

DEFICIENT INDOOR AIR QUALITY: A SERIOUS THREAT TO HOSPITALS

Enhanced indoor air quality achieved by energy recovery ventilation improves occupant health, cognitive function, productivity and wellbeing

By Nick Agopian



Deficient IAQ threatens the health, cognitive function, productivity and wellbeing of hospital occupants

Hospital buildings are extremely vulnerable to deficient indoor air quality (IAQ). This is especially true with improved air-sealing methodologies on the rise that not only trap in air but also numerous internally generated contaminants.

The best way to enhance IAQ is with increased ventilation, but conventional HVAC systems waste energy. So how can IAQ be enhanced energy-efficiently, cost-effectively and sustainably in order to support the health and wellbeing of hospital occupants? The answer is through increased and balanced ventilation via energy recovery ventilators (ERVs). Let's take a look at why this is the case.

THE CHALLENGE

Deficient IAQ Threatens Hospital Buildings

With [buildings becoming increasingly air-sealed](#), a consequence is a rise in deficient IAQ, which is a serious—yet often unnoticed—threat to occupant

health, cognitive function, productivity and general wellbeing. Deficient IAQ is especially concerning because people are indoors about 90% of the time (the elderly 95%). Moreover, the Environmental Protection Agency (EPA) found that indoor air may be two to five times, and occasionally greater than 100 times, more polluted than outdoor air.¹

Hospitals are at particular risk of experiencing deficient IAQ due to their high-occupant densities, constant maintenance needs and budget constraints. In fact, there are so many indoor air contaminants in hospitals that the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) stated in its HVAC Design Manual for Hospitals and Clinics that, "Healthcare facilities are environments of controlled hazards."²

After suffering through the COVID-19 pandemic, the perilous effects of poor-quality indoor air are even more acute. Indeed, airborne viruses can cause real harm to indoor occupants if not cleared out with sufficient ventilation. This situation is particularly important in hospitals where rooms house higher proportional amounts of occupants compared to other structures.

¹ All EPA facts from this paragraph are sourced from: "Why Indoor Air Quality is Important to Schools," EPA, <http://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools>.

² Dan Pollock, "Surgical Suite: Creating the Optimal Environment," Trane, October 2009, <https://www.paperzz.com/doc/6962183/surgical-suite--creating-the-optimal-environment>.

Deficient IAQ has Many Adverse Effects on Hospital Occupants

Deficient IAQ has numerous adverse effects on the health, cognitive function, productivity and general wellbeing of all indoor occupants. Specific to hospitals, these include:

Adverse Effects of Deficient IAQ on Hospital Occupants	
Increased infections	Healthcare-associated infections (HAIs) are aggravated by deficient IAQ because many infection threats in hospitals are airborne. ³ According to the Centers for Disease Control and Prevention (CDC), each day, approximately one in 31 U.S. patients and 1 in 43 nursing home residents' contracts at least one infection. While much progress has been made, more needs to be done to prevent HAIs in a variety of settings. ⁴ Furthermore, up to one-third of all HAIs are caused by airborne contaminants, such as inorganic particles, mold and bacteria. This means that poorly ventilated hospitals suffer from greater instances of airborne infections due to poor-quality indoor air. ⁵
Transmitted diseases via airborne viruses	When patients are sick, they can easily spread diseases and viruses through the air via skin microbiota and coughing, thus contributing to deficient IAQ. ⁶ The COVID-19 pandemic demonstrated the transmission risk posed by airborne viruses. Therefore, it's essential for a ventilation system to remove these diseases and viruses from the indoor air.
Aggravated patient harm	Patients are already in a vulnerable state due to their weakened condition. Thus, patients are apt to suffer aggravated harm due to deficient IAQ. This is especially true for patients with compromised immune systems who can be exposed to contaminants if a hospital is poorly ventilated. Moreover, a multi-hospital study found that high levels of indoor air contaminants negatively impact patient health. ⁷
Compromised surgeries	Patients undergoing surgeries are particularly vulnerable to deficient IAQ because sensitive tissues and organs are often exposed to the air. Therefore, such patients can be negatively impacted by airborne bacteria, viruses and other microbes. ⁸
Cognitive impairment of staff	Deficient IAQ causes cognitive impairment, as shown in studies by NASA, the Harvard School of Public Health and the Lawrence Berkeley National Laboratory in which CO2 negatively impacted thinking and decision-making. NASA even found instances of cognitive impairment in astronauts at much lower CO2 levels than expected. ⁹ This means that all hospital staff are at risk of their cognitive function being seriously impaired, which can severely impact patient care.
Productivity decline for staff	Deficient IAQ causes serious losses in productivity for businesses of every type, including hospitals, due to worker sickness and absenteeism. In fact, total costs to the U.S. economy from poor IAQ range as high as \$168 billion per year. ¹⁰
Increased financial costs	According to the CDC, the overall annual direct medical costs of HAIs to U.S. hospitals can be up to \$45 billion. ¹¹ A large amount of these financial costs can be attributed to increased instances of infections due to deficient IAQ.

