Natural Ventilation of Health Care Facilities

*Engineering Methods for the Control of Airborne Infections: An International Perspective*

Harvard School of Public Health
20th July 2008

Dr Rod Escombe MD DTM&H PhD

Honorary Research Fellow, Wellcome Centre for Clinical Tropical Medicine & Department of Infectious Diseases & Immunity, Imperial College London, UK.
Senior Investigator, Asociación Benéfica PRISMA, Lima, Perú.
GP Registrar, St Mary’s Hospital, London, UK.
1. Bonifacio N. Emerg Inf Dis 2002; 8:747
Ventilation and control of airborne infection in health care facilities

- Dilutional ventilation is the mainstay of environmental control measures for airborne infections
- Aim to reduce the concentration of infectious airborne particles
- Reduce exposure of patients, staff and visitors
Measuring ventilation: Air Changes per Hour (ACH)

Effect of ACH on concentration of airborne particles
Wells-Riley equation:

\[ C = S (1 - e^{-\frac{qpt}{Q}}) \]

- \( C \): new cases
- \( S \): susceptibles
- \( I \): number of infectors
- \( q \): infectious quanta produced per hour
- \( p \): pulmonary minute ventilation
- \( t \): duration of exposure
- \( Q \): absolute ventilation (= ACH x room volume)
Effect of dilutional ventilation on risk of airborne infection

Yuguo Li
Mechanical ventilation

- Air changes dilute infectious particles
- Negative pressure
- Standard of care

CDC Guidelines 2005: 6-12 ACH for high-risk areas
Natural ventilation

- Passive supply of outdoor air to a building interior for ventilation and cooling
- Historically all buildings employed natural ventilation

Pantheon, Rome – 120 AD
Natural ventilation in health care facilities

“The very first canon of nursing, the first and the last thing upon which a nurse’s attention must be fixed, the first essential to the patient, without which all the rest you can do for him is as nothing, with which I had almost said you may leave all the rest alone, is this: to keep the air he breathes as pure as the external air, without chilling him”

Notes on Nursing – What it is and what it is not. 1860. London
TB sanatoria

- Pre-antibiotic era
- Fresh air therapy
With modern building design, advent of HVAC, natural ventilation fell from favour
Renewed interest in natural ventilation

General building design

• Need to reduce energy costs: “green buildings”

Health care facilities

• TB & HIV epidemics, emergence of drug resistance and recognition of nosocomial spread\(^1\)
• *TB prevention low resource settings*. WHO 1999\(^2\)
• *TB Infection control in era of HIV*. WHO 2007\(^3\)
• *Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care*. WHO Interim guidelines 2007\(^4\)

Evidence base so far is slim

• Data from Peru

Natural ventilation

- Simply opening windows
- Low cost
- Maintenance free
- Climate dependant
Natural ventilation – basic principles

Cross ventilation

Stack effect

Hot air rises
Natural ventilation – basic principles

Layout

Poor

Improved

WHO guidelines
Natural ventilation in Lima hospitals

• 8 hospitals
  – 5 old-fashioned design built pre-1950
  – 3 modern hospitals built 1970-90

• 70 naturally ventilated rooms
  – Respiratory isolation rooms
  – TB, respiratory, infectious disease, HIV, general medical wards
  – Emergency departments
  – Out-patient clinics and waiting rooms

• 12 mechanically ventilated respiratory isolation rooms
  – Built in 2000, renovated by Wellcome Trust in 2004