm in diameter, which rapidly settle out of the air by gravity, with the infective range being within a short distance of the source. Airborne infection applies to dried-out infectious droplet nuclei derived directly from droplets less than 100 µm, which remain suspended in the air for a long time and could

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Prof. W.H. Seto, Hong Kong
Broadcast live from the 2014 Healthcare Infection Society conference, Lyon, France

Influenza Virus Aerosols in Human Exhaled Breath: Particle Size, Culturability, and Effect of Surgical Masks

We only detected infectious virus in exhaled breath samples with high (10^4 to 10^5) copy numbers by quantitative RT-PCR.

It is not yet known whether the low recovery of infectious virus (despite high copy numbers of viral RNA) represents technical difficulties in sampling and culturing exhaled breath samples or whether the vast majority of the virus exhaled by influenza A patients is actually non-infectious.

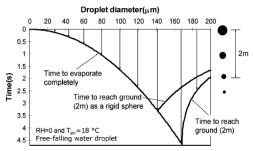

Fig. 1 The Wells evaporation–falling curve of droplets [reproduced and modified from Wells (1934)]

According to Wells (1934), droplet infection is transmitted by droplets larger than 100 μm in diameter, which rapidly settle out of the air by gravity, with the infective range being within a short distance of the source. Airborne infection applies to dried-out infectious droplet nuclei derived directly from droplets less than 100 μm, which remain suspended in the air for a long time and could

Our investi-gation revealed that his evaporation model was an extremely simple one, and the curve was probably

Expiratory droplet exposure between individuals in a ventilated room

Submitted by

LIU, Li

For the Degree of Doctor of Philosophy
Department of Mechanical Engineering
at The University of Hong Kong
in July 2011

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

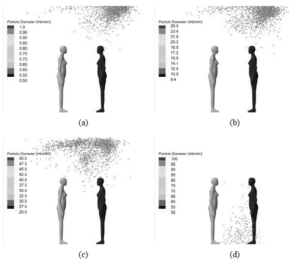

Figure 6-5 The predicted exposure of the susceptible manikin versus initial diameters of expiratory droplets (a) 1μm, (b) 25μm, (c) 50μm, (d) 100μm.

Expiratory droplet exposure between individuals in a ventilated room

Submitted by

LIU, Li

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

CHAPTER 7 CONCLUSIONS **pp 152**

The inhalation of the droplets and droplet nuclei and deposition of the droplets and droplet nuclei on the body surface of the susceptible person were investigated at a separation distances of 0.5, 1.0, 1.5 and 3.0 m. For each breath from the source person, 1600 droplets were released. Three and nine droplet nuclei were inhaled by the susceptible person at a mutual distance of 0.5 and 1.0 m, respectively. No droplet nuclei were inhaled at 1.5 and 3.0 m.

Can Influenza be transmitted by air?

……the risk is probably low

A. Are Most Respiratory Viral Infections Airborne?

Most studies done – Influenza and SARS

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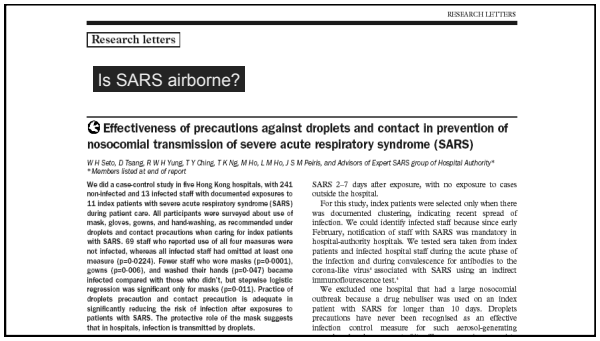


RESEARCH LETTERS

Research letters

Is SARS airborne?

Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS)

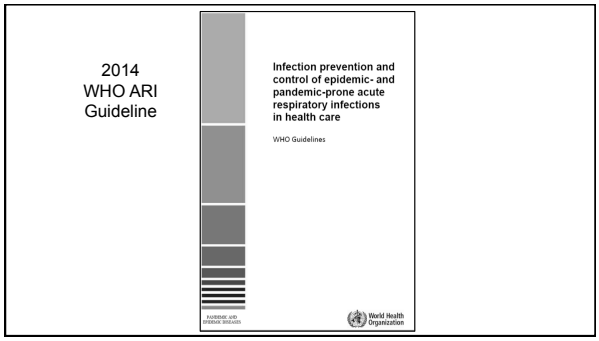
W H Seto, D Tsang, R W H Yung, T Y Ching, T K Ng, M Ho, L M Ho, J S M Peiris, and Advisors of Expert SARS group of Hospital Authority *Members listed at end of report*

We did a case-control study in five Hong Kong hospitals, with 241 non-infected and 13 infected staff with documented exposures to 11 index patients with severe acute respiratory syndrome (SARS) during patient care. All participants were surveyed about use of mask, gloves, gowns, and hand-washing, as recommended under droplets and contact precautions when caring for index patients with SARS. 69 staff who reported use of all four measures were not infected, whereas all infected staff had omitted at least one measure (p=0·0224). Fewer staff who wore masks (p=0·0001), gowns (p=0·006), and washed their hands (p=0·047) became infected compared with those who didn't, but stepwise logistic regression was significant only for masks (p=0·011). Practice of droplets precaution and contact precaution is adequate in significantly reducing the risk of infection after exposures to patients with SARS. The protective role of the mask suggests that in hospitals, infection is transmitted by droplets.

SARS 2–7 days after exposure, with no exposure to cases outside the hospital.

For this study, index patients were selected only when there was documented clustering, indicating recent spread of infection. We could identify infected staff because since early February, notification of staff with SARS was mandatory in hospital-authority hospitals. We tested sera taken from index patients and infected hospital staff during the acute phase of the infection and during convalescence for antibodies to the corona-like virus[1] associated with SARS using an indirect immunofluorescence test.[1]

We excluded one hospital that had a large nosocomial outbreak because a drug nebuliser was used on an index patient with SARS for longer than 10 days. Droplets precautions have never been recognised as an effective infection control measure for such aerosol-generating



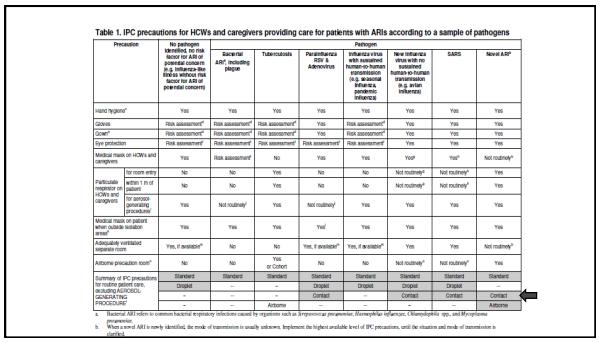
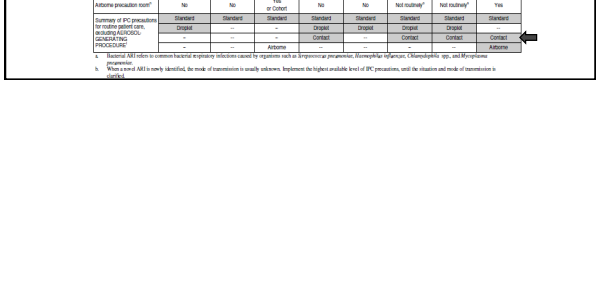


Table 1. IPC precautions for HCWs and caregivers providing care for patients with ARIs according to a sample of pathogens