*“Up to one-third of all HAIs are **caused by airborne contaminants**, such as inorganic particles, mold and bacteria. This means that **poorly ventilated hospitals suffer from greater instances of airborne infections due to poor-quality indoor air.**”*

-Trane

³ Laura Rygielski Preston, “Breath of fresh air: Indoor air quality critical to effective infection control,” Medical Construction & Design, January/February 2011, https://www.trane.com/content/dam/Trane/Commercial/global/markets/healthcare/FdMCD0111_52-54-IF-IAQ.PDF.

⁴ “2021 National and State Healthcare-Associated Infections Progress Report,” Centers for Disease Control and Prevention (CDC), 2021, <https://www.cdc.gov/hai/pdfs/progress-report/2021-Progress-Report-Executive-Summary-H.pdf>.

⁵ Dan Pollock, “Surgical Suite: Creating the Optimal Environment,” Trane, October 2009, <https://www.paperzz.com/doc/6962183/surgical-suite--creating-the-optimal-environment>.

⁶ Christopher J. Stipe, “Indoor air quality in hospitals,” Consulting-Specifying Engineer, July 14, 2015, <https://www.csemag.com/articles/indoor-air-quality-in-hospitals/>.

⁷ Hadir Gawili et al., “Indoor Air Quality in Benghazi’s Hospitals and Its Impact among Patients,” Asian Journal of Medicine and Health, February 15, 2021, <https://journalajmah.com/index.php/AJMAH/article/view/489>.

⁸ Andrew J. Streifel, “A Guide to Best Practices in Hospital IAQ,” ACHR News, November 19, 2007, <http://www.achrnews.com/articles/105354-a-guide-to-best-practices-in-hospital-iaq>.

⁹ Joe Romm, “Exclusive: Elevated CO2 Levels Directly Affect Human Cognition, New Harvard Study Shows,” Climate Progress, October 26, 2015, <https://archive.thinkprogress.org/exclusive-elevated-co2-levels-directly-affect-human-cognition-new-harvard-study-shows-2748e7378941/>.

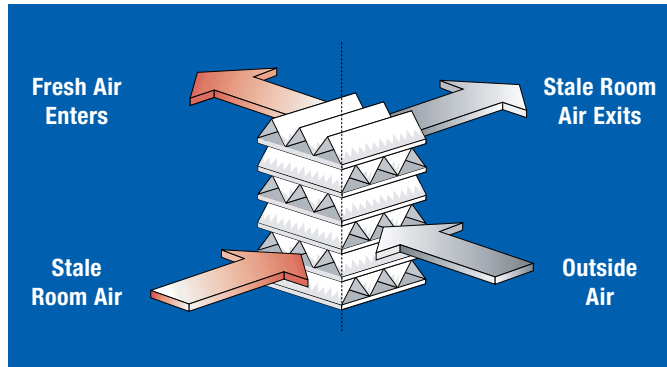
¹⁰ Ljubica Stefanovska Ceravolo, Dejan Mirakovsk, Radmil Polenakovik, Emilija Ristova-Drewanz, Zlatko Sovreski, “Indoor air quality (IAQ) as a parameter affecting workplace productivity,” ResearchGate, September 2012, https://www.researchgate.net/publication/232612934_Indoor_air_quality_IAQ_as_a_parameter_affecting_workplace_productivity.

¹¹ R. Douglas Scott II, “The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention,” Centers for Disease Control and Prevention (CDC), March 2009, http://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf.

THE SOLUTION

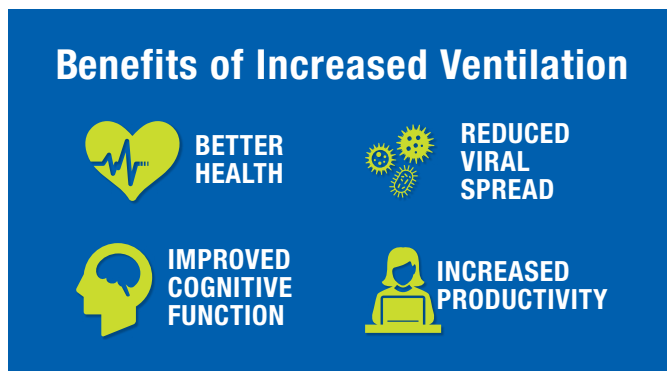
Energy Recovery Ventilation is the Best Choice for Enhancing IAQ

