Rethinking ventilation: Design to protect patients and staff from airborne contamination

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Disclosures

Ms. Warye is a consultant to Avidicare AB.

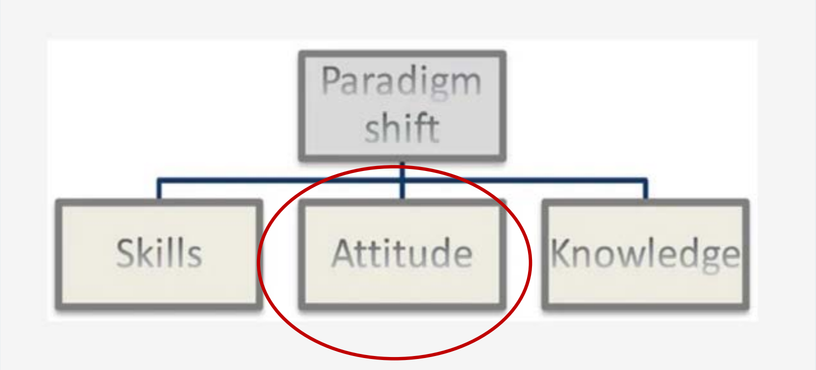
Learning Objectives

1) Compare ventilation concepts used in today's healthcare institutions.

2) Describe the evidence base and current guidance pertaining to ventilation systems.

3) Explain the science of Temperature-controlled Air Flow technology.

Paradigm shift?

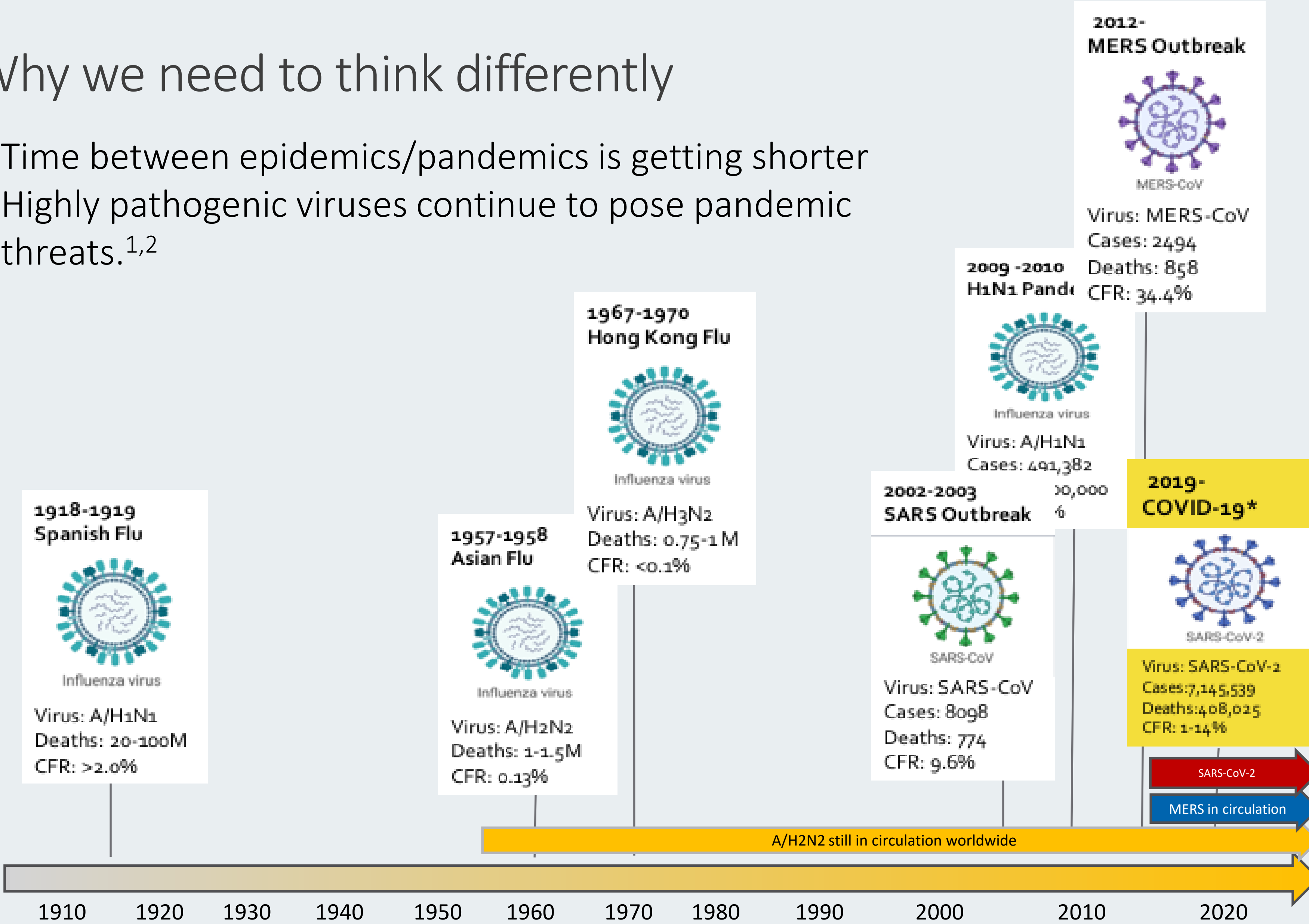


- Since the early 20th century, there has been resistance to accept that diseases transmit through the air.
- This orientation was particularly damaging during the COVID-19 pandemic.
- *"The very slow and haphazard acceptance of the evidence of airborne transmission of SARS-CoV-2 by major public health organizations contributed to a suboptimal control of the pandemic."*

Jimenez, JL, Marr, LC, Randall, K, et al. **What were the historical reasons for the resistance to recognizing airborne transmission during the COVID-19 pandemic?** *Indoor Air*. 2022; 32: e13070.

Why we need to think differently

- Time between epidemics/pandemics is getting shorter
- Highly pathogenic viruses continue to pose pandemic threats.[1,2]



1. Past pandemics. Centers for Disease Control and Prevention, Atlanta. https://www.cdc.gov/flu/pandemic-resources/basics/past-pandemics.html. Accessed April 5, 2021.
2. Amanpreet Behl, et al. Threat, challenges, and preparedness for future pandemics: A descriptive review of phylogenetic analysis based predictions, Infection, Genetics and Evolution, Vol. 98, 2022.

SARS-CoV-2/COVID 19: A continuing airborne threat

- Healthcare-associated transmission to patients:
  - 0.1% to 5% of total census during surges. [1]
- More than 3,600 US HCP deaths attributable to Covid-19.[2]
- The pattern of infection is unique and unpredictable.[3]

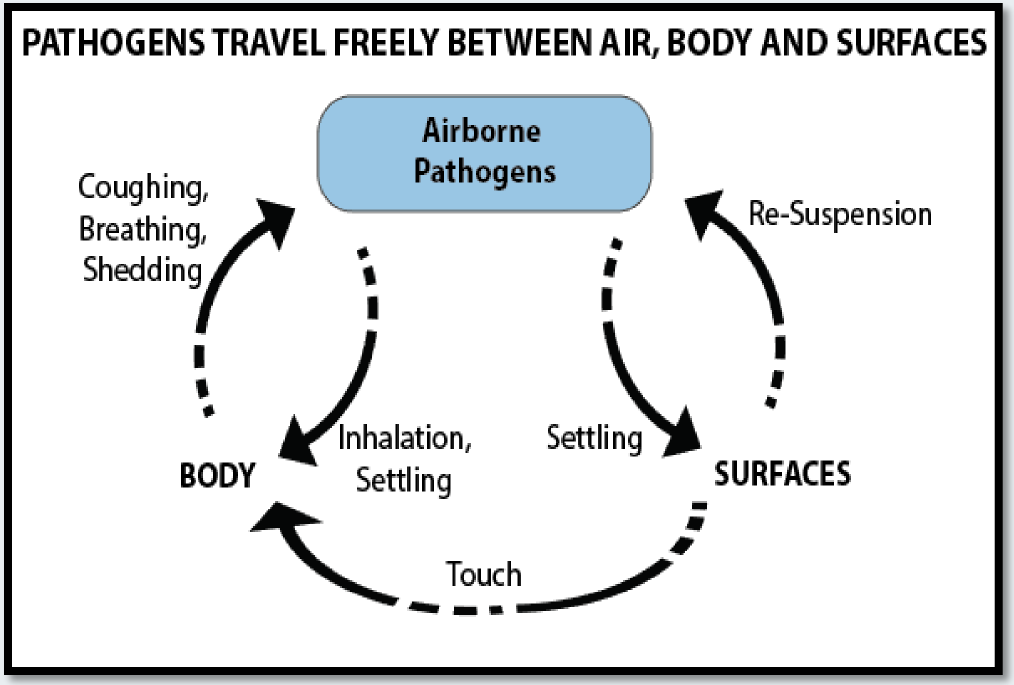
DEATHS BY OCCUPATION

Nurse	32%
Healthcare support	20%
Physician	17%
Medical first responder	7%
Admin/ Admin support	6%
Diagnosing clinician	4%
Healthcare technologist	4%
Community or social worker	3%
Cleaner	2%
Other	2%
Security personnel	1%
Culinary/food services	1%
Coroner	0%

Kaiser Health News/The Guardian: *Lost on the Frontlines*, March 22, 2022 [1]

1. Evans, Melanie. As Omicron Surged, Non-Covid-19 Patients Contracted Virus in Hospitals in Higher Numbers. Wall Street Journal. Feb. 18, 2022. Accessed Mar 28, 2022.
2. Jewett C, Lewis R, Bailey M. Lost on the Frontline. More Than 2,900 Health Care Workers Died This Year-And the Government Barely Kept Track. Kaiser Health News. Mar 28, 2022.
3. Nagler, Jacob. (2020). Unpredictable pandemic COVID-19 spreading behavior characteristics. Preprint. https://www.researchgate.net/publication/340666451_Unpredictable_pandemic_COVID-19_spreading_behavior_characteristics2.

