

INCREASED VENTILATION: THE MEDICINE HOSPITALS NEED FOR HEALTHY IAQ

By Nick Agopian

Healthy indoor air quality (IAQ) in hospitals is of utmost importance to support patient healing and a high-performing staff. But challenges exist to make it a reality, such as ventilation energy consumption and additional costs. In this paper we'll examine the state of IAQ in hospitals and then look at what can be done to enhance it while also saving energy and cutting costs.

Deficient IAQ is a Threat to Hospitals

As hospitals become more airtight, a consequence is deficient IAQ due to a buildup of internally generated contaminants. This is a serious threat to the health, cognitive function, productivity and wellbeing of all hospital occupants. In fact, levels of hazardous indoor-air pollutants in some areas inside hospitals can be up to 70 times greater than in outdoor air.¹

In hospitals, many viruses travel easily through the air, thus spreading diseases and fouling indoor air. Did you know that 50% of all hospital illnesses are caused/aggravated by polluted indoor air² and that airborne pathogens trigger over 30% of hospital-acquired infections (HAIs)?³ This harms patient health and the bottom line since HAIs via airborne agents cost hospitals \$4-5 billion per year.⁴

Increased Ventilation Enhances IAQ in Hospitals

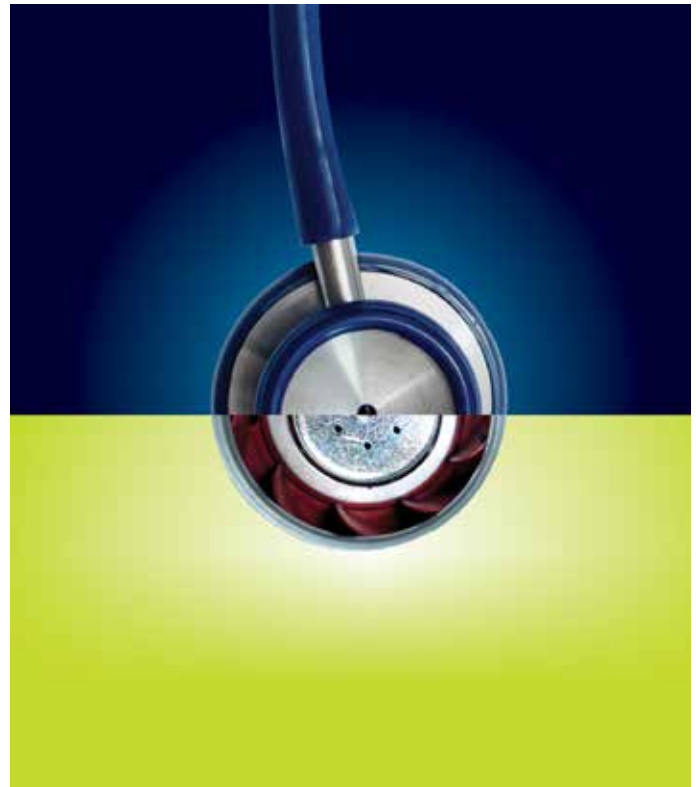
What's the most effective way to enhance IAQ in hospitals? The answer is increased and balanced ventilation. As long as enough controlled and filtered fresh outdoor air is coming in and replacing equal parts of stale indoor air, IAQ will be improved. The American Lung Association states that proper ventilation is essential for keeping the air fresh and healthy indoors.⁵

Further, according to ASHRAE Standard 170, without high-quality ventilation in healthcare facilities, patients, workers and visitors can become infected through normal respiration of particles in the air.⁶ These airborne organisms pose a risk to all hospital occupants, but are especially dangerous to patients with weaker immune systems.⁷

Benefits of Increased Ventilation for Hospital Patients and Staff

By enhancing IAQ in hospitals, increased ventilation has many benefits for patients and staff alike, such as:

- Reduced infection rates: Since airborne pathogens are a primary cause of infections in hospitals, ventilating out the stale and



contaminated indoor air and replacing it with fresh and filtered outdoor air can significantly reduce infection rates. Consider these findings:

- According to a study by Clemson University, the importance of good air quality in controlling and preventing airborne infections in healthcare facilities cannot be overemphasized. Providing clean filtered air and effectively controlling indoor air pollution through ventilation are two key aspects of maintaining good air quality.⁸

¹ 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://oaktrust.library.tamu.edu/bitstream/handle/1969.1/94139/ESL-IC-10-10-88.pdf?sequence=1&isAllowed=y>.