Precaution		No pathogen identified, no risk factor for ARI or potential concern (e.g. influenza-like illness [ILI] in a setting or factor for ARI of potential concern)	Pathogen: Bacterial ARI[a], including plague	Tuberculosis	Parainfluenza RSV & Adenovirus	Influenza virus with sustained human-to-human transmission (e.g. seasonal influenza, pandemic influenza)	New influenza virus with no sustained human-to-human transmission (e.g. avian influenza)	SARS	Novel ARI[a]
Hand hygiene[c]		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gloves		Risk assessment[d]	Risk assessment[d]	Risk assessment[d]	Yes	Risk assessment[d]	Yes	Yes	Yes
Gown[e]		Risk assessment[d]	Risk assessment[d]	Risk assessment[d]	Yes	Risk assessment[d]	Yes	Yes	Yes
Eye protection		Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Risk assessment[f]	Yes	Yes	Yes
Medical mask on HCWs and caregivers		Yes	Risk assessment[g]	No	Yes	Yes	Yes[h]	Yes[h]	Not routinely[h]
Particulate respirator on HCWs and caregivers	for room entry	No	No	Yes	No	No	Not routinely[h]	Not routinely[h]	Yes
	within 1 m of patient	No	No	Yes	No	No	Not routinely[h]	Not routinely[h]	Yes
	for aerosol-generating procedures[i]	Yes	Not routinely[j]	Yes	Not routinely[j]	Yes	Yes	Yes	Yes
Medical mask on patient when outside isolation areas[k]		Yes	Yes	Yes	Yes[l]	Yes	Yes	Yes	Yes
Adequately ventilated separate room		Yes, if available[m]	No	No	Yes, if available[m]	Yes, if available[m]	Yes	Yes	Not routinely[n]
Airborne precaution room[o]		No	No	Yes or Cohort	No	No	Not routinely[n]	Not routinely[n]	Yes
Summary of IPC precautions for routine patient care, excluding AEROSOL-GENERATING PROCEDURE[p]		Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
		Droplet	--	--	Droplet	Droplet	Droplet	Droplet	--
		--	--	--	Contact	--	Contact	Contact	Contact
		--	--	Airborne	--	--	--	--	Airborne

a. Bacterial ARI refers to common bacterial respiratory infections caused by organisms such as *Streptococcus pneumoniae, Haemophilus influenzae, Chlamydophila* spp., and *Mycoplasma pneumoniae*.
b. When a novel ARI is newly identified, the mode of transmission is usually unknown. Implement the highest available level of IPC precautions, until the situation and mode of transmission is clarified.



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

Seto WH, Conly JM, et al: Infection prevention and control measures for acute respiratory infections in healthcare settings: an update. East Mediterr Health J. 2013;19 Suppl 1:S39-47. Review.

Recommendations	Ranking
1. Use clinical triage for early identification of patients with ARIs to prevent the transmission of ARI pathogens to HCWs and other patients	Strong
2. Respiratory hygiene (i.e. covering the mouth and nose during coughing or sneezing with a medical mask, tissue, or a sleeve or flexed elbow followed by hand hygiene) should be used in persons with ARIs to reduce the dispersal of respiratory secretions containing potentially infectious particles.	Strong
3. Spatial separation (distance of at least 1 metre) between beds should be maintained to reduce the transmission of ARI pathogens from one patient to another. Spatial separation (distance of at least 1 metre) between the patient and the HCW without the use of PPE should be maintained to reduce the transmission of ARI pathogens to the HCW	Strong
4. Cohorting, the placement of patients infected or colonized with the same pathogens in the same designated unit, zone or ward (with or without the same staff), or special measures, the placement of patients with the same suspected diagnosis (similar epidemiological and clinical information) in the same designated unit, zone or ward (with or without the same staff) within a health care setting, could be used in certain settings for the implementation of isolation precautions for patients with ARIs to reduce transmission of ARI pathogens to HCWs and other patients	Conditional
5. According to the risk assessment (according to the procedure and suspected pathogen), PPE may be needed when providing care to patients presenting with ARI syndromes and may include an appropriate combination of the following: medical mask (surgical or procedure mask), gloves, long-sleeved gowns, and eye protection (goggles /face shields)	Strong
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[1]. The available evidence suggests performing or being exposed to endotracheal intubation either by itself or combined with other procedures (e.g. cardiopulmonary resuscitation, bronchoscopy) was consistently associated with increased risk of transmission.	Conditional
7. Adequately ventilated single rooms should be used when performing aerosol generating procedures that have been consistently associated with increased risk of ARI transmission.	Conditional
8. Vaccination for influenza should be used for HCWs caring for patients at higher risk of severe or complicated illness from influenza to reduce influenza illness & mortality among these patients	Strong
9. Considerations for Ultraviolet Germicidal Irradiation – no recommendations possible.	-
10. Additional IPC precautions in health care settings for patients with ARIs should be based on the duration of symptomatic illness (according to the pathogen and patient information!) to reduce the transmission of ARI pathogens to HCWs and other patients. Note that Standard Precautions should always be used. There is no evidence to support the routine application of laboratory tests for the determination of duration of IPC precautions.	Conditional

B. Can we define the aerosols generating procedures?

Recommendations	Overall Ranking
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[1]. The available evidence suggests performing or being exposed to endotracheal intubation either by itself or combined with other procedures (e.g. cardiopulmonary resuscitation, bronchoscopy) was consistently associated with increased risk of transmission.	Conditional

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Figure 5: Selection of publications for the systematic review, *Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Diseases: A systematic Review* [126]

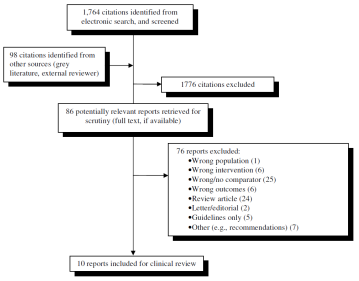
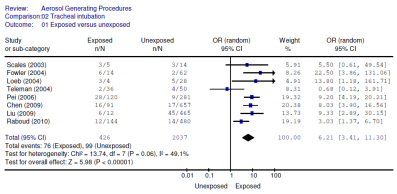


Figure 6: Risk of SARS transmission to HCWs exposed to tracheal intubation [126]



WHO meta-analysis

The most consistent statistically significant association of an increased risk of SARS transmission to HCWs was found for tracheal intubation (8 studies) (see Table 13 and Fig. 6). Increased risk of SARS transmission was also reported when performing non-invasive ventilation (2 studies), tracheotomy (1 study) , and manual ventilation before intubation (1 study), however these findings were identified from a very limited number of very low quality studies which makes interpretation difficult

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

OPEN ACCESS Freely available online PLoS one

Risk Factors for SARS Transmission from Patients Requiring Intubation: A Multicentre Investigation in Toronto, Canada

Janet Raboud[1,2], Altynay Shigayeva[3], Allison McGeer[2,3,4,*], Erika Bontovics[3], Martin Chapman[5,7], Denise Gravel[6], Bonnie Henry[3], Stephen Lapinsky[8,10], Mark Loeb[11], L. Clifford McDonald[12], Marianna Ofner[3,4], Shirley Paton[3], Donna Reynolds[13], Damon Scales[11,14], Sandy Shen[3], Andrew Simor[4,7], Thomas Stewart[13,15], Mary Vearncombe[16,7], Dick Zoutman[17], Karen Green[3]

	HCWs who did not develop SARS N = 598	HCWs who developed SARS N = 26	p value	All N = 624
Potential HCW exposure to respiratory secretions[a]				
Non-invasive ventilation	99 (17%)	10 (38%)	<0.01	109 (17%)
High flow oxygen	106 (18%)	2 (8%)	0.29[b]	108 (17%)
Mechanical ventilation	227 (38%)	9 (35%)	.73	236 (38%)
HCW involvement in intubation[c]				
Intubation (including fiber optic intubation)	132 (22%)	12 (46%)	<0.01	144 (23%)
Suctioning before intubation	106 (18%)	7 (27%)	0.29[b]	113 (18%)
Suctioning after intubation	155 (26%)	10 (38%)	0.16	165 (26%)
Manual ventilation before intubation	108 (18%)	10 (38%)	0.02[b]	118 (19%)

Poor infection control practices

	HCWs who did not develop SARS N = 598	HCWs who developed SARS N = 26	p value	All N = 624
Respiratory protection while in patient room	49 (8%)	3 (12%)	0.04[a]	52 (8%)
➢ None	25 (4%)	5 (19%)		30 (5%)
➢ Surgical mask	496 (83%)	18 (69%)		514 (82%)
➢ N95 or equivalent	28 (5%)	0 (0%)		28 (4%)
➢ Higher protection than N95 (e.g., N95 plus Stryker hood, PAPRs)				
Personal protective equipment removal[a]	41 (7%)	3 (12%)	0.56[a]	44 (7%)
➢ None used	192 (32%)	11 (42%)		203 (33%)
➢ No hand hygiene performed	290 (48%)	8 (31%)		298 (48%)
➢ No hand hygiene before removing face protection, hand hygiene at the end	14 (2%)	0 (0%)		14 (2%)
➢ Hand hygiene before removing face protection, no hand hygiene at the end	61 (10%)	4 (15%)		65 (10%)
➢ Hand hygiene before removing face protection, plus hand hygiene at the end				
Infection control training	173 (29%)	16 (62%)	0.009[a]	189 (30%)
➢ None	9 (2%)	0 (0%)		9 (1%)
➢ Other (information from colleagues)	136 (23%)	2 (8%)		138 (22%)
➢ Email or written instructions	127 (21%)	2(8%)		129 (21%)
➢ Group sessions	153 (26%)	6 (23%)		159 (25%)
➢ Individual face to face instruction				

Table 4. Multivariate Generalized Estimating Equation logistic regression model of the probability of transmitting SARS from patient to health care worker.

Parameter	OR	95% CI	p value
HCW's eye/mucous membranes exposed to body fluids	7.34	(2.19, 24.52)	.001
Patient APACHE II score ≥20	17.05	(3.20, 90.75)	.009
HCW present during ECG	3.52	(1.56, 7.96)	.002
HCW present during intubation	2.79	(1.40, 5.58)	.004
Patient PaO_2 to FiO_2 ratio ≤59	8.65	(2.31, 32.36)	.001

HCW = health care worker.
doi:10.1371/journal.pone.0010717.t004

Parameter
HCW's eye/mucous membranes exposed to body fluids
Patient APACHE II score ≥20
HCW present during ECG
HCW present during intubation
Patient PaO_2 to FiO_2 ratio ≤59

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

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NIVs OR>1

Am J Respir Crit Care Med Vol 169. pp 1198–1202, 2004

Transmission of Severe Acute Respiratory Syndrome during Intubation and Mechanical Ventilation

Robert A. Fowler, Cameron B. Guest, Stephen E. Lapinsky, William J. Sibbald, Marie Louie, Patrick Tang, Andrew E. Simor, and Thomas E. Stewart

TABLE 2. ASSOCIATION OF ENDOTRACHEAL INTUBATION WITH THE DEVELOPMENT OF SEVERE ACUTE RESPIRATORY SYNDROME AMONG PHYSICIANS AND NURSES

Any Involvement with Intubation	n	Developed SARS	RR	95% Confidence Interval	p Value
All healthcare workers					
Yes	14	6	13.29	2.99–59.04	0.003
No	62	2			
For nurses					
Yes	4	3	21.38	4.89–93.37	0.001
No	57	2			
For physicians					
Yes	10	3	3.82	0.23–62.24	0.5
No	5	0			

Definition of abbreviations: RR = relative risk; SARS = severe acute respiratory syndrome.

TABLE 3. ASSOCIATION OF VENTILATION STRATEGIES WITH THE DEVELOPMENT OF SEVERE ACUTE RESPIRATORY SYNDROME AMONG HEALTHCARE WORKERS

Ventilation Mode	n	Developed SARS	RR	95% Confidence Interval	p Value
Patient treated with NIPPV					
Yes	6	1	2.33	0.25 to 21.76	0.5
No*	28	2			
Patient treated with HFO					
Yes	38	2	0.74	0.11 to 4.92	0.6
No*	28	2			

Definition of abbreviations: HFO = high-frequency oscillatory; NIPPV = noninvasive positive-pressure ventilation; RR = relative risk; SARS = severe acute respiratory syndrome.
* Conventional ventilation is the reference, with an odds ratio of developing SARS = 1.

Research article

Open Access

Which preventive measures might protect health care workers from SARS?

Wei-Qing Chen*[1], Wen-Hua Ling[2], Ci-Yong Lu[1], Yuan-Tao Hao[4], Zhong-Ning Lin[3], Li Ling[1], Jian Huang[4], Gang Li[5] and Guang-Mei Yan[6]

Tracheostomy

Several limitations of the study ought to be mentioned here. First, our investigation was limited to two affiliated hospitals of Sun Yat-sen University. This is not representative of all of the hospitals in which patients with SARS were admitted and cared for in Guangzhou. Therefore, this is a typical case investigation. Second, ventilation in the wards was not objectively assessed for some reason, meaning that we could not exactly evaluate the influence of the ventilation in the wards on the transmission of SARS among HCWs. Third, we could not trace the tree structure of the primary, secondary, and third class cases, which prevented us from clarifying the association of the HCWs infected by SARS with the index case directly or indirectly. Fourth, some factors, such as oxygen therapy and bi-level positive airway pressure ventilation were found to be related to nosocomial infection of SARS in other study [21], were not included in the present study, which indicated that we missing an opportunity to find some effective measures for protecting HCWs from SARS or to assess their effect. Fifth, in the early stage of SARS epidemic, the diagnosis of SARS was based on the history of epidemiology, signs and symptoms suggested by the Health Ministry of China [12], not on the directive biomarkers of SARS-CoV or antibodies against SARS-CoV,

CDC Centers for Disease Control and Prevention

Aerosol-generating procedures

Some procedures performed on patients are more likely to generate higher concentrations of respiratory aerosols than coughing, sneezing, talking, or breathing, presenting healthcare personnel with an increased risk of exposure to infectious agents present in the aerosol. Although there are limited objective data available on disease transmission related to such aerosols, many authorities view the following procedures as being very high exposure risk aerosol-generating procedures for which special precautions should be used:

- Bronchoscopy
- Sputum induction
- Endotracheal intubation and extubation
- Open suctioning of airways
- Cardiopulmonary resuscitation
- Autopsies

Aerosol-generating high risk procedures.

Both WHO/CDC: Intubation, bronchoscopy, autopsies, cardiopulmonary resuscitation, open suction of airways.

CDC only: extubation, sputum induction;

WHO only: collection of lower respiratory tract specimens.

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

WHO meta-analysis

of very low quality studies which makes interpretation difficult. There was not a statistically significant difference in the risk of SARS transmission between exposed and unexposed HCWs for all other procedures evaluated (i.e. suction before intubation, suction after intubation, manual ventilation after intubation, bronchoscopy, nebulizer treatment, manipulation of oxygen mask, manipulation of BiPAP mask, defibrillation, chest compressions, insertion of nasogastric tube, collection of sputum sample, high frequency oscillatory ventilation, high flow oxygen, endotracheal aspiration, suction of body fluid, administration of oxygen, chest physiotherapy, mechanical ventilation).

Nebulizers

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

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

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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 demonstrate efficient transmission even before nebulizer therapy was begun on the afternoon of March 6.

Table 3. Time schedule of the clinical assessment of 19 medical students*

Time		Ill/total
6 March 2003	10:00–10:40 a.m.	0/3
	10:40–11:20 a.m.	2/3
	11:30 a.m.–12:00 p.m.	3/3
	12:00–12:40 p.m.	1/1
7 March 2003	10:00–10:40 a.m.	1/2
	10:40–11:20 a.m.	0/3
	11:30 a.m.–12:00 p.m.	0/3
	12:00–12:40 p.m.	0/1

*Excluding the student-patient whose illness had a long incubation period.

C. Is N95 Fit Testing Necessary?

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 correlated with passing at initial fit-test or receipt of instruction

No, fit testing is not needed.

- **No added value to adequate training:**

TABLE 2
RESULTS OF QUALITATIVE FIT TESTING OF PARTICIPANTS IN GROUP A (INDIVIDUALLY TRAINED AND FIT TESTED), GROUP B (TRAINED BY CLASSROOM DEMONSTRATION AND NOT FIT TESTED), AND GROUP C (NO PRIOR TRAINING), STRATIFIED BY PREVIOUS EXPERIENCE USING RESPIRATORS

	Group A	Group B	Group C
Used respirators			
Passed	35	33	19
Failed	1	5	3
Never used respirators			
Passed	14	25	31
Failed	2	1	10
Passed/participants (%)	49/52 (94)	58/64 (91)	50/63 (79)*

*Stratified Mantel-Haenszel chi-square: Group A versus Group B, $P=.7$, odds ratio (OR)=1.65; 95% confidence interval (CI_{95}), 0.4 to 6.6).
Group A versus Group C, $P=.16$, OR=3.0 (CI_{95}, 0.8 to 11.6).
Group B versus Group C, $P=.15$, OR=2.6 (CI_{95}, 0.9 to 7.9).
Group (A+B) versus Group C, $P=.05$, OR=2.9 (CI_{95}, 1.1 to 7.8).

Hannum D, et al. The effect of respirator training on the ability of healthcare workers to pass a qualitative fit test. Infect Control Hosp Epidemiol. 1996;17:636-40

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

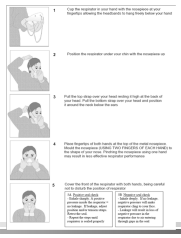
Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care

WHO Guidelines

- Train those who may need to wear a particulate respirator in how to use the device (e.g. putting on of respirator, avoiding self-contamination during use and on removal, and achieving the best seal) (*158*). The inclusion of fit-testing in respirator user-training has not been shown to be an effective means to improve compliance with proper use of respirators (*158*). Follow local regulations regarding the regular performance of the fit test.

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



Seal check

5 Cover the front of the respirator with both hands, being careful not to disturb the position of respirator

5A Positive seal check
- Exhale sharply. A positive pressure inside the respirator = no leakage. If leakage, adjust position and/or tension straps. Retest the seal.
- Repeat the steps until respirator is sealed properly

5B Negative seal check
- Inhale deeply. If no leakage, negative pressure will make respirator clings to your face.
- Leakage will result in loss of negative pressure in the respirator due to air entering through gaps in the seal

IDSA
Infectious Diseases Society of America

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

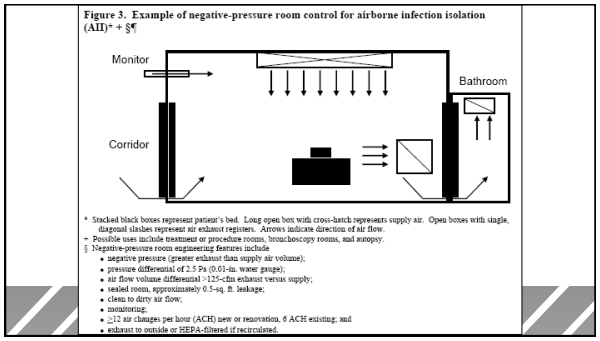
However, we disagree with the next sentence, which is inherently contradictory, "However, HCWs should undergo initial and periodic fit testing." There is no sound evidence to support initial and periodic fit testing.

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

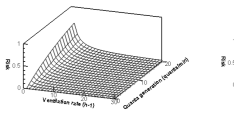
A Webber Training Teleclass
www.webbertraining.com

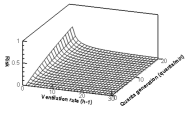


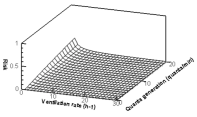
Airborne transmission isolation room:

- **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 UVGI only as adjunct**
- **Avoid within room circulation (eg. fans)**


(a) 15 minutes exposure time


(b) 10 minutes exposure time


(c) 5 minutes exposure time

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

Windows open (100%), Doors open (100%)	= 45.4 ACH
Windows open (100%), doors close	= 20.2 ACH
Windows open (50%), doors close	= 15.5 ACH
Windows close , doors close	= 0.6 ACH
Windows close, doors open	= 3 .4 ACH

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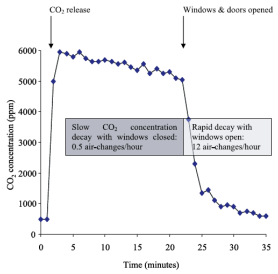

WHO Publication/Guidelines

Natural Ventilation for Infection Control in Health-Care Settings

Edited by:
James Atkinson, Yves Chartier, Carmen Lúcia Pessoa-Silva, Paul Jensen, Yuguo Li and Wing-Hong Seto

http://www.who.int/water_sanitation_health/publications/natural_ventilation.pdf

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 pressures or pressure generated by the density difference between indoor and outdoor air.

TB incidence in Grantham and HA hospitals
1996-2005

Mean Incidence (per 100,000 pat year)

HA hospitals: (257 cases) 60.4

GH: (5 cases) 65.2

p = 0.9

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Director, Hospital Infections and Antimicrobial Resistance Program Tennessee Dept. of Health

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, all 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.

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www.webbertraining.com

Sister Mary Gabriel O'Mahoney (1921-2006)
Source: Hong Kong Tuberculosis, Chest and Heart Diseases Association

Opening your windows,

The key to natural ventilation..