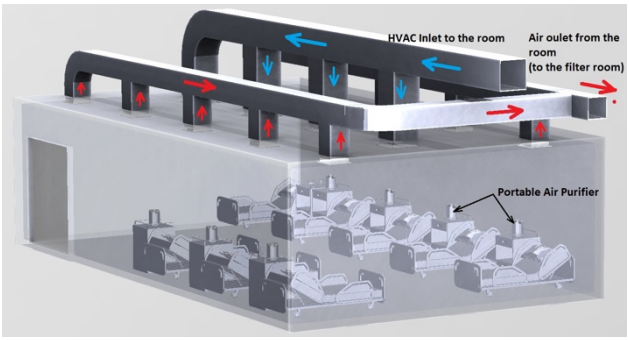
INTENSIVE CARE UNIT

Acquisition of Infection and AIR CHANGE

Jaspreet S. Dhau, President ASIRE



I want to start with a disclaimer; I am neither a physician nor a medical expert. My pain has propelled me to dig into scientific literature about airborne infections and control measures associated with ICUs in India. As part of my role as an R&D director for Molekule, I've read many scientific articles on air purification. But as a son of a strong woman who was hospitalized while battling serious illness, I've gone to great lengths to familiarize myself on the subject of airborne infections and control measures in ICUs—references to some of these sources are given at the end of this article. I will be happier if someone can shred my inferences from these readings, as it will bring peace to many whose loved ones may be in an ICU. They can find solace knowing that their relative is at a reduced risk of acquiring deadly airborne disease from the hospital.

Your life's most challenging time is when your loved one is on an Intensive Care Unit (ICU) bed, and you are helpless and pondering what to do and the following related emotional battle. You evaluate doctors, hospital staff, and infrastructure and hope they are the best for the situation. At this moment, your belief makes you understand that the hospital is doing everything it could do for the patient. I was in a similar situation in the torrid times of 2020 when the world saw a surge in coronavirus infection (SARS-CoV-2) cases with no sign of the pandemic slowing down. My mother was fighting for her life due to pneumonia and severe sepsis, and septic shock in a reputed hospital in Punjab, India. Since she was on a ventilator and struggling with an airborne infection, and I being familiar with the impact of air quality on patient's health having respiratory issues,[1] I decided to place an air purifier by her bedside.

To get the right air purifier, I asked the doctor about the number of air changes per hour (ACH) in the ICU. The answer shook me to the core; **NONE**. Due to my research in air purification and some knowledge about airborne infectious microbes, I could apprehend that her health would deteriorate further. How could she improve in an environment which is a breeding ground for drug-resistant bacteria and highly infectious viruses such as SARS-CoV-2! I did what every son and any reasonable person in my situation would do; I decided to shift my mother to a better-equipped hospital. Shifting was not straightforward due to COVID restrictions with hospitals refusing admission to new patients. However, I moved her to one of the best and expensive hospitals in the region, assuming higher expenses mean a better-equipped hospital. However, even there, I came for a rude shock, **no AIR CHANGE in the ICU**. According to my understanding, this is unacceptable anywhere in the world as good indoor air quality is a critical non-pharmacological strategy to prevent hospital-acquired infections.

In all these uncertainties, the fiercest warrior in our family lost the battle of her life, which I believe is partly due to ill-equipped (for sure) and probably non-compliant ICUs in hospitals. Can an ICU in the hospitals be without AIR CHANGE or, in other words, without a standard' heating, ventilation, and air-conditioning (HVAC)' system? Are there any regulations and guidelines on ACH for ICUs in India? If there are regulations and policies, what and where are they? So, I started the quest to find answers, and hence this article.

Several medical studies have established that infection in the ICU is highest in the hospital, partly due to inadequate facilities.[2] Many antibiotic-resistant bacteria such as *methicillin-resistant Staphylococcus aureus* (MRSA), *Serratia marcescens*, and *vancomycin-resistant enterococci* (VRE) are found to survive and persist in the hospital environment and are responsible for hospital-acquired diseases. I looked into whether these microbes are transmitted through contaminated surfaces (fomite exposure) only or if they could be airborne also. Shiomori et al. (2001) have reported that MRSA may be airborne and may play a role in nasal colonization in the nasal cavity or respiratory tract in MRSA infections.[3] The Shiomori research group recommends measures to prevent airborne MRSA spread to control nosocomial MRSA infection in hospitals. The airborne transmission of SARS-CoV-2 through aerosols is also now well established. The SARS-CoV-2-laden droplets released during expiratory activities (talking, coughing, and sneezing) of infected persons become airborne through evaporation. Besides, several medical and surgical procedures may also generate aerosolized infectious particles.[4] The fate of these airborne particles depends on the airflow. In inadequate ventilation cases, the airborne particle could remain in the ICU room, leaving patients, staff, and visitors to potentially inhale these infectious particles. It is therefore essential to remove these infectious aerosols through the use of adequate ventilation systems. That's why guidelines on ventilation in ICUs must be strictly applied all across the world.