What's the best way to provide cleaner and healthier air inside hospitals? The answer is increased and balanced ventilation. As long as enough controlled and filtered fresh outdoor air is coming in and stale indoor air is exhausted out, indoor spaces will enjoy high-quality air. In fact, the American Lung Association states that proper ventilation is essential for keeping the air fresh and healthy indoors.¹²



ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. Source: RenewAire

Further, to stop the spread of airborne viruses, cognitive authorities recommend a [layered approach with increased ventilation at its core](#). For example, the CDC advises using multiple mitigation strategies, including improvements to building ventilation, to reduce the spread of disease and



lower the risk of exposure.¹³ In addition, ASHRAE states that: “Ventilation and filtration provided by heating, ventilating and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air.”¹⁴

How can IAQ be enhanced while also minimizing costs? The best way is via energy recovery ventilation through ERVs, which [enhance IAQ while maximizing energy efficiency and sustainability](#). ERVs precondition the outdoor air coming in with the otherwise-wasted exhaust air's heat and humidity. This can lead to substantial reductions in energy and equipment costs. Consequently, the EPA states that “ERVs provide excellent opportunities for saving energy, controlling humidity and providing sufficient outdoor air to promote IAQ.”¹⁵

Increased Building Ventilation Rates Bolster Occupant Health

In the post-pandemic new normal, a spotlight has been shown on the criticality of enhanced IAQ to safeguard occupant health. This can be achieved with greater amounts of fresh and filtered outdoor air that's ventilated indoors. With increased ventilation rates, aerosols and other indoor air contaminants are continuously diluted.

In fact, ASHRAE recommended the following in its [Epidemic Task Force Building Readiness Report](#): “There is potential that building operators could increase their systems outdoor air ventilation to reduce the recirculation air back to the space. The guidance indicates that this should be done, if it is the selected mitigation strategy for this system, as much as the system and or space conditions will allow.”¹⁶

In addition, the market demands buildings that are better for both occupant health and the environment. Standards are evolving to keep up, such as the forthcoming ASHRAE 62.1, Section 42 on “Enhanced Indoor Air Quality in Commercial and Institutional Buildings.” It's still under review, but once approved it will recommend exceeding minimum building ventilation requirements for enhancing IAQ.¹⁷

What's more, several green-building certifications require extra ventilation over code. These include:

- **LEED:** Requires increasing breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2007.¹⁸
- **WELL:** The Enhanced Ventilation feature of the WELL certification requires implementation of advanced ventilation strategies that can secure higher air quality levels. Projects exceeding outdoor air supply rates described in ASHRAE 62.1-2010 by 30% or 60% receive one or two points respectively. If CO2 levels are kept at either 900 ppm, 750 ppm or 600 ppm, it's worth one, two or three points respectively.¹⁹

¹² “Ventilation: How Buildings Breathe,” American Lung Association, <https://www.lung.org/clean-air/at-home/ventilation-buildings-breathe>.

¹³ All information in this paragraph and subsequent bullets sourced from: “Ventilation in Buildings,” Centers for Disease Control and Prevention (CDC), June 2, 2021, <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>.

¹⁴ “ASHRAE EPIDEMIC TASK FORCE FILTRATION & DISINFECTION,” ASHRAE, October 21, 2021, https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf.

¹⁵ “IAQ Building Education and Assessment Model (I-BEAM),” U.S. Environmental Protection Agency (EPA), January 19, 2017, https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/text_modules_energy_efficiency.pdf.

¹⁶ “BUILDING READINESS,” American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), <https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf>.

¹⁷ “ASHRAE Guideline 42P, Enhanced Indoor Air Quality in Commercial and Institutional Buildings (Public Review Draft),” ASHRAE, July 2021, <https://docplayer.net/217513149-Enhanced-indoor-air-quality-in-commercial-and-institutional-buildings.html>.

¹⁸ Increased ventilation, LEED, <https://www.usgbc.org/credits/eq13>.

¹⁹ “Enhanced Ventilation,” WELL, <https://v2.wellcertified.com/v/en/air/feature/6>.