² Ibid.

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 Jeff Elsner, P.E., Mechanical Engineer, Ventilation and Energy in Healthcare Buildings, 2014 Rocky Mountain ASHRAE Technical Conference, http://rockymtnashrae.com/downloads/2014_Technical_Conference/healthcare_ventilation.pdf.

⁵ "Ventilation: How Buildings Breathe," American Lung Association, <http://www.lung.org/our-initiatives/healthy-air/indoor/at-home/ventilation-buildings-breathe.html>.

⁶ Jeff Elsner, P.E., Mechanical Engineer, Ventilation and Energy in Healthcare Buildings, 2014 Rocky Mountain ASHRAE Technical Conference, http://rockymtnashrae.com/downloads/2014_Technical_Conference/healthcare_ventilation.pdf.

⁷ J. Patrick Banse, PE, LEED AP, "IAQ, infection control in hospitals," Consulting-Specifying Engineer, February 7, 2013, <https://www.csemag.com/single-article/iaq-infection-control-in-hospitals.html>.

⁸ Anjali Joseph, Ph.D., "Impact of the Environment on Infections in Healthcare Facilities," The Center for Health Design, 2006, https://www.researchgate.net/publication/237520192_The_Impact_of_the_Environment_on_Infections_in_Healthcare_Facilities.

- According to a report for The Center for Health Design, evidence from many studies leaves no doubt that hospital air quality and ventilation play decisive roles in affecting air concentrations of pathogens such as fungal spores and, in this way, have major effects on infection rates.⁹
- A report in Healthcare Facilities Today states that dilution ventilation helps to control infectious particles by introducing outdoor air, usually two to five air changes/hour (ACH) to dilute space air, and then exhausting that amount out as contaminated air.¹⁰
- Faster patient recovery: Breathing in cleaner and healthier indoor air as a result of increased ventilation can speed up the recovery process for hospital patients. Consider these findings:
 - According to the American National Standards Institute (ANSI), in healthcare facilities, poor ventilation can be dire because unfavorable indoor environmental conditions can worsen a patient's symptoms or ailments.¹¹
 - A report in Consulting-Specifying Engineer states that poorly ventilated healthcare facilities are places where the likelihood of pathogenic particles in the air is high.¹² Such a scenario can impair patient recovery.
 - A report for The Center for Health Design supports the importance of adequate ventilation with good maintenance for ensuring both staff and patient safety in hospitals.¹³ Without patient safety, recuperating from illnesses will be more difficult.
- Staff cognitive improvement: Healthy IAQ through increased ventilation supports better thinking and decision-making for doctors, nurses and the whole hospital staff. This is supported by several findings:
 - A study in Environmental Health Perspectives compared thinking abilities of occupants in three simulated indoor environmental "days" – a conventional building day with standard IAQ, a green building day with better IAQ and a green+ building day with maximized IAQ achieved by doubling the minimum ventilation rate to 40 CFM per person and supplying 100% outdoor air ventilation. When compared to the conventional building day, indoor occupants' cognitive scores were 61% higher on the green

building day and 101% higher on the green+ building day.¹⁴

- A study by the Harvard T.H. Chan School of Public Health found that doubling the ventilation rate to 40 CFM per person leads to an astounding productivity increase of \$6,500 per person, per year and costs less than \$40 per person, per year.¹⁵

Outdoor Air is Critical for Maximizing IAQ in Hospitals

Healthy IAQ is essential for the wellbeing of hospital indoor occupants, and this can be achieved through increased ventilation, which leads to many benefits. But, similar to the cognition study mentioned above, what if it were possible to create "green+" conditions in hospitals by maximizing IAQ?

Bringing enough fresh and filtered outdoor air indoors is the main factor for realizing the best IAQ possible in hospitals. The reason for this is because air inside hospitals can be contaminated quickly with the plethora of airborne pathogens that are present. If this stale and polluted indoor air isn't exhausted out and replaced with sufficient amounts of outdoor air, hospital IAQ will be deficient.

Supporting this notion is the American Society for Health Care Engineering (ASHE), which states that adequate amounts of outdoor air should be supplied to indoor occupied spaces to promote acceptable IAQ in hospitals.¹⁶ The ASHE also asserts that without adequate outdoor air, indoor airborne contaminants in hospitals may rise to uncomfortable or unhealthy concentrations.¹⁷

For example, measles and influenza viruses, as well as tuberculosis bacteria, are transmitted via shared air between infected and susceptible persons.¹⁸ Studies indicate that one of the primary means of transmission of these pathogens is within-room exposure and recirculated contaminated air,¹⁹ thus demonstrating the importance of ventilating in enough outdoor air.

In addition, the U.S. Environmental Protection Agency (EPA) states that increasing the amount of outdoor air indoors lowers the number of indoor air pollutants.²⁰ And the U.S. Consumer Product Safety Commission (CPSC) asserts that inadequate ventilation can increase indoor pollutants by not bringing in enough outdoor air to dilute emissions and by not carrying indoor air pollutants out.²¹

⁹ Roger Ulrich, Xiaobo Quan, Craig Zimring, Anjali Joseph, Ruchi Choudhary, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," The Center for Health Design for the Designing the 21st Century Hospital Project, September 2004 https://www.healthdesign.org/system/files/Ulrich_Role%20of%20Physical_2004.pdf.

¹⁰ Forrest Fencel, "Hospital infection control: reducing airborne pathogens," Healthcare Facilities Today, June 9, 2014, <https://www.healthcarefacilitiestoday.com/posts/Hospital-infection-control-reducing-airborne-pathogens--5523>.

¹¹ Brad Kelechava, "ANSI/ASHRAE/ASHE Standard 170-2017: Ventilation of Health Care Facilities," American National Standards Institute (ANSI), December 14, 2017, <https://blog.ansi.org/2017/12/ansiashraeashe-standard-170-2017/#gref>.

¹² J. Patrick Banse, PE, LEED AP, "IAQ, infection control in hospitals," Consulting-Specifying Engineer, February 7, 2013, <https://www.csemag.com/single-article/iaq-infection-control-in-hospitals.html>.

¹³ Roger Ulrich, Xiaobo Quan, Craig Zimring, Anjali Joseph, Ruchi Choudhary, "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," The Center for Health Design for the Designing the 21st Century Hospital Project, September 2004 https://www.healthdesign.org/system/files/Ulrich_Role%20of%20Physical_2004.pdf.

¹⁴ Joseph G. Allen, Piers MacNaughton, Usha Satish, Suresh Santanam, Jose Vallarino and John D. Spengler, "Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments," Environmental Health Perspectives, October 26, 2015, <https://ehp.niehs.nih.gov/doi/10.1289/ehp.1510037>.

¹⁵ MacNaughton P, Pegues J, Satish U, Santanam S, Spengler J, Allen J, "Economic, Environmental and Health Implications of Enhanced Ventilation in Office Buildings," International Journal of Environmental Research and Public Health, November 18, 2015, <https://www.mdpi.com/1660-4601/12/11/14709/html>.

¹⁶ "Outdoor Air Supply," The American Society for Health Care Engineering (ASHE), http://www.ashe.org/compliance/ec_02_05_01/01/outdoorairsupply.shtml.

¹⁷ Ibid.

¹⁸ Forrest Fencel, "Hospital infection control: reducing airborne pathogens," Healthcare Facilities Today, June 9, 2014, <https://www.healthcarefacilitiestoday.com/posts/Hospital-infection-control-reducing-airborne-pathogens--5523>.

¹⁹ Ibid.

²⁰ "Improving Indoor Air Quality," U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/indoor-air-quality-iaq/improving-indoor-air-quality>.

²¹ "The Inside Story: A Guide to Indoor Air Quality," U.S. Consumer Product Safety Commission, <https://www.cpsc.gov/Safety-Education/Safety-Guides/Home/The-Inside-Story-A-Guide-to-Indoor-Air-Quality>.

100% Outdoor Air Should be the Goal for Hospitals

If outdoor air is essential for maximizing IAQ in hospitals, then 100% outdoor air should be the goal of any healthcare engineer or facility manager. Studies show that if 100% of all supply air were outdoor air, nearly that amount of airborne infectious particles might be exhausted.²²

However, a challenge does arise when seeking to increase ventilation and supply more outdoor air inside hospitals.

Increased Ventilation and Outdoor Air Require More Energy

The challenge presented by increasing the amount of ventilation and outdoor air inside hospitals is the greater amount of energy needed for HVAC operations. This is an especially tough pill to swallow for hospitals since they already consume an exorbitant amount of energy and spend large sums in the process. Consider these facts:

- Inpatient healthcare facilities are the second-most energy-intensive building type in the U.S., with heating (including reheat), cooling and ventilation accounting for 52% of their energy use.²³
- The median hospital in the Rocky Mountains burns two gallons of gas a day per patient room in energy use.²⁴
- Healthcare facilities in the U.S. spend more than \$9.7 billion annually on energy.²⁵
- A typical 200,000-square-foot, 50-bed hospital in the U.S. annually spends \$680,000 – or roughly \$13,611 per bed – on electricity and natural gas.²⁶

As a result, this means that increased ventilation and outdoor air are out of the question for hospitals, right? Not so fast – there's a way to achieve this while also saving energy.

Reuse Energy, Not Air with Energy Recovery Ventilation

The final question then is how can ventilation be increased, plenty of outdoor air be supplied indoors and IAQ be maximized in hospitals, all while energy use is minimized? The medicine that hospitals need to achieve healthy IAQ, while also saving energy, is energy recovery ventilation.

Energy recovery ventilation optimizes energy efficiency by conditioning fresh and filtered outdoor air coming in with otherwise-wasted total energy and humidity of the exhaust air going out. This exchange of reused energy moderates temperatures and moisture, decreases HVAC loads and equipment needs, drives operational efficiencies, conserves energy and generates significant financial savings.

The EPA states that energy recovery ventilation offers “excellent opportunities for saving energy, controlling humidity and providing sufficient outside air to promote IAQ.”²⁷ And in the study mentioned above in which cognitive scores increased by 101% on green+ days, researchers determined that adding an energy recovery ventilator (ERV) largely mitigates the energy costs of increasing ventilation.²⁸

What's more, by reusing exhaust-airstream energy to condition the outdoor air coming inside, energy recovery ventilation supports the environment and hospital sustainability in several ways, including:

- **Optimized energy efficiency:** By recovering and reusing total energy and humidity (that would typically be discarded by conventional systems) to condition incoming outdoor air, energy recovery ventilation is incredibly energy efficient.
- **Reduced HVAC loads:** Because less energy is used in the ventilation process, HVAC loads can be drastically reduced. This results in even further reductions in HVAC energy use and costs, as well as capital-equipment downsizing.
- **Minimized carbon footprint:** The combination of less energy used and HVAC loads being reduced minimizes a carbon footprint, thus supporting the environment and strengthening sustainability efforts.

Increase Ventilation and Save Energy with RenewAire DOAS

Now we understand why energy recovery ventilation is the most efficient way to maximize IAQ in hospitals, but how can it be applied? The solution is a Dedicated Outdoor Air System or DOAS. The DOAS handles all of the outdoor-air ventilation needs by bringing the outdoor air inside, filtering it and conditioning it to comfortable levels, thus handling both sensible and latent loads.

The DOAS is part of a decoupled system and works in conjunction with ventilation equipment used solely for space conditioning. Because the DOAS manages all of the outdoor air, the space-conditioning equipment is freed up to only have to deal with sensible loads for occupancy comfort, which means it can be considerably downsized.