Professional and scientific bodies in the US, UK, and Europe have published guidelines on ICUs' design and layout and emphasized ventilation's importance. In India too, detailed guidelines on ICU planning and designing have been specified in 2010 and 2020.[5,6] The guidelines are clear on the ICU to be fully air-conditioned with control over temperature, humidity, and a minimum of six ACH per room, with two ACH (33%) composed of outside air. Further recommendations are for the re-circulated air passing through filters with 99% filtration efficiency in the particle size range of <5 microns. The guidelines have been there for a while now, yet I wonder why the hospitals are not following them. How are they getting approvals? Aren't there checks and inspections by regulatory bodies to ensure that hospitals follow guidelines? After all, we've been through as a species in the last year, we, the people, deserve these answers.

It is not inevitable that following these guidelines will mitigate the issue. Still, it will be an excellent start to reduce airborne infections in the ICUs and improve the health service quality. There is an urgent need to educate the general population about the existing

guidelines and cultivate the habit of maintaining cleanliness in a hospital.

With the advent of new technologies, infrastructure, and knowledge, there are several opportunities to upgrade to ICUs' ventilation guidelines. According to the ISCCM guidelines, 2010 and 2020,[5,6] if air conditioning and air change are not possible, then ICU should have windows that can be opened. In 2010 guidelines, I could understand, but in 2020, the exemption is unreasonable since we pride ourselves on electricity reaching every city and village in the country. It appears that the hospitals in India are exploiting this loophole and conveniently violating the guidelines on the air changes, which is unacceptable. In my view, ACH should be mandatory in ICUs, and ventilation through windows could only be an additional option.

Here are some of the other suggestions for improving air quality in ICUs:

1. **Higher Filtration Efficiency**. Enhance requirements on the filtration efficiency of HVAC filters. The guideline recommends using filters with 99% mechanical efficiency for particles up to 5 µm; however, a significant level of airborne pathogen-laden aerosols is smaller than 5 microns. Therefore, the regulatory body should enhance the requirement on the filtration efficiency of HVAC filters. Integrate filters into the HVAC system that give a filtration efficiency of at least 99.9% for aerosols/particles smaller than 5 microns.

2. **HVAC Maintenance**. HVAC systems/ventilation ducts need to be regularly deep cleaned to ensure that the system doesn't become breeding ground and a potential source of infectious microbes' transmission. This aspect should be incorporated into the inspection guidelines of the hospital.

3. **Next Generation Filtration Technologies.** Utilize air filters or technologies that could destroy microbes to add an extra layer of protection to the HVAC system. For this, technologies that destroy airborne microbes should be integrated into the HVAC system.

4. **Personalized Air Purification Systems (Portable Air Purifiers)**. The medical community has not widely recognized the use of a personalized air purification system (PAPS) such as portable air purifiers. PAPS provides clean, infection-free air into the patient's breathing zone by removing microbe-laden droplets and droplet nuclei. A personalized air cleaning system decreases inhaled pollutant concentrations by 2-50x compared with an HVAC system alone.[7] Therefore, PAPS systems in the ICU environment close to the patient's breathing zone will benefit their health, see image at the beginning of the article.

A study by Pantelic *et al.* has reported using a personalized ventilation system to mitigate the risk of airborne transmissible infection.[8] Further, a study by Molekule has shown that HVAC filters reduce microbes but not completely (full disclosure: I currently serve as Molekule's Senior Director of R & D.). The indoor air purifier prefilter had more pathogenic microbes than the HVAC final filter, indicating infectious microbes remained in the air for a significant amount of time before the HVAC system could remove them.[9] This may leave everyone in the hospital environment vulnerable to infection. I would recommend using a portable air purifier in all ICUs, especially in ICUs without adequate ventilation. These systems are inexpensive, low maintenance, and offer additional benefits such as the destruction of infectious microbes and the oxidation of toxic pollutants found in the hospital environment.

THE TIME HAS COME WHEN WE TAKE AIR QUALITY IN ICU SERIOUSLY AND HOLD HOSPITALS AND OURSELVES ACCOUNTABLE.

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The article is dedicated to my mother, Mrs. Ranjit Kaur. Miss you, Mom!