THE RESULTS

Enhanced IAQ Improves the Health, Cognitive Function, Productivity & Wellbeing of Hospital Occupants

Enhancing IAQ energy-efficiently, cost-effectively and sustainably through energy recovery ventilation results in numerous benefits for hospital occupants. These include:

Benefits of Enhanced IAQ for Hospital Occupants	
Reduced infections	According to the CDC, 70% of HAIs are preventable. ²⁰ Indoor air contaminants are a primary contributor to increased infection rates, and therefore, by enhancing IAQ, the number of HAIs can be reduced. Along these lines, the Center for Health Design found that: <ul style="list-style-type: none"> ♦ Providing clean filtered air and effectively controlling indoor air pollution through ventilation are two key aspects of maintaining good air quality.²¹ ♦ Controlling airflow, temperature and humidity in hospitals can help maintain excellent IAQ, which can help control the growth of molds, bacteria, viruses and other pathogens.²²
Minimizing the spread of COVID-19	A recent study looking at ventilation and COVID-19 in hospitals found that a poorly designed ventilation system enormously increases the spread of infections. However, when air is injected from the ceiling and extracted from behind the patient beds, the infection spread is least probable because the particles exit the room much faster. ²³
Faster patient recovery	According to a study by Texas A&M University, patients with controlled high-level IAQ improve quicker than patients in an uncontrolled environment. ²⁴ Maintaining the right temperature can also help create an indoor environment that promotes healing and prevents pathogens from growing and spreading. ²⁵
Boosted staff health and productivity	Higher-quality indoor air results in healthier doctors, nurses and support staff, thus reducing sickness and absenteeism. In addition to better health, workers will also experience improved cognitive function, thus further boosting productivity. In fact, a Harvard study found that doubling the rate of a conventional ventilation system from 20 CFM per person (the rate recommended by ASHRAE) to 40 CFM per person only costs about \$32 per person, per year and leads to a productivity increase of \$6,500 per person, per year. And if an ERV system is added, the anticipated increase in energy costs can be reduced by up to 60%. ²⁶ Thus, by using an ERV you can double ventilation rates and still cut energy costs by up to 10% compared to when you started.
Financial savings	Reducing infections through enhanced IAQ can generate significant financial savings for hospitals. According to the Pennsylvania Patient Safety Authority, preventing 70% of all infections in the U.S. could translate into potential savings of up to \$31.5 billion per year. ²⁷

In Sum

Hospitals are at tremendous risk of suffering from deficient IAQ. Indeed, with increased air-sealing methodologies on the rise, the quality of indoor air is getting worse. On top of that, the risks of low-level IAQ were only amplified in the COVID-19 era because the consequences resulted in serious harm.

By enhancing IAQ through increased and balanced ventilation, the benefits to hospital occupants are numerous. These include improved health, cognitive function, productivity, wellbeing and peace of mind knowing you're safeguarded from airborne viruses. And this can all be achieved energy-efficiently, cost-effectively and sustainably through energy recovery ventilation.

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²⁰ Laura Rygielski Preston, "Breath of fresh air: Indoor air quality critical to effective infection control," Medical Construction & Design, January/February 2011, https://www.trane.com/content/dam/Trane/Commercial/global/markets/healthcare/FdMCD0111_52-54-IF-IAQ.PDF.

²¹ Anjali Joseph, "The Impact of the Environment on Infections in Healthcare Facilities," The Center for Health Design, July 2006, https://www.healthdesign.org/system/files/Joseph_The_Impact_of_Environment_2006.pdf.

²² Ibid.

²³ Hamed Arjmandi et al., "Minimizing the COVID-19 spread in hospitals through optimization of ventilation systems," American Institute of Physics (AIP)'s Physics of Fluids, March 2, 2022, <https://aip.scitation.org/doi/10.1063/5.0081291>.

²⁴ M. Ramaswamy, Farooq Al-Jahwari, Saif M. Masoud Al-Rajhi, "IAQ in Hospitals – Better Health through Indoor Air Quality Awareness," Texas A&M University, 2010, <https://core.ac.uk/download/pdf/79627196.pdf>.

²⁵ Laura Rygielski Preston, "Breath of fresh air: Indoor air quality critical to effective infection control," Medical Construction & Design, January/February 2011, https://www.trane.com/content/dam/Trane/Commercial/global/markets/healthcare/FdMCD0111_52-54-IF-IAQ.PDF.

²⁶ Piers MacNaughton et al., "Economic, Environmental and Health Implications of Enhanced Ventilation in Office Buildings," International Journal of Environmental Research and Public Health, November 18, 2005, <http://www.mdpi.com/1660-4601/12/11/14709/html>.

²⁷ Kelly M. Pyrek, "Understanding HAI Burden, Demonstrating ROI Essential to Making a Business Case," Infection Control Today, November 13, 2013, <https://www.infectioncontroltoday.com/view/understanding-hai-burden-demonstrating-roi-essential-making-business-case>.