We know that the DOAS enables HVAC equipment to be downsized, but the real magic happens when energy recovery is incorporated into the system. With energy recovery ventilation, the DOAS can reuse otherwise-wasted, exhaust-airstream total energy to condition the outdoor air coming inside. This process reduces sensible and latent loads and leads to major energy savings every year over the long-term.

RenewAire's DOAS is the Best Choice for Increasing Hospital Ventilation

For 35 years, RenewAire has been a pioneer in improving people's health, cognitive function, productivity and wellbeing by enhancing IAQ via energy recovery ventilation technologies. This is done energy-efficiently, cost-effectively and sustainably via fifth-generation, static-plate, enthalpy-core ERVs and DOAS units.

The RenewAire DOAS with fixed-plate energy recovery effectively conditions outdoor air with efficient and sustainable technology. By enabling HVAC units to operate independently depending on building load, as well as incorporating energy recovery ventilation, the RenewAire DOAS will elevate any ventilation strategy.

²² Forrest Fencil, “Hospital infection control: reducing airborne pathogens,” Healthcare Facilities Today, June 9, 2014, <https://www.healthcarefacilities.com/posts/Hospital-infection-control-reducing-airborne-pathogens--5523>.

²³ Travis R. English, “Engineers’ Perspectives on Hospital Ventilation,” HPAC Engineering, May 2, 2014, <https://www.hpac.com/iaq-ventilation/engineers-perspectives-hospital-ventilation>.

²⁴ Jeff Elsner, P.E., Mechanical Engineer, Ventilation and Energy in Healthcare Buildings, 2014 Rocky Mountain ASHRAE Technical Conference, http://rockymtnashrae.com/downloads/2014_Technical_Conference/healthcare_ventilation.pdf.

²⁵ U.S. Department of Energy's Better Buildings, <https://betterbuildingsinitiative.energy.gov/alliance/sector/healthcare>.

²⁶ “Managing Energy Costs in Hospitals,” <http://dslectric.coopwebbuilder2.com/sites/dslectricdslectric/files/images/Business/hospitals.pdf>.

²⁷ “Indoor Air Quality and Energy Efficiency,” U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/indoor-air-quality-iaq/indoor-air-quality-and-energy-efficiency>.

²⁸ Joseph G. Allen, Piers MacNaughton, Usha Satish, Suresh Santanam, Jose Vallarino and John D. Spengler, “Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments,” Environmental Health Perspectives, October 26, 2015, <https://ehp.niehs.nih.gov/doi/10.1289/ehp.1510037>.

RenewAire's DOAS can downsize HVAC equipment, decrease capital costs and realize significant operating savings. It also offers innovative cooling and heating features and hot-gas reheat. By installing a RenewAire DOAS, hospitals can cut ventilation heating and cooling loads by up to 70% and ventilation energy costs by up to 65%.²⁹

In Summary

Healthy IAQ challenges all hospitals. Indoor air contaminants are prevalent, energy use is extensive and costs are high. The medicine hospitals need to maximize IAQ is increased ventilation and outdoor air, and this can be done energy-efficiently and cost-effectively via a RenewAire DOAS with fixed-plate energy recovery. The result is that hospital occupants can take deep breaths of cleaner and healthier indoor air.

For more information on RenewAire energy recovery ventilation technologies that enhance IAQ energy-efficiently, cost-effectively and sustainably, contact us today.

Nick Agopian is Vice President, Sales and Marketing at RenewAire. For 35 years, RenewAire has been a pioneer in improving people's health, cognitive function, productivity and wellbeing by enhancing IAQ via energy recovery ventilation technologies. This is done energy-efficiently, cost-effectively and sustainably via fifth-generation, static-plate, enthalpy-core Energy Recovery Ventilators (ERVs) and Dedicated Outdoor Air Systems (DOAS). For more information, visit: www.renewaire.com.

²⁹ All data pertains to a RenewAire HE2XINH ERV when compared to conventional exhaust equipment at 1,500 CFM of OA in Minnesota using DX cooling and gas heat. Future energy costs calculated based on current energy costs. For more information view: https://www.renewaire.com/wp-content/uploads/2017/09/MAR_LIT_RGB_0317_PX800_080_00.pdf.