Natural Ventilation in the Healthcare Environment
Russell Olmsted, Dick Moeller, and Linda Dickey
Broadcast live from the 2015 APIC conference... www.apic.org

Natural Ventilation in the Healthcare Environment
APIC 2015 Annual Conference
Russell N. Olmsted, MPH, CIC – Trinity Health
Dick Moeller PE FASHE – Mazzetti
Linda Dickey, RN, MPH, CIC – UC Irvine Health

Is it Time to Consider NV?

“Is it really an innovative approach, but I'm afraid we can't consider it. It's never been done before.”

“Af people never tried anything new, we wouldn't be living in caves.”

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Mechanical Natural Ventilation

“Natural ventilation is the flow of outdoor air caused by wind and thermal pressure through intentional openings in the building’s shell.”

Ventilation and Energy: Filtration (aseptic air)

<table>
<thead>
<tr>
<th>Nature (Screens)</th>
<th>ASHRAE Standard 62.1</th>
<th>ASHRAE Standard 170</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>MERV 5</td>
<td>MERV 7 MERV 14</td>
</tr>
</tbody>
</table>

15 μg / m³

12 μg / m³

11 μg / m³

1 μg / m³

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Codes and Guidelines

- CDC Environmental Guideline
- The FGI Guidelines for Design and Construction of Hospitals and Outpatient Facilities - 2014
- AHJ’s
Key Perspectives:

- Patient Safety (Location)
- Facility operations
- Financial feasibility

DO NOT CONSIDER FOR NATURAL VENTILATION

- Operating Rooms
- Sterile Core
- Procedure Suite
- Interventional Radiology / Cardiology
- Intensive Care Units
- Airborne Isolation Areas
- Protective Environment
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### Natural Ventilation in Healthcare

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Ventilation</th>
<th>Mechanical Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Acuity Facilities</td>
<td>100% MECHANICAL SYSTEMS</td>
<td>High Acuity Spaces/Critical Pressure Relationships- OR's, C-section room, Prep/ Hold Recovery, Sterile, ICU, NICU, Isolation, Procedure, Trauma, Protective Environment rooms, Sterile Processing Dept (clean, sterile storage &amp; decontamination)</td>
</tr>
<tr>
<td>Moderate Acuity Facilities</td>
<td>25% NV Infusion, Circulation</td>
<td>75% MECHANICAL SYSTEMS Non Invasive Radiology, Lab, Outpatient procedures, Isolation</td>
</tr>
<tr>
<td>Medium Acuity Facilities</td>
<td>50% NATURAL VENT Physical therapy, Back corridors, M/S Patient rooms, Mother/Baby</td>
<td>50% MECHANICAL Isolation, landlocked areas, clean rooms, Rehab rooms, procedure</td>
</tr>
<tr>
<td>Low Acuity facilities</td>
<td>75 - 100% NATURAL VENT Low Acuity Spaces- Public cir., Waiting areas, Team spaces, Clinics, Skilled nursing</td>
<td>25% MV Landlocked, Procedure areas, Exam rooms</td>
</tr>
</tbody>
</table>

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Hospitals use lots of energy....


Energy and Hospitals: ...it’s the ventilation systems.

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Pinderfields Hospital
Wakefield, West Yorkshire, UK

Veterans Home Skilled Nursing Facility in USA

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Veterans Home Skilled Nursing Facility

- The project’s key strategy is a natural cooling system that capitalizes on the site’s mild microclimate and sea breezes.
- 240 operable windows give residents access to fresh air and control over their environment—helping set a precedent for the dignified, empowered treatment of elderly veterans.

Russ’s initial reaction to NV in Health Care:

“I’m full of fears and I do my best to avoid difficulties and any kind of complications.”
- A. Hitchcock

But let’s take a closer look at frequency and cost of healthcare-associated infections (HAIs)...

