BUILDING THERAPY

The healing power of indoor air

By Stephanie Taylor

Human beings are living in an era that is both frightening and exciting. The global emergence of new infectious viruses and bacteria, combined with the reemergence of pathogens that people thought they were safe from, has healthcare personnel on edge. These microorganisms not only carry the threat of severe illness; many are resistant to antiviral or antibiotic treatment. In addition to the increased risk of infection, the percentages of people suffering from autoimmune and inflammatory diseases are on the rise. On the bright side, there are new tools that can assist with understanding why these alarming disease trends are occurring and reveal strategies to lower the risk of becoming ill.

Still, why are the rates of some diseases rising despite extensive vaccination programs, and sophisticated medical diagnostic and treatment protocols?

The answer may lie in the pages of an old elementary biology textbook. In 1859, Charles Darwin published *On the Origin of Species*. He described how living organisms adapt to their environment — their shapes and physiological processes evolving in order to survive and reproduce within the surrounding fields of gravity, magnetic forces and chemical reactions.

Now, 160 years after the publication of Darwin's theory, 'survival of the fittest,' modern-day humans spend more than 85 per cent of their time in buildings. This means the conditions created in the indoor environment have become powerful evolutionary forces.

Which begs the questions: How does the indoor environment impact both humans and microbes? Are buildings being designed and operated in a way that selects the bacteria and viruses that cause disease while simultaneously weakening the immune systems of human occupants? Are the microbial communities in buildings contributing not only to acute infectious diseases but also to chronic inflammatory conditions and autoimmune disorders that people are suffering from?

Thanks to the same genetic analysis tools that were used to crack the DNA code of the human genome, such questions can now be answered. These tools, generally referred to as metagenomic techniques, can identify the communities of microbes in buildings and human occupants.

Information revealed by metagenomics has provided a completely new understanding of the relationships humans have with microbes. Prior to these revelations, bacteria, viruses and fungi were thought of as 'germs' that cause disease and needed to be eradicated as soon as possible. However, this is incorrect. The human body is a living ecosystem, host to trillions of microbes that actually outnumber human cells tenfold. These tiny microbes not only cohabitate on and in the body but they take up residence in people's homes and in other occupied buildings. Most of these microbