

THE UNIVERSITY OF HONG KONG

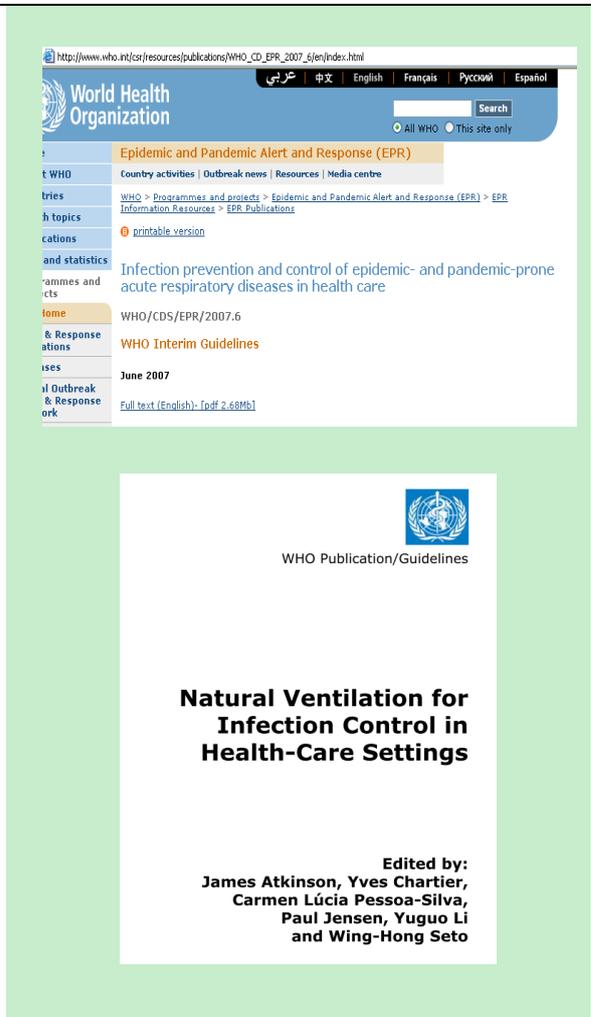
IMPACT CASE HISTORY

New Understanding and Guidelines on Ventilation for Better Infection Control in Hospitals

1. Summary

Research led by Professor Yuguo Li of The University of Hong Kong demonstrates how excellence in research can be applied to real problems of importance to the community, in this case how infectious diseases such as Severe Acute Respiratory Syndrome (SARS) and influenza might be transmitted through, and on the other hand, controlled by, ventilation. The research has been developed into principles and guidelines for ventilation systems in hospital environment settings, and achieved international impact.

The World Health Organization (WHO) has incorporated the research findings of Professor Li’s team into the ventilation chapter of its 2007 interim infection control guidelines for healthcare settings, which were widely used in the 2009 pandemic influenza management by WHO. The team also led and developed the new WHO guidelines on natural ventilation for infection control in health-care settings in 2009, which have been particularly useful for application in resource-limited countries.



2. Underpinning Research

The underpinning research has been carried out by the research team led by Professor Yuguo Li, Professor in the Department of Mechanical Engineering, Faculty of Engineering, since the SARS outbreak in Hong Kong in 2003. The virus in the 2003 SARS epidemic or the 2009 influenza pandemic might have jumped from animals to humans, but it is in buildings that viruses are transmitted between people. In 2003, Professor Li was encouraged by the then Dean of Engineering, among a team of engineers, to produce a plausible explanation based on engineering principles related to ventilation on how the SARS virus had spread within one complex, Amoy Gardens. The work was eventually published in the *New England Journal of Medicine*.

Working with experts from other disciplines and the Hong Kong Institution of Engineers' SARS Busters, Professor Li's team also constructed a six-bed SARS ward test room and demonstrated the basic principles of isolation ventilation to hundreds of medical doctors, nurses, engineers, health officials, and media from Hong Kong and Asia. The team went on to study the critical issues in ward ventilation design.

Since 2003, Professor Li's team has studied how expiratory droplets dry up and disperse, and how ventilation can minimize the exposure of the droplet nuclei in hospitals, particularly in isolation rooms. They carried out field measurement in more than 50 SARS wards in 9 hospitals in 2005 and identified key research needs, which were supported by grants from the Research Fund for the Control of Infectious Diseases (RFCID). They studied how SARS and influenza were transmitted in a number of outbreaks in Hong Kong and Beijing, the right negative pressure, the optimum ventilation method, how droplets evaporate in the indoor environment, how cough works, and why Grantham Hospital had been naturally ventilated since 1957, etc.

In the past, guidelines on hospital environments were developed by medical doctors and infectious disease control professionals with very little input from engineers. The objective was to remove droplets but they assumed the droplets would be heavy and would fall. Hence they put the ventilation exhaust in the lower part of the room. Professor Li and his team showed that droplets could also disperse upwards and that ventilation at the top of the room was better at managing dispersion. Their findings have implications for a range of infectious diseases, such as avian flu and swine flu.

3. References to the Research

The research was supported by 4 grants from the Research Grants Council's General

Research Fund (GRF), 1 grant from the National Science Foundation of China (NSFC) and 4 grants from the Research Fund for the Control of Infectious Diseases (RFCID), as well as financial support from WHO, the Hospital Authority (via RFCID) and the Hong Kong Institution of Engineers. The team published 36 articles in reputable engineering and medicine journals. 1/3 of them have been cited more than 20 times (SCI), and the top one has been cited over 200 times.

Key peer-reviewed publications:

Yu ITS, Li Y, Wong TW, Tam W, Chan A, Lee JHW, Leung DYC and Ho T (2004). Evidence of airborne transmission of the severe acute respiratory syndrome virus. *New England Journal of Medicine*, 350, 1731-1739.

Li Y, Huang X, Yu ITS, Wong TW and Qian H (2005). Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong. *Indoor Air*, 15:83-95. (Received the Best Paper Award of Indoor Air Journal 2005-2007)

Li Y, GM Leung, JW Tang, X Yang, CYH Chao, JZ Lin, JW Lu, PV Nielsen, J Niu, H Qian, AC Sleight; H-J J Su, J Sundell, TW Wong, PL Yuen (2007). Role of ventilation in airborne transmission of infectious agents in the built environment – a multidisciplinary systematic review. *Indoor Air*, 17 (1), 2-18.

Xie, XJ, Li Y, Sun HQ and Liu L (2009). Exhaled droplets due to talking and coughing. *Journal of The Royal Society Interface*, 6: S703-S714.

Qian H, Li Y, Seto WH, Ching P, Ching WH and Sun H (2010). Natural ventilation for reducing airborne infection in hospitals. *Building and Environment*, 45, 559–565.

Qian H and Li Y (2010). Removal of exhaled particles by ventilation and deposition in a multibed airborne infection isolation room. *Indoor Air*, 20 (4), 284-297. (Received the Best Paper Award of Indoor Air Journal 2008-2010)

Selected external grant funding:

1. Dispersion and ventilation control of exhalation pollutants in hospital wards (HKU 7115/04E)
 Funding Scheme: GRF
 Principal Investigator: Professor Yuguo Li
 Period: 2004-2007
 Amount Awarded: HK\$380,047
2. BioPassVent - a theory of enclosure ventilation for purging combined pollutants (HKU 7150/06E)
 Funding Scheme: GRF

	Principal Investigator: Professor Yuguo Li
	Period: 2006-2009
	Amount Awarded: HK\$884,850
3.	ConnectVent - Ventilation of "connected" indoor environments in controlling airborne disease transmission (HKU 714608E)
	Funding Scheme: GRF
	Principal Investigator: Professor Yuguo Li
	Period: 2008-2010
	Amount Awarded: HK\$327,937
4.	Proximity effect - Exploring short-range and long-range airborne routes of expiratory exposure between people in indoor environment (HKU 7142/12)
	Funding Scheme: GRF
	Principal Investigator: Professor Yuguo Li
	Period: 2012-2015
	Amount Awarded: HK\$905,425
5.	Understanding droplets due to the use of nebulizers and respiratory activities (HA-NS-002)
	Funding Scheme: RFCID
	Principal Investigator: Professor Yuguo Li
	Period: 2004-2006
	Amount Awarded: HK\$798,360
6.	Evaluating factors that affect ventilation effectiveness in SARS wards (HA-NS-003)
	Funding Scheme: RFCID
	Principal Investigator: Professor Yuguo Li
	Period: 2004-2005
	Amount Awarded: HK\$731,824
7.	NatVent: Use of natural ventilation as an infection control measure (HA-NS-006)
	Funding Scheme: RFCID
	Principal Investigator: Professor Yuguo Li
	Period: 2008-2011
	Amount Awarded: HK\$697,150
8.	WardVent: How movement and anteroom affect ventilation performance in a ward setting (HA-NS-007)
	Funding Scheme: RFCID
	Principal Investigator: Professor Yuguo Li
	Period: 2008-2011
	Amount Awarded: HK\$713,700

9. Formation of droplet nuclei and airborne exposure in hospital wards

Funding Scheme: NSFC
 Principal Investigator: Professor Yuguo Li
 Period: 2012-2015
 Amount Awarded: RMB850,000

4. Details of the Impact or Benefit

Through engagement processes that involve extensive interactions with the healthcare sector and medical and engineering professionals, the research of Professor Li's team has achieved significant and global impact.

Based on their research findings, Professor Li's team assisted WHO in drafting the ventilation chapter of its 2007 interim infection control guidelines and the tuberculosis control guidelines. Furthermore, the team led and developed the new WHO guidelines on natural ventilation for infection control in health-care settings in 2009, which have been particularly useful for application in resource-limited countries. The 2007 WHO guidelines have been translated into Arabic, French, Spanish and Bahasa Indonesia, and were widely used in the 2009 pandemic influenza management by WHO. The 2009 guidelines were also translated into French and Spanish.

Professor Li was invited as WHO's temporary advisor and assisted the Indonesian Ministry of Health in reviewing the avian flu isolation room design in more than 20 hospitals.

Since 2006, about 1,500 infection control nurses and professionals from Hong Kong and other countries in the region have attended training lectures delivered by Professor Li, which he gives at least twice each year. The training lectures are organized by the Hong Kong Infection Control Nurses' Association and have become regular events. Professor Li also co-ordinated part of the 2007 training course for the Centre for Health Protection (CHP) of the Department of Health, HKSAR Government. He is often invited by other engineering, infection control and occupational health associations to give keynote talks on ventilation control of infection in Hong Kong, Australia, USA, Taiwan, Korea, Japan, and Mainland China, etc. His talks have reached thousands of infection and engineering professionals worldwide.



Professor Li was a co-author of the position paper on airborne infection of the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). He has been invited by ASHRAE as their Environmental Health Committee member to develop further research priority in hospital ventilation. He was also invited to be the 2012 ASHRAE Distinguished Lecturer to give talks to their local chapters worldwide on the issue of building ventilation for infection control. In 2013, he was invited to serve as a Member of the Scientific Committee on Infection Control of the CHP. The research continues and the results have had impacts around the world.

5. References to the Corroboration of Impact or Benefit

- **WHO Guidelines:**

- Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care, WHO Interim Guidelines, June 2007:
http://www.who.int/csr/resources/publications/WHO_CDS_EPR_2007_6c.pdf
- Natural ventilation for infection control in health-care settings, WHO Guideline 2009:
http://www.who.int/water_sanitation_health/publications/natural_ventilation/en/

- **Award received:**

Professor Li received part of the 2010 National Science and Technology Advance Award (Second Prize).

- **Contributions to the Professions and Invited Presentations to External Groups:**

- Li, Y. (2005). Special Section on Engineering Control of Respiratory Infectious Diseases, *Hong Kong Institution of Engineers*.
- The regular twice per year training lectures on ventilation in health care settings for the Hong Kong Infection Control Nurses' Association since 2006
- Li, Y. 'Control of airborne/droplet-borne infectious disease in hospitals – where is engineering', invited talk, AGM of The Institute of Healthcare Engineering and Estate Management, Hong Kong Branch, March 28, 2006.
- Short Course on "Geospatial and Fluid Dynamics Modelling of Infectious Diseases" organized for the Centre for Health Protection (CHP), January 18-20,

2007. Professor Li's contribution included 2 lectures and half-day hands-on sessions, and co-ordination of the efforts of fluid modeling.

• **Membership of External Bodies:**

- Professor Li has been invited by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) as their Environmental Health Committee member to develop further research priority in hospital ventilation. He was also invited to be the 2012 ASHRAE Distinguished Lecturer to give talks to their local chapters worldwide on the issue of building ventilation for infection control.
- In 2013, he was invited to serve as a Member of the Scientific Committee on Infection Control of the CHP.

• **Media Coverage:**

The studies on the isolation room and Amoy Garden outbreak were reported widely in local and international media.