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How Many & Who Get HAIs? 1/ every 25 patients on any given day in U.S. hospitals

- 44% are 65 or older

1 in 9 die

Magill SS, et al NEJM 2014

Specific Sites and Prevalence of Healthcare Associated Infections (HAIs)

- Point Prevalence Survey; National Healthcare Safety Network (NHSN)
  N=183 hospitals, 2011
- Patients at risk = 11,282
  - 452 (4.0%) with ≥ one HAI
  - Distribution by site:
    - SSI & pneumonia most prevalent
- Nationwide estimates:
  - 648,000 patients with 721,800 HAIs/year

Magill SS et al. NEJM 2014;370:1198-208

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Point Prevalence; HAIs in Europe, 2011-12.
www.ecdc.europa.eu

Figure 1. Distribution of HAI types by presence of HAI on admission, HAI present on admission (left)
HAI onset during hospitalisation (right)

- Pneumonia/LRT: 14%
- Urinary tract: 10%
- Surgical site: 12%
- Bloodstream: 33%
- Gastrointestinal: 9%
- Systemic: 9%
- Skin/Soft tissue: 9%
- Other/unspecified: 9%

LRT: Lower respiratory tract

N = 231,459 patients in 947 hospitals
Data from a single ward were collected on a single day
Overall prevalence = 6.0% (range 2.3%–10.8%)

Perspective on Modes of Transmission of Pathogens; comparing the risks

Contact: most common mode for pathogens - HAIs
Direct & Indirect

Droplet: microbe in respiratory droplets produced by cough or sneeze; droplets travel 1-2 meters; examples: influenza, MERS-CoV

Airborne: microbe in respirable droplet becomes airborne and can travel long distance and be inhaled deep into lung; examples: Mycobacterium tuberculosis, Aspergillus spp.

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Historical Experience with Natural Ventilation (NV); What Did Florence DO?

“At her behest, new windows capable of opening were installed to air out the wards.”
Nightingale in Scutari:

OUTCOME SCORECARD:
F. Nightingale arrives, Scutari, 1854
Mortality Rate among soldiers:
Jan-Mar. 1855 = 33%
Apr-June 6%
July-Sept. 2%

Review
Roles of sunlight and natural ventilation for controlling infection: historical and current perspectives
R. A. Hobday, S. J. Dancer
E Springgrove, Cowden, Tonbridge, UK
Department of Microbiology, Nunnery Hospital, East Kilbride, Lanarkshire G75 8RG, UK

1) "Current knowledge of indoor transmission of pathogens is inadequate, partly due to lack of agreed definitions for particle types and mechanisms of spread. There is recent evidence to support historical data on the effects of natural ventilation but virtually none for sunlight...

2) ...designing buildings to allow increased exposure to sunlight and outdoor air may discourage survival and spread of infectious agents

3) consequential health benefits for occupants potential benefits from sunlight penetration and natural ventilation merit further investigation…”

Journal of Hospital Infection 84 (2013) 271-282

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**Important Need for Preventing Healthcare Associated Aspergillosis – Limitation of NV**

- 53 clusters or outbreaks:
  - 458 patients
  - Overall case fatality rate = 57.6%
- In one half of these the probable / possible source =
  - Construction &/or demolition work in healthcare facilities
- Infections observed even with concentration of Aspergillus spp in air was ≤ 1 colony-forming unit /m³

---

**The Building Microbiome Project; study site = acute care hospital in Oregon**

“...we found that the abundance of potentially pathogenic bacteria was not higher in NV compared to MV rooms.”

Russ’s observations:
- The predominant bacteria in MV made up of microbes on our skin.
- Does this study instead suggest MV system did a good job removing microbes in outdoor air?
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What’s Frequency of CLABSI in Facilities in Country with Fewer Resources/Infrastructure?

16 ICUs in 11 hospitals in India

Yes, study found 53% drop in CLABSI rates after improvement program + feedback of data to providers

WHO Surgical Safety Checklist, 8 cities

PANP I
Toronto, Canada

EURO
London, UK

EMRO
Amman, Jordan

APIC
Ifakara, Tanzania

SEARO
New Delhi, India

AFRO II
Seattle, USA

AFRO II
Manila, Philippines

AFRO II
Auckland, NZ

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Outcome Indicators; Surgical Morbidity Around the Globe

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline</th>
<th>Checklist</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>3733</td>
<td>3955</td>
<td>-</td>
</tr>
<tr>
<td>Death</td>
<td>1.5%</td>
<td>0.8%</td>
<td>0.003</td>
</tr>
<tr>
<td>Any Complication</td>
<td>11.0%</td>
<td>7.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SSI</td>
<td>6.2%</td>
<td>3.4%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Unplanned Reoperation</td>
<td>2.4%</td>
<td>1.8%</td>
<td>0.047</td>
</tr>
</tbody>
</table>