Healthcare-associated Infections (HAIs) and the airborne route of transmission

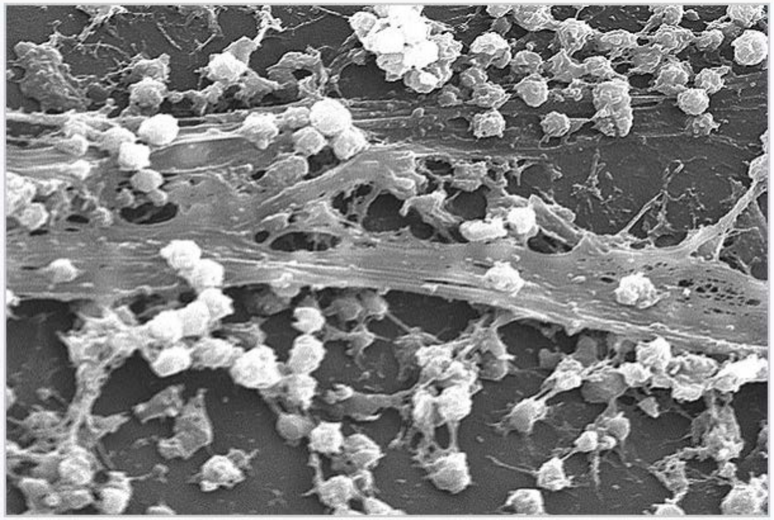


Approximately 1/3 of all HAIs involve airborne transmission at some point between the origin and the susceptible host.

Kowalski W, Air-Treatment Systems for Controlling Hospital Acquired Infections, HPAC Engineering, Jan 2007

Airborne Bioburden and Surgical Site Infection: 60 Years of Evidence

- A large, multi-center study *majority* of bacteria contaminating the surgical wound likely reached it by the airborne route. [1]
- 98% of bacteria in patients' wounds, after surgery in conventionally ventilated OR, came directly or indirectly from the air. [2]
- Airborne transmission accounted for 20%–24% of post-operative wound infections. [3]

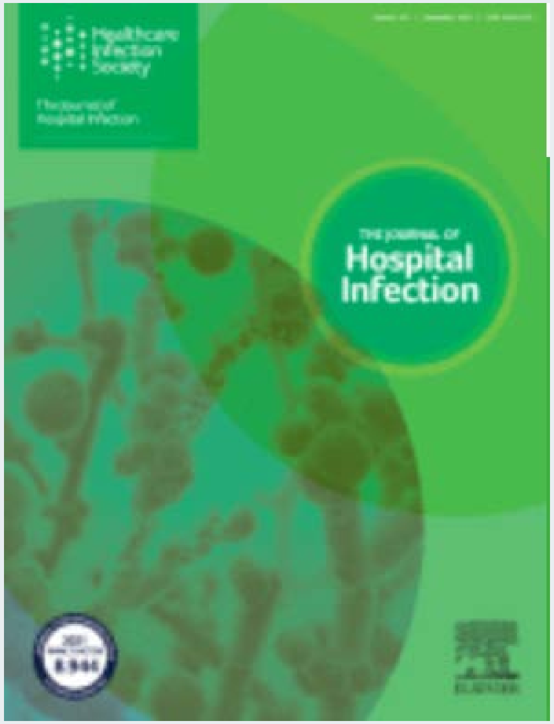


Staphylococcus aureus biofilm on an indwelling catheter

1. Charnley, J., Eftekhar, N. Postoperative infection in total prosthetic replacement arthroplasty of the hip-joint with special reference to the bacterial content of the air of the operating room. 1969. Br J Surg. 1969;56.
2. Lidwell OM, et al. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. *J Hosp Infect*. 1983;4(2):111–131.
3. Lidwell et al. Bacteria isolated from deep joint sepsis after operation for total hip or knee replacement and the sources of the infections with Staphylococcus aureus. *J Hosp Infect*. 1983;4(1):19–29.

Relationship of Colony Forming Units (CFU) of bacteria to PJI

- By reducing CFU level from 600 CFU/m^3 down to <10 CFU/m^3, reduced PJI from 8.5% to 0.7%. [1]
  - o 6000+ patients, *no antibiotics*
  - o Direct correlation between CFU levels and PJI rate
- Confirmed in a prospective, controlled, multicenter study [2]
  - o 8,000+ patients.
  - o 3 *independent* arms: Antibiotics, air cleanliness and clothing
  - o Rooms with over 50 CFU/m^3 were 2.6x more likely to have postoperative infection than those with 10-20 CFU.

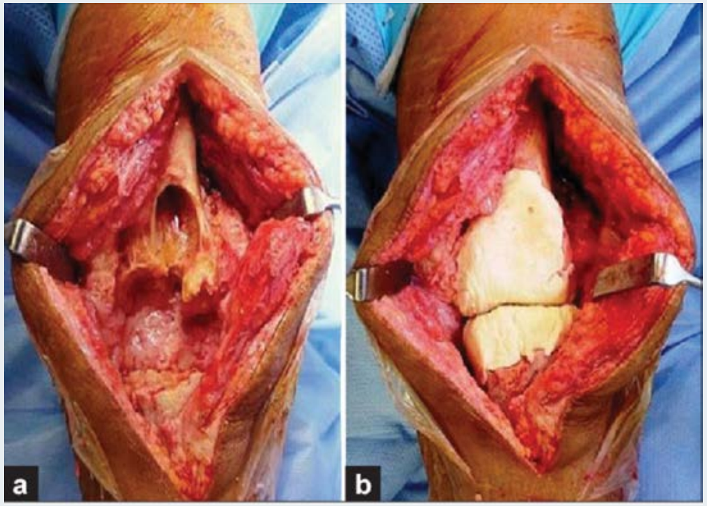


Ultraclean = <10CFU/m^3

1. Charnley, J., Eftekhar, N. Postoperative infection in total prosthetic replacement arthroplasty of the hip-joint with special reference to the bacterial content of the air of the operating room. 1969. Br J Surg. 1969;56.
2. Lidwell OM, et al. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. *J Hosp Infect*. 1983;4(2):111–131.

Factors contributing to increased airborne contamination risk:

- Number of personnel in the OR
- Movement of personnel and equipment
- Door openings and closings
- Length and type of procedure
- Exposure of sterilize instruments and implants: *The minimal infecting dose decreases 100,000 fold in the presence of a foreign body.* [1,2]

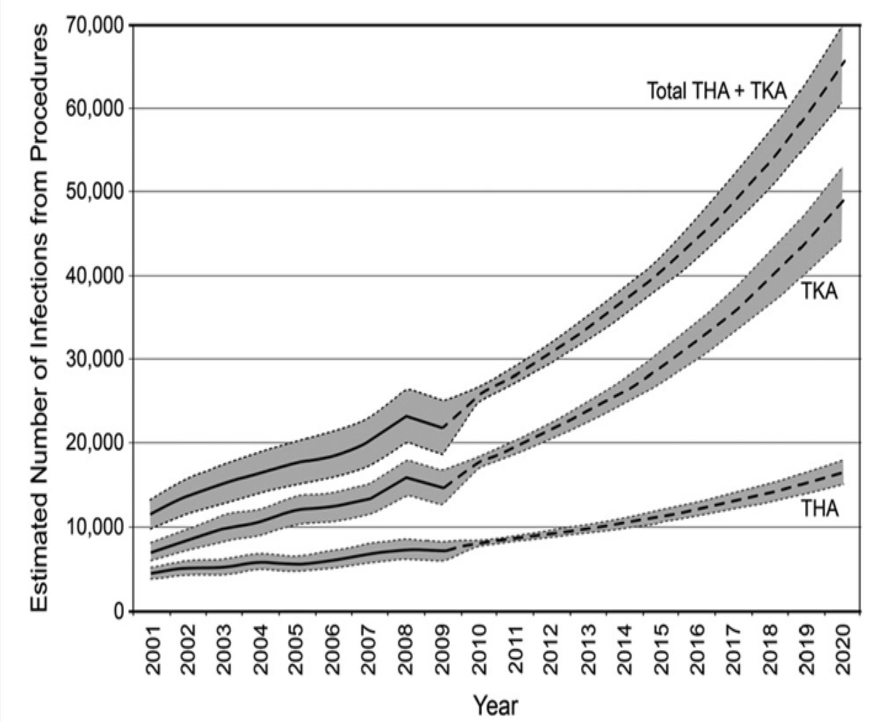


1. Edmiston CE. Prosthetic device infections in surgery. In: Nichols RL, Nyhus LM, editors. Update surgical sepsis. Philadelphia (PA): J.B. Lippincott Co.; 1993.pp. 196-222.
2. Parvisi et al, Environment of care: Is it time to reassess microbial contamination of the operating room air as a risk factor for surgical site infection in total joint arthroplasty? Am J Infect Cont, Vol 45, Issue 11, 1267 – 127.

Why Surgical Site Infection Matters

Clinical and economic consequences of Prosthetic Joint Infection (PJI)

- 2.18% of hip and knee implants become infected.[1]
- Rates of PJI rising, expected to increase to 6.5% and 6.8%, respectively, by 2030.[1]
- Cost - $100,000 direct expense, $474,000 cost to society.[2, 3]
- Mortality rate 2–7%. 5-year survival worse than many cancers.[4]
- Volume of hip/knee arthroplasties expected to grow exponentially.[5,6]
    - ➢ Revisions THA: 142% ⬆
    - ➢ Revisions TKA: 190% ⬆

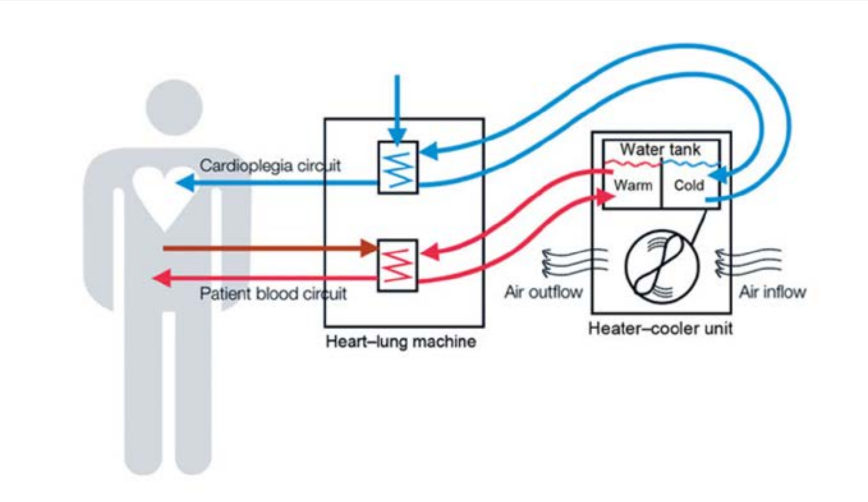


Historical number of infected THA/TKA procedures in the United States [1]

1. Kurtz SM, 2012. Economic burden of periprosthetic joint infection in the United States. J. Arthroplasty 27:61–65.
2.Parisi TJ, What is the Long-term Economic Societal Effect of Periprosthetic Infections After THA. Clin Orthop Relat Res. 2017 Apr 7
3.Tande AJ, Patel R. Prosthetic Joint Infection. Clinical Microbiology Reviews. 2014;27(2):302-345.
4. Jeppe, Chronic Periprosthetic Hip Joint Infection. A Retrospective, Observational Study on the Treatment Strategy and Prognosis in 130 Non-Selected Patients PLoS One. 2016; 11(9).
5. Edmiston Jr, et al. Impact of patient comorbidities on surgical site infection within 90 days of primary and revision joint (hip and knee) replacement. Am J Infect Cont. 2019; 47 (10): 1225-1232.
6. Projected volume of primary and revision total joint replacement in the U.S. 2030 to 2060, Abstract presented at 2018 AAOS Annual Meeting. https://aaos-annualmeeting-presskit.org/2018. Accessed Sept 30, 2020.

M. chimaera invasive infections linked to heater-cooler units

- *M. chimaera* in water tanks of heater-cooler units. [1,2]
- Droplets containing *M. chimaera* suspended in air, entered surgical cavity or contaminated implants (heart valves). Infections tracked to Stockert 3T units contaminated during manufacturing.[3]



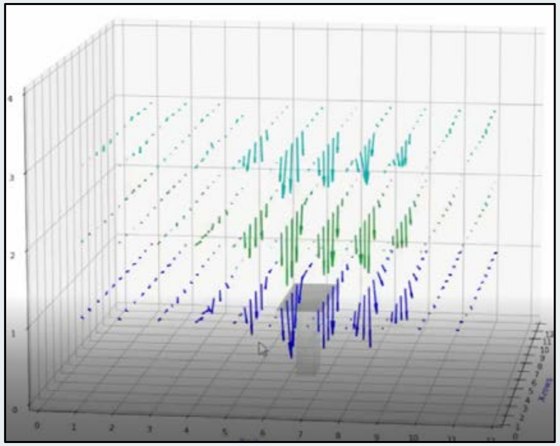
FDA Guidance for Hospitals [3]

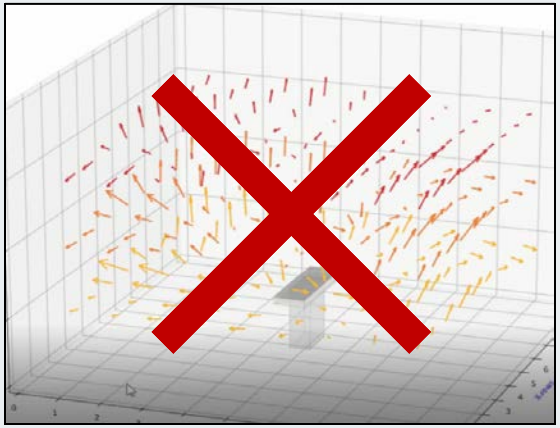
- Direct heater-cooler exhaust away from surgical field.
- Remove from service units showing discoloration in fluid lines/circuits, may indicate bacterial growth.

1. European Centre for Disease Prevention and Control (ECDC). Invasive cardiovascular infection by *Mycobacterium chimaera* potentially associated with heater-cooler units used during cardiac surgery. 2015. Stockholm: ECDC. 30 Apr 2015
2. Haller S, et al. Contamination during production of heater-cooler units by *Mycobacterium chimaera* potential cause for invasive cardiovascular infections: results of an outbreak investigation in Germany, April 2015 to February 2016. Euro Surveill. 2016;21(17):30215
3. FDA's Ongoing Evaluation and Continued Monitoring of Reports of Nontuberculous Mycobacteria Infections Associated with Water-Based Heater-Cooler Devices https://www.fda.gov/medical-devices/what-heater-cooler-device/fdas-ongoing-evaluation-and-continued-monitoring-reports-nontuberculous-mycobacteria-infections. Accessed Sept 26, 2022.

Core principles: Pressure, direction and velocity

- Positive pressure: Avoids flow of air from contaminated areas into adjacent areas (AIIR, OR)
- Direction: Consistent, perpendicular, downward flow (unidirectional) sweeps air down to exhaust vents
- Velocity: Air must be driven at speed that ensures:
  1) Uni-directionality,
  2) High enough to overcome, obstacles and heat convection from staff,
  3) Minimize turbulence.
- Temperature & Humidity: Can also influence transmission





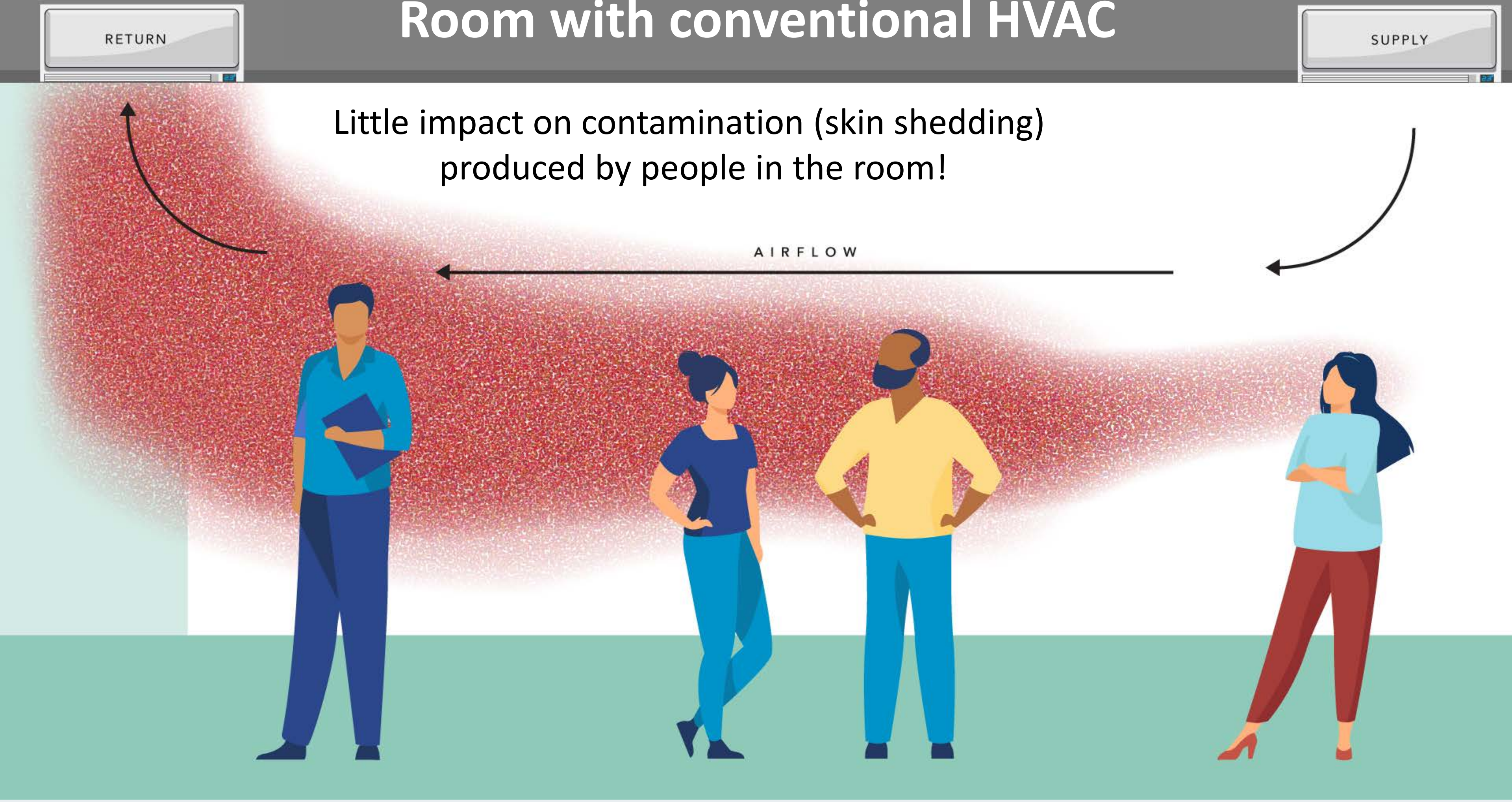
Even if operating correctly, will not tell you if you have a contaminated room.

Current standards/guidelines for management of airborne contamination date to the 1960s

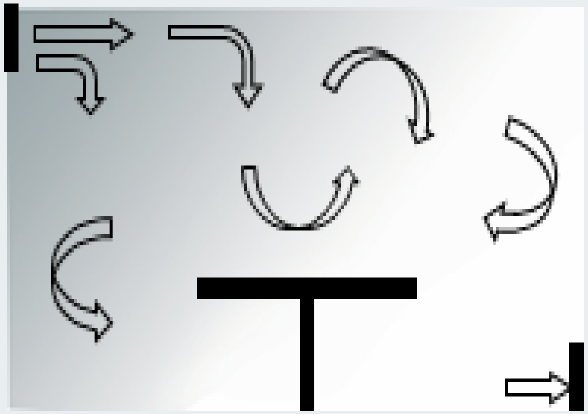
FGI & ASHRAE 170	CDC
• Air pressure relationships (positive/negative pressure based on risk and patient population, Airborne isolation rooms – negative pressure) • Air Exchange Rate (ACH) • Filtration • Temperature • Humidity	• Relationship to adjacent area (positive/negative pressure – AAIR/OR) • Minimum ACH based on area (6-20 ACH) • Exhausted or recirculated • Relative humidity

Room with conventional HVAC

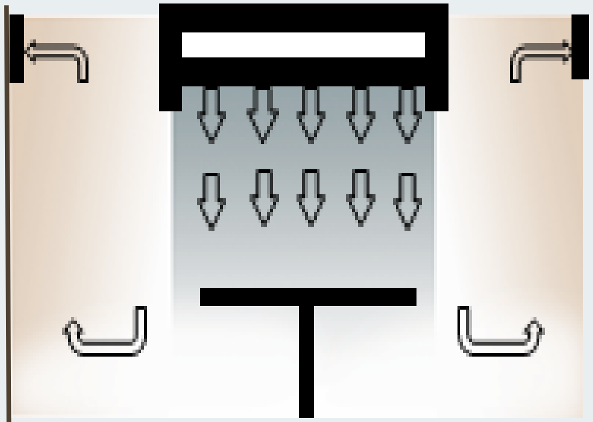
Little impact on contamination (skin shedding) produced by people in the room!



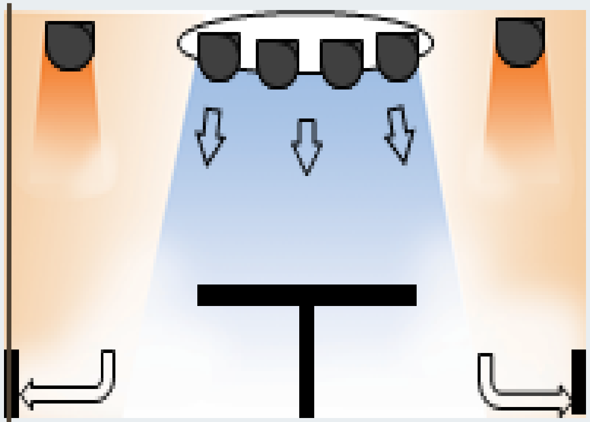
Three types of ventilation concepts in healthcare institutions



Turbulent mixed Airflow (TMA)



Uni-directional or Laminar Airflow (UDF/LAF)

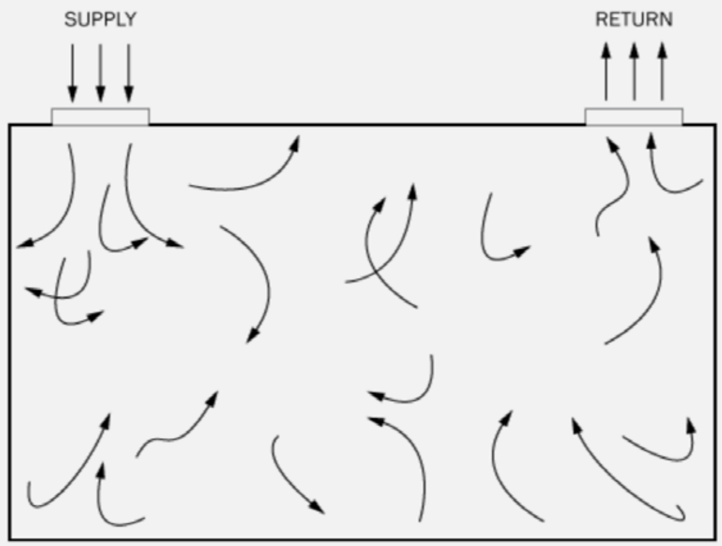


Temperature-controlled AirFlow (TcAF)

Turbulent Mixed Airflow (TMA)

- Based on dilution principle, filtered inlet air streamed into space provoking *turbulent* mixing of clean air with contaminated air.

- Key parameter: Number of ACH



Turbulent Flow, ArchToolBox

- Air moves in an unpredictable manner as dictated by pressure and temperature differences. Air molecules are constantly colliding creating contamination of the air as particles are transported around the room before leaving via the return grille.[1]

- Inefficient - scales linearly, to halve CFU-level, requires 2X airflow.

Laminar Flow vs. Turbulent Flow. ArchToolBox: https://www.archtoolbox.com/materialssystems/hvac/laminarflowvsturbulentflow.html. Accessed March 15, 2022

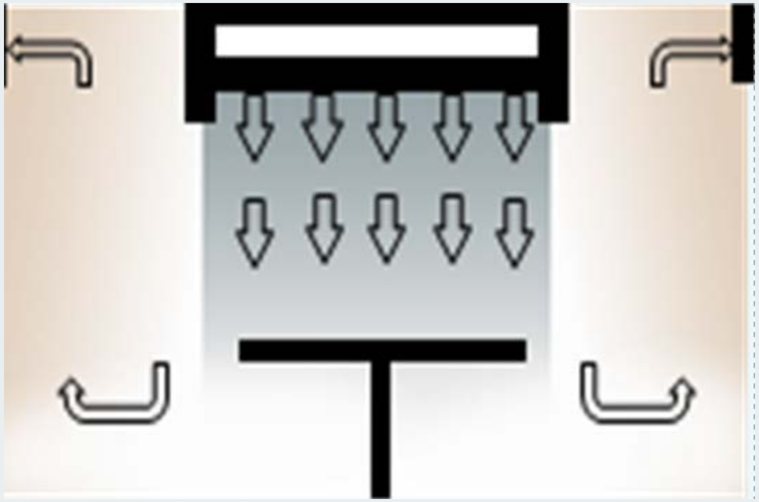
Turbulent Mixed Air Flow (TMA)

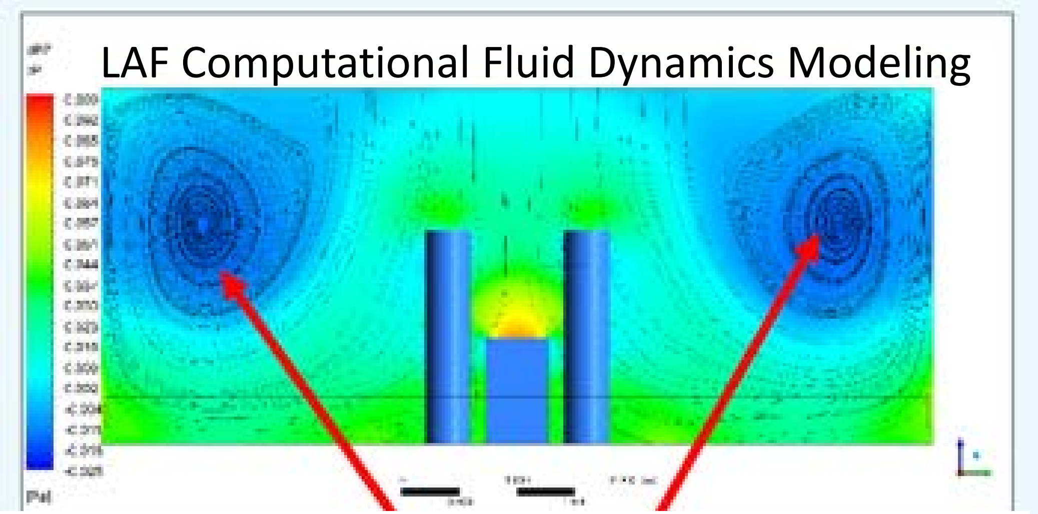
Where is TMA installed?


Code Black Movie

Everywhere except isolation, OR and specialized environments.

Current state of ventilation in US operating rooms
Limitations of conventional Laminar Air Flow ventilation





- Unidirectional over OT
- Velocity & ACH
- Very limited clean (<10/CFUm^3) zone
- Even at 60 ACH does *not* produce ultraclean throughout

Influence of different ventilation systems on device contamination [1]

- Mean values of airborne CFUs outside protected zone - *55-fold higher* than values inside.

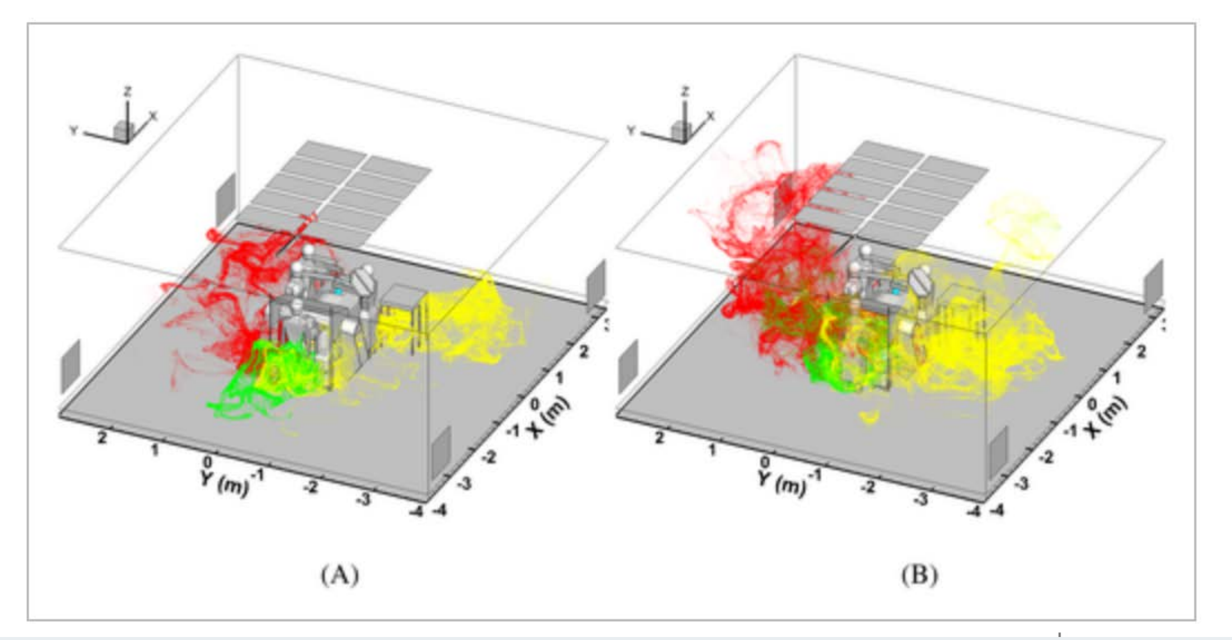
20

1-Benen T, Wille F, Clausdorff L. Influence of different ventilations systems upon the contamination of medical devices. *Hyg Med*. 2013; 38–41.

Limitations of conventional LAF ventilation

Effect of heated-air blanket on the dispersion of squames in an operating room.

Statistically significant number of particles lifted above the OT, some reaching height of surgeons. Particles rise due to buoyancy, get flushed down onto the table by the incoming ventilation air.

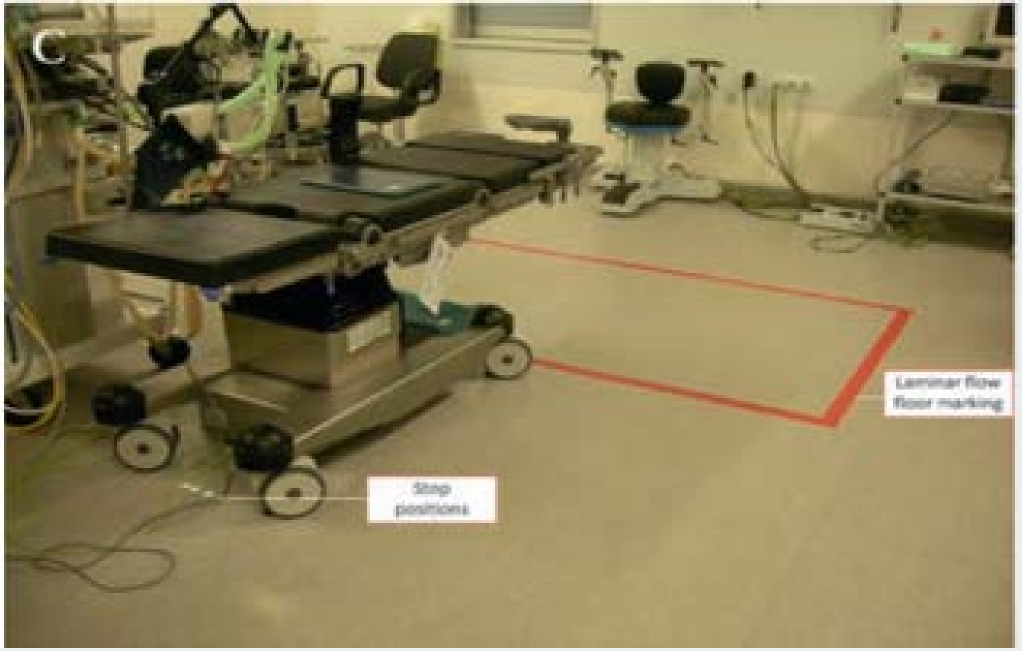


He X, Karra S, Pakseresht P, Apte SV, Elghobashi S. Effect of heated-air blanket on the dispersion of squames in an operating room. Int J Numer Method Biomed Eng. 2018 May;34(5):e2960.

Limitations of conventional LAF

Surgical instruments, implants and devices should be placed within the ultraclean zone. How often is this requirement met?

Safety by design: Effects of operating room floor marking on the position of surgical devices to promote clean air flow compliance and minimise infection risks.

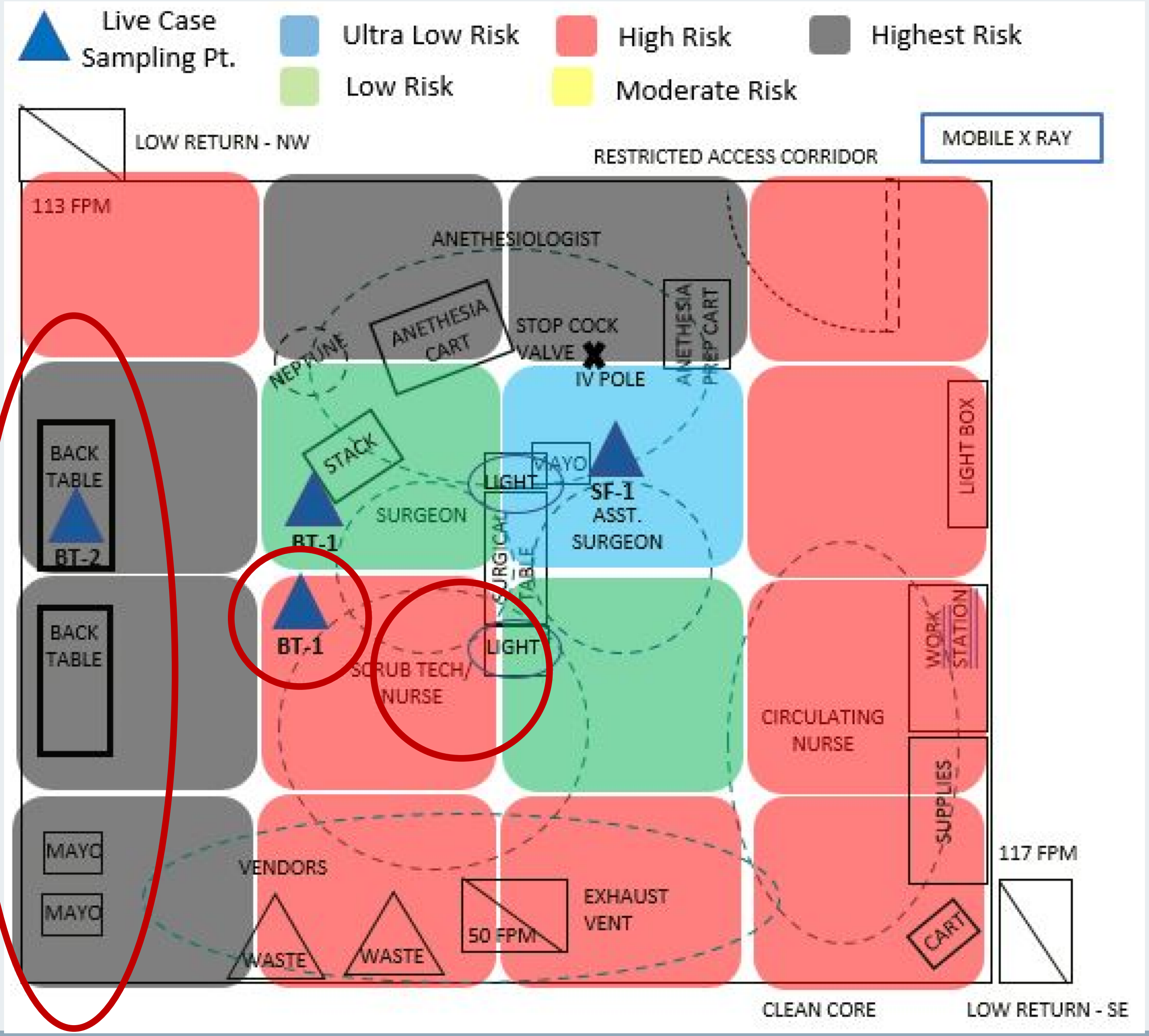


Prior to marking:

- Devices in the clean zone in only 6.1% of surgeries.
- After marking, devices in clean zone in 36-52% of cases.

de Korne DF, van Wijngaarden JDH, van Rooij J, et al. Safety by design: effects of operating room floor marking on the position of surgical devices to promote clean air flow compliance and minimise infection risks. *BMJ Quality & Safety.* 2012;21:746-752.

CFU heat map during live case with conventional ventilation

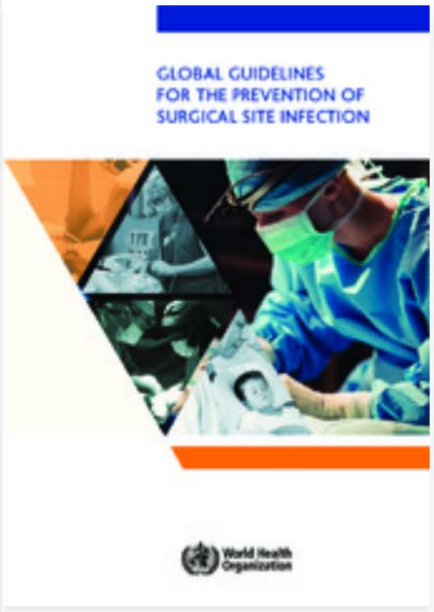


LAF no longer recommended for infection sensitive surgery

Based on a growing body of evidence, LAF is no longer recommended for infection sensitive surgery:[1-5]

- CDC: 2003, recommended LAF for joint surgery. 2017 Guideline for Prevention of SSI, back-tracked, LAF is an "*unresolved issue*." [6]

- WHO: 2017 conditional recommendation "*LAF ventilation should not be used to reduce the risk of SSI for patients undergoing total arthroplasty.*" [7]



1.Gastmeier P, et al. Influence of laminar airflow on prosthetic joint infections: a systematic review. J Hosp Infect. 2012;81(2):73–78.

2. Bischoff P, et al. Effect of laminar airflow ventilation on surgical site infections: a systematic review and meta-analysis. Lancet Infect Dis. 2017;17(5):553–561

3. Breier AC, et al. Laminar airflow ceiling size: no impact on infection rates following hip and knee prosthesis (published correction appears in Infect Control. Hosp Epidemiol.) 2012 May;33(5):538]. Infect Cont Hosp Epidemiol. 2011;32(11):1097–1102.

4. Singh S, et al. Does laminar airflow make a difference to the infection rates for lower limb arthroplasty: a study using the National Joint Registry and local surgical site infection data for two hospitals with and without laminar airflow [published correction appears in Eur J Orthop Surg Traumatol. 2017 Jul;27(5):711]. Eur J Orthop Surg Traumatol. 2017;27(2):261–265.

5. Hooper GJ, et al. Does the use of laminar flow and space suits reduce early deep infection after total hip and knee replacement? the ten-year results of the New Zealand Joint Registry. J Bone Joint Surg Br. 2011;93(1):85–90.

6.Berríos-Torres SI, Umscheid CA, Bratzler DW, et al. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. *JAMA Surg.* 2017;152(8):784–791. PJI Supplement.

7. Global guidelines on the prevention of surgical site infection. World Health Organization. 2016. http://www.who.int Accessed 4/9/2020.

PJI Global Consensus Group

"LAF may no longer be recommended."

"There are several explanations for the wide variability of reported results with LAF.

First, the parallel airflow of the ***LAF system can be easily disrupted*** *by objects or personnel around the surgical field.*

Second, the association between air contamination and the deep infection rate is logarithmic. It is necessary to achieve ***a 10-fold reduction in air contamination to halve the infection rate.***

Third, ***LAF systems fail to address the environment outside of the immediate LAF zone****, leaving scant room for implant and instrument trays and tables. Laminar airflow systems may be associated with the contamination of these areas by blowing bacteria off personnel and the floor onto instrumentation and other personnel."*

Wang Q, Xu C, Goswami K, Tan TL, Parvizi J. Association of laminar airflow during primary total joint arthroplasty with periprosthetic joint infection. *JAMA Netw Open*. 2020;3(10):


TOWARDS ZERO INFECTIONS
A unique system for ultra-clean air in operating theaters

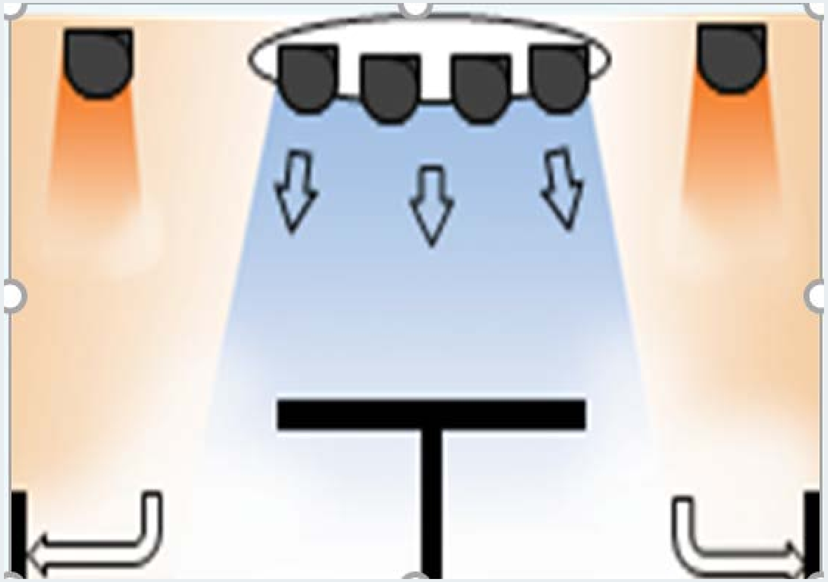
Temperature-controlled Air Flow Technology (TcAF)

- Designed for the modern operating room:
  - o Achieve ultraclean (<10 CFU/m^3) conditions throughout the entire space
  - o Improve comfort
  - o Optimize energy use

- 300 installations in Europe
- Validated in 900+ microbial measurements during *live* surgery
- Meets (exceeds) ASHRAE 170
- Approved by CA and NY for installation
- First U.S. installation: University of Rochester

The Science of Temperature-controlled Air Flow (TcAF) [1,2]

- HEPA filtered air dispersed from air showers at 1.5C cooler than ambient room temperature.
- Temperature differential creates a gravity-driven down-flow, consistent direction throughout the space.
- Fall speed of the air (>0.25 m/s), high enough to counteract heat convention from staff, lamps and equipment.



Temperature /humidity:
Set at any level to ensure patient safety, staff comfort.

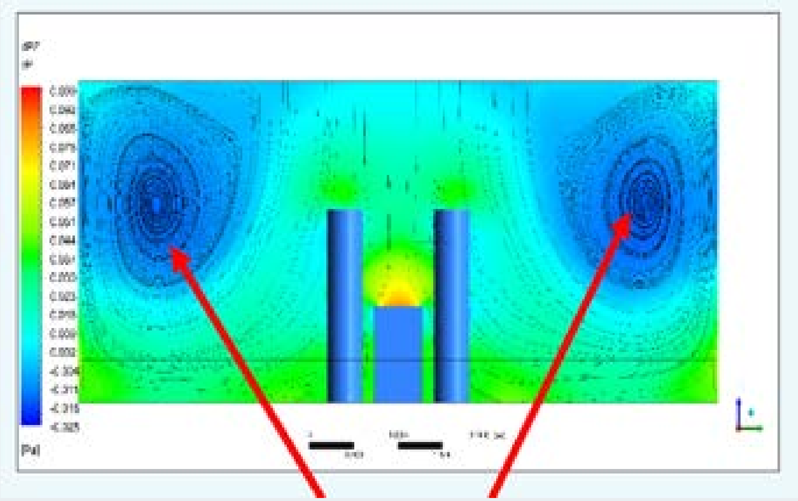
- Air supplied in the periphery pushes air downward to prevent stagnation zones.

1.Wang C. Ventilation Performance in Operating Rooms: A Numerical Assessment. Doctoral Thesis. KTH and the Built Environment. Stockholm, Sweden. 2019.
2. Alsved M, et al. Temperature-controlled airflow ventilation in operating rooms compared with laminar airflow and turbulent mixed airflow. *J Hosp Infect*. 2018;98(2):181-190.

How conventional Laminar Air Flow (LAF) and Temperature-controlled Air Flow (TcAF) compare

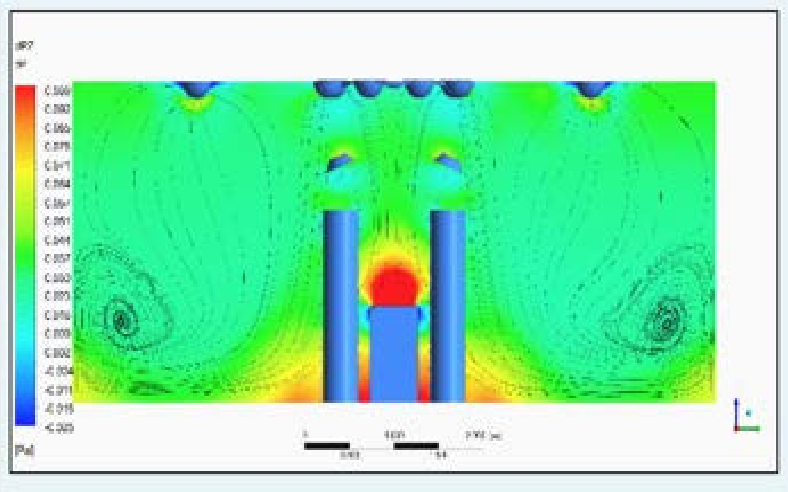
Computational Fluid Dynamics (CFD) Simulations
Royal Institute of Technology, Stockholm, Sweden

UDI/Laminar Air Flow



- Air direction & velocity
- Challenged by vortices
- Ultraclean in surgical field only

TcAF



- Temperature gradient & gravity
- Able to maintain ultraclean in entire space

Wang C. Ventilation Performance in Operating Rooms: A Numerical Assessment. Doctoral Thesis. KTH and the Built Environment. Stockholm, Sweden. 2019.

Conventional Laminar Air Flow

Obstacles disrupt airflow

Unable to protect periphery

Temperature-controlled Air Flow

Navigates obstacles, maintains downward airflow throughout the room, including the periphery

Stress Testing TcAF: Independent validation

Leeuwarden Medical Center

- 640 bed teaching hospital, specialization in cardiovascular and neurosurgery
- Building project: 12 new ORs, with 2 hybrid rooms

Independent validation

- Measure performance against new Dutch standard for OR air quality
  - Requires ≤10 CFU/m^3 for "infection-prone surgery," mean value of ≤5 CFU/m^3
- To "test the limits" of TcAF, gauge robustness

Maximuse
Minor plus est

Stress-testing TcAF: Results

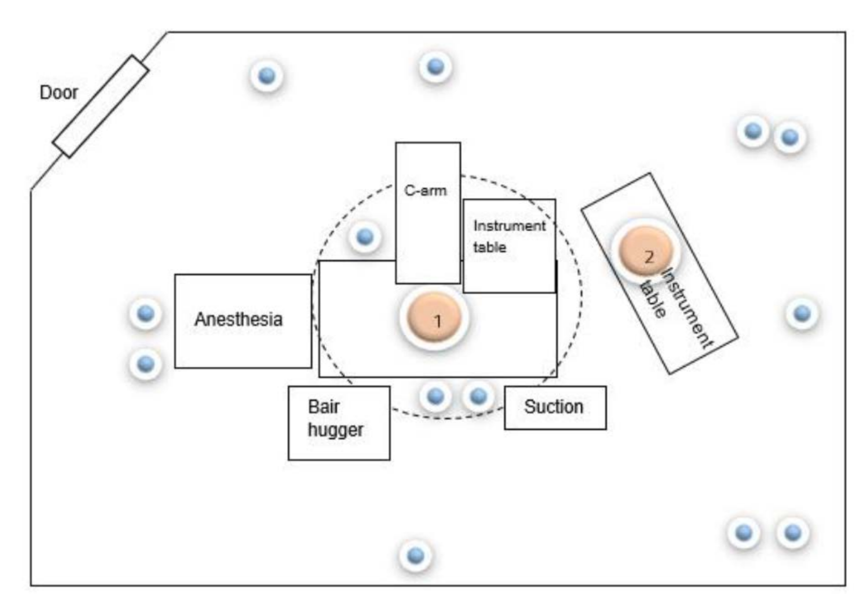


Fig. 1. Upper leg trauma procedure. Location of staff, equipment and placement of agar plates.

Upper Leg Trauma Procedure

- 13 surgical personnel
- 2 instrument tables, 2 lamps
- Anesthesia machine, suction unit, Bair Hugger
- Equipment switched on, maximum heat loads
- C-arm brought into OR, drawn up
- Considerable movement "*not quiet*"
- 36 door openings
- Duration: 50 minutes

Results

- Average CFUs wound: 0.75
- Average CFUs instr. table: 7.0

"This procedure… was an extreme example in which maximum efforts were made to provoke the system." R. Noor MSc., CTO, Maximuse B.V.

TcAF implementation: Statistically significant reduction in SSI

Clinical validation and efficacy of a temperature-controlled ventilation system (TcAF) in the OR to reduce surgical site infections

Objective

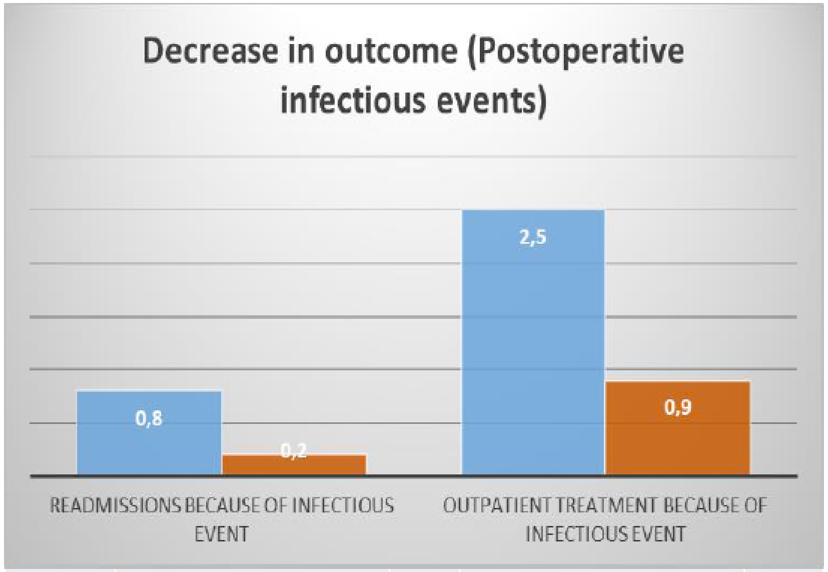
Evaluate efficacy of TcAF under routine conditions, assess impact on rates of Prosthetic Joint Infection (PJI).

Methods

Retrospective analysis of 1,000 consecutive cases of total joint arthroplasty before and 1,000 consecutive cases after installation of TcAF.

Results

Surgical site infection rate decreased from 3.1 to 1% . OR - 0.3259 (95%CI, 0.16-0.65, $p<0.05$).



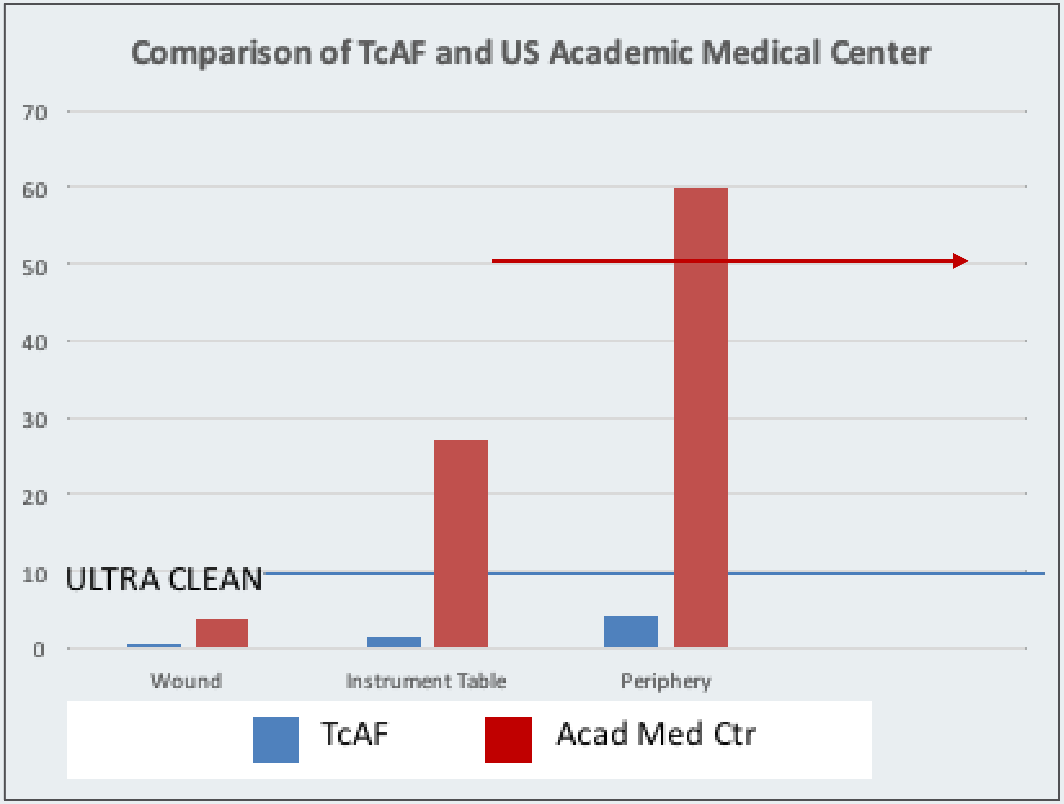
test group (n)	readmissions because of infectious event	in percent	outpatient treatment because of infectious event	in percent
1000	2	0,2	9	0,9
control group (n)	renewed hospital stay	in percent	ambulat treatment	in percent
1000	8	0,8	25	2,5

Decrease in PJI before (blue) and after (orange) TcAF

Vasiuk S, et al. Clinical validation and efficacy of a temperature-controlled ventilation system (TcAF) in the OR to reduce surgical site infections. Curr Dir in Biomed Eng. 2019:5 (1):1-3.

Comparison of TcAF and U.S. Academic Medical Center

Airborne contamination 10x higher than TcAF

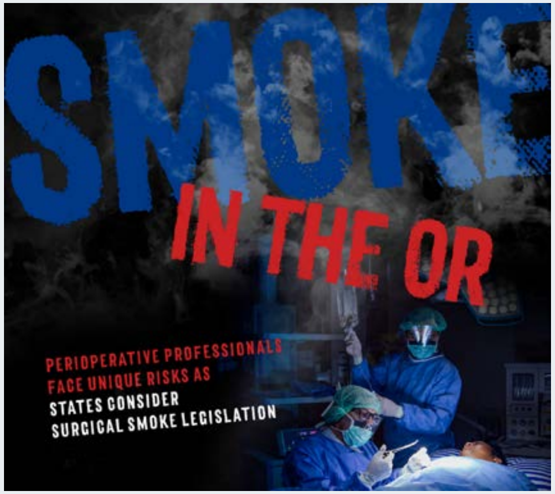


> 50 CFU/m^3

2.6X more likely to have post-operative infection

- TcAF: 700 measurement events, live surgery, 30 procedure types, 2-11 personnel, different clothing
- Academic Medical Center: Live neurosurgery, multiple operating rooms

Ventilation and Surgical Personnel



OR Today Magazine, Apr 1, 2020

Airborne hazards

- Surgical smoke has been shown to cause adverse health outcomes: viral/bacterial infection, cancer. [1-4]
- Adverse heath effects from exposure to gases, inhalation of disinfectants.
- Aerosols shown to spread from 5-9 m during orthopedic surgery. [5]

Noise

- Noise is a known patient safety risk. Background noise created by high-speed ventilation, a source of discomfort and distraction.[6]

Thermal conditions

- Ventilation as a source of thermal discomfort and distraction.[7,8]

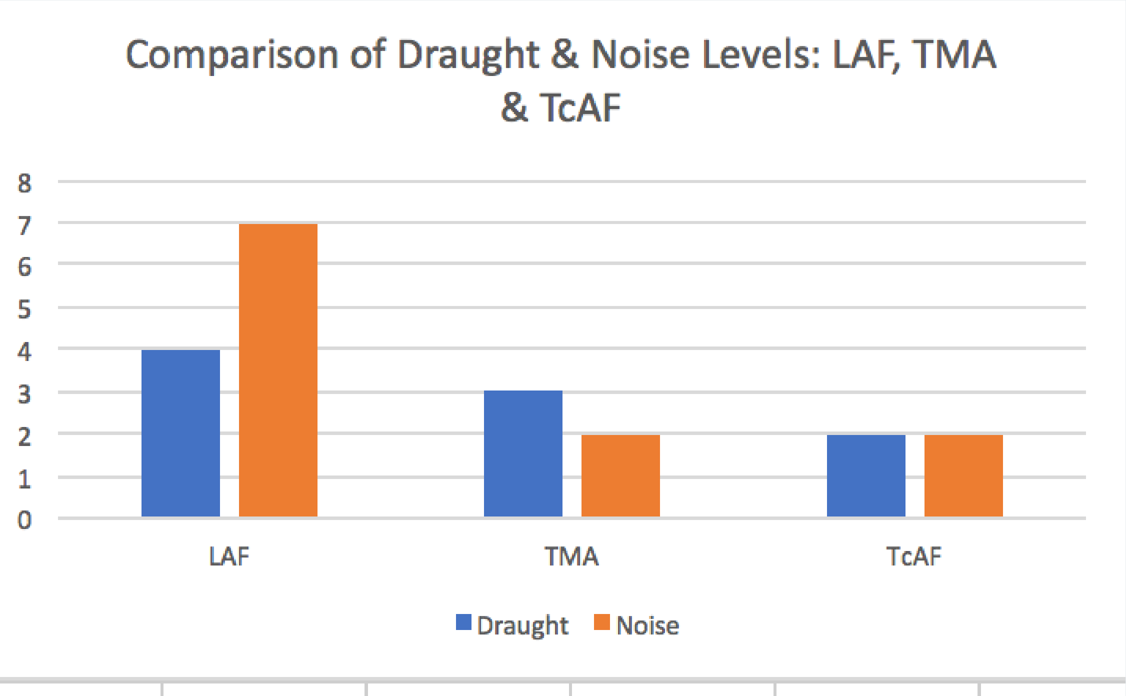
1. M. Ogg. Surgical Smoke Inhalation: Dangerous Consequences for the Surgical Team. NIOSH/CDC Science Blog. June 18, 2020. https://blogs.cdc.gov/niosh-science-blog/2020/06/18/surgical-smoke/ Accessed 4/4/20.
2. Capizzi PJ, et al. Microbiologic activity in laser resurfacing plume and debris. Lasers Surg Med. 1998;23(3):172-174.
3. Baggish MS. et al. Presence of human immunodeficiency virus DNA in laser smoke. *Lasers Surg Med.* 1991;11:197-203
4. Kwak HD. et al. Detecting hepatitis B virus in surgical smoke emitted during laparoscopic surgery. *Occup Environ Med.* 2016;73:857-63
5. Nogler M, et al. Aerosols produced by high-speed cutters in cervical spine surgery: extent of environmental contamination. Eur Spine J. 2001;10(4).
6. Keller S, et al. Noise in the operating room distracts members of the surgical team. An observational study. World J Surg. 2018;42(12):3880-388
7. Karahan A. et al. Factors Affecting the Thermal Comfort of Perioperative Personnel in the OR. AORN J 2020(111);3.
8. Hakim M, et al. The Effect of Operating Room Temperature on the Performance of Clinical and Cognitive Tasks. *Pediatr Qual Saf*. 2018;3(2).

Comfort of Surgical Personnel
Working environment survey of LAF, TMA and TcAF

Q1: Do you perceive cold draught from the ventilation in the room?
Q2: What is your perception of noise from the ventilation system?

Very loud/
Uncomfortable

Very quiet/
Comfortable

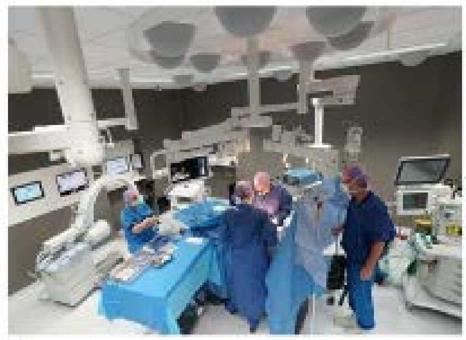


Adapted from Alsved M, et al. Temperature-controlled airflow ventilation in operating rooms compared with laminar airflow and turbulent mixed airflow. J Hosp Infect. 2018 Feb;98(2):181-190.

TcAF in the Hybrid OR

- Smaller footprint facilitates placement of equipment
- More effectively navigates obstacles
- Ultraclean (<10CFU/m^3) throughout room supports Hybrid OR workflow, safety of patient through various movements.

Flexible configuration enables installation in *any location where minimizing airborne contamination is a priority*



Operating Room Configurations

Hybrid OR

Surgical Prep

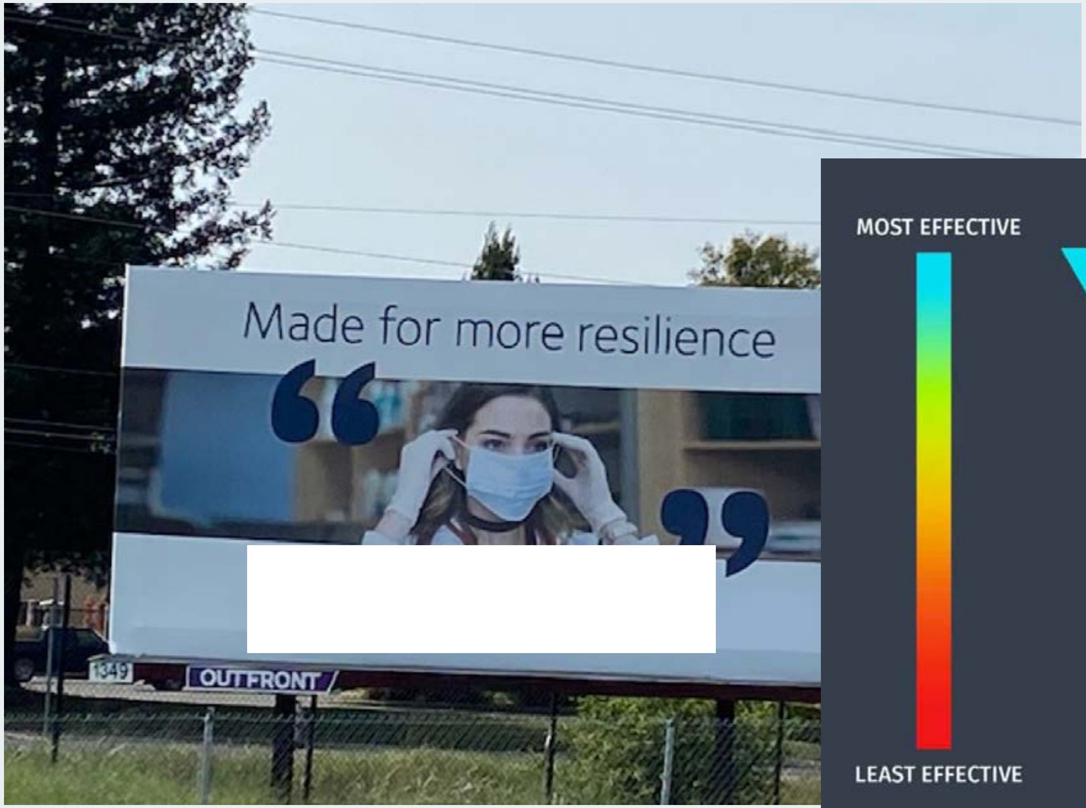
Central Sterile Supply

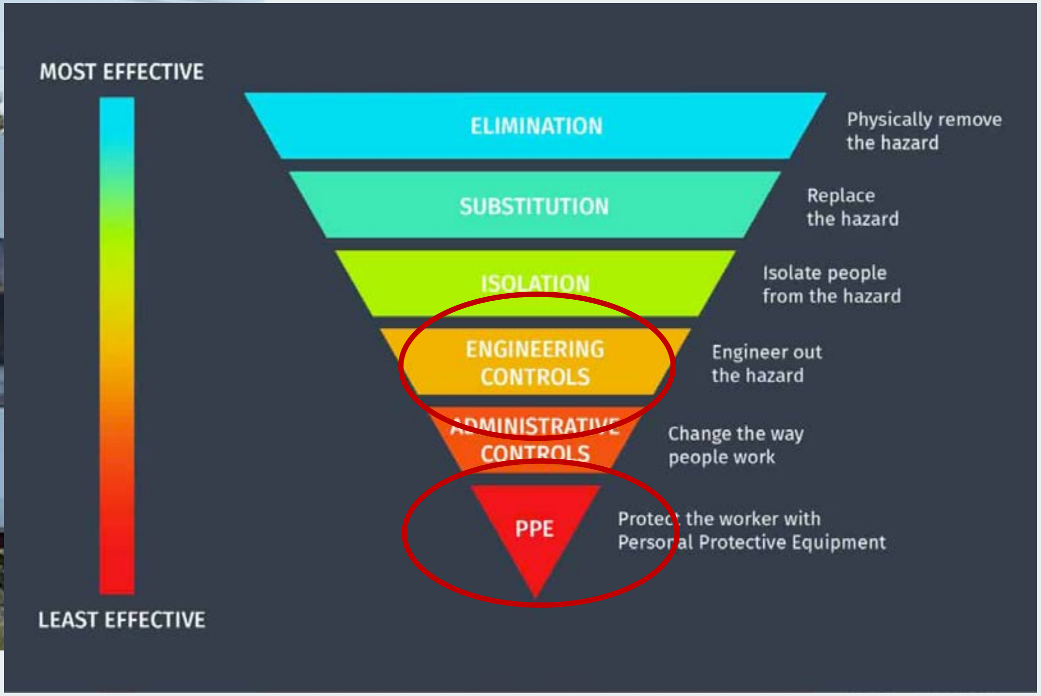
Radiology

Pharmaceutical Laboratory

Countries with limitations on airborne contamination

Country	CFU Limits	ISO Clean Room	Document	Comments
Australia	Class 6, ISO 14644-1	ISO Class 6	ANZ/NZS ISO 14644-1	
Sweden	≤10 CFU/m^3 for procedures utilizing implants		Standards Institute Teknisk Specification SIS-TS 39	
Netherlands	≤10 CFU/m^3 for procedures utilizing implants			Mean value of ≤5 CFU/m3 targeted, to ensure ≤10 CFU/m3
Germany	Recommended <4 CFU/m^3, limit of <10 CFU/m^3		Standard DIN 1946-4-2008 Standard VD 2167	3 classes of rooms
Switzerland	<10, 50 & 200/CFU/m^3 depending on risk			3 classes of rooms by risk
France	≤20 CFU/m^3		NF S 90-351	2 classes of rooms
UK	≤35CFU/m^3 rooms at rest, <10 for ultraclean rooms, not to exceed 180CFU/m^3 for more than 5 min		British Standard 52-95-1	
Wales	<10 CFU/m^3		HTM 03-1	
Italy	<180 CFU/m^3		ISPESL 2010	
Russia	<5 CFU/m^1 at OT, <20 CFU/m^1 periphery		GOST R 52539	5 classes of rooms including CFU limitations in ED
South Africa		Class 5, ISO 14644-1	Design of mechanical installations (Core Standards 2006)	





NIOSH *Prevention through Design:* Control risks at the source, as early as possible in the lifecycle of design, redesign or retrofit.

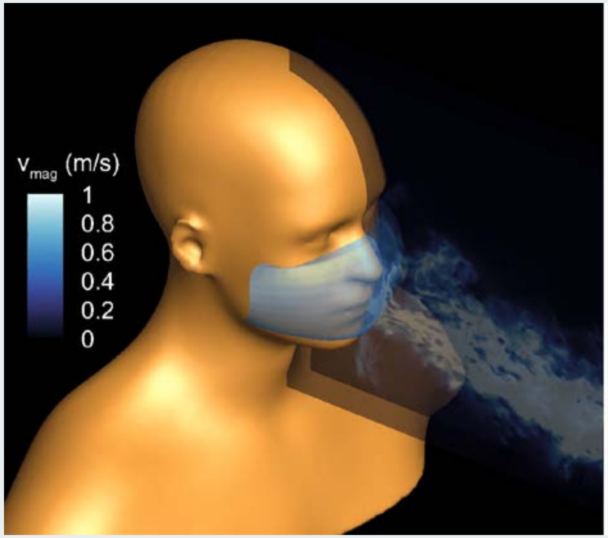
NIOSH Hierarchy of Controls. https://www.cdc.gov/niosh/topics/hierarchy/default.html.

Design for yesterday? Or design for tomorrow?

Opportunity to rethink exposure to airborne contamination.

The next pandemic:

Over 14 known and emerging infectious diseases with epidemic/pandemic potential. [1]



The benefits of better ventilation could be far reaching:

- More effectively protect patients and staff from airborne threats,
- Reduce airborne HAIs/SSIs/MDROs/slow antimicrobial resistance,
- Increase *resilience* against the next pandemic.

1. World Health Organization. https://openwho.org/courses/pandemic-epidemic-diseases

What we covered

- ✓ The contribution of airborne contamination to SSI/PJI.
- ✓ Factors that contribute to airborne contamination in the operating room.
- ✓ How the three primary ventilation concepts used in healthcare institutions differ in their impact on the control of airborne contamination.
- ✓ The limitations of conventional ventilation in protecting against SSI/PJI.
- ✓ The science of Temperature-controlled Air Flow technology.

QUESTIONS

Infection Prevention Partners
STRATEGIC INITIATIVES WORLDWIDE

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