WHO Guidance on NV; Min. hourly ave. ventilation rates: 160 l/s/patient (AIIR)
60 l/s/patient (gen. wards, outpatient care)
2.5 l/s/m3 (corridors)

Natural Ventilation for Infection Control
In Healthcare Settings. WHO, 2009

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Juxtaposition of Two Principles:
Indoor air quality / Preventing cross transmission of pathogens

In U.S., design guidance (FGI) and trend is towards single patient rooms.
Rationale;
spatial separation = less transmission

Summary Points on NV & Infection Prevention

• The predominant mode of transmission of pathogens that cause HAIs is via direct or indirect contact.

• For facilities in the U.S.; design and operation of HVAC that uses NV must not disrupt or inhibit recommended pressure relationships of key areas, e.g. OR, AIIR, PE.

• Surveillance of HAIs differ between countries but does not seem that HVAC design accounts for major difference in frequency of endemic HAIs

• There remain continued questions on NV and more experience/evidence is needed comparing incidence of HAIs in buildings with NV vs MV.
Butaro Hospital - Rwanda

In 2005 patients with HIV entered a relatively well-resourced hospital in a rural town in South Africa but within weeks all but one were dead. The death certificates recorded that they died from a new drug-resistant form of tuberculosis.

But behind the diagnoses lay a larger problem: They were killed by visiting the place where they had hoped to find treatment.
Butaro Hospital - Rwanda

‘Many hospitals in poorer countries are based on designs from other countries, regardless of whether or not they are site appropriate’, according to a co-author of the WHO’s new guidelines on design for infection control.

The problem is compounded by a desire to utilize complex technology but, without the resources for its upkeep.

Women’s & Children’s Center

- Operable Windows in Patient Family Rooms – low acuity spaces
- Extraordinary setting for natural ventilation

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Post Occupancy reviews with staff:

- It’s the dustiest facility ever experienced in her career - dust bunnies are a usual occurrence
- Thin, fine layer of dust reportedly found on computer screens and desk tops daily
- Can’t maintain pressure differential between rooms/corridors
- Security doors won’t close due to strong building pressure, etc.

Post project reviews with staff:

“Fresh flowers brought to the office die in less than 2 days - flowers from the same bouquet survive up to 7 days in the home environment. Do we need a canary?”

“Obviously the HVAC system doesn’t work.”
Facility Response:

Facility self-inspection + review by a certified industrial hygienists for HVAC and building analysis - conclusion: ‘The HVAC system was properly designed, installed & maintained.’

(Third party tape lifts showed: tire dust, charred wood, insect/plant/bird parts, humus, soil, dog/cat dander, fern spores, rust, soil, metal wear, aerosolized dog feces . . .)

New Rural Medical Center

- Operable windows in all patient rooms
- Water and energy conservation
- HVAC components optimized for energy and IAQ
Patient perception versus reality:

Even though the windows were open, building pressurization was adjusted so that all airflow was outward - however, the patient perceived a better environment and was much happier.

The FM commented “Who am I to explain they’re wrong when it was an obvious benefit to the patient”.

Natural Ventilation Considerations:

- Non-filtered air into the facility
- Loss of environmental control within the NV area
- ‘Downstream’ effects of NV space
- Misuse of the NV system through intent, misunderstanding or ‘system’ failure
- Increased staff/housekeeping impact
- Litigation
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Litigation:

My Lawyer Can Beat Up Your Lawyer

Design Attorney Comment:

“It would be wise to exclude ‘consideration of appropriateness’ from your scope.

The Owner should be required to decide this as they will also decide which patients are suited to a room with NV”.

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Ventilation and Energy:

Designers & Contractors

Infection Control

Know Your Information Source:

Google Hits:
• Hybrid Ventilation – 1,470,000
• NV for Infection Control in Healthcare Settings – 24,200
• NV in Healthcare Settings – 173,000
• Unnatural Ventilation – 12,600,000

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When Considering NV Information:

- Is the "study" published in a true peer-reviewed, scientific publication?
- Consider the methodology described in the study by the authors
- Designers typically review trade journals different from what IPs review-Design/Function vs Pt. Outcomes
- Context of the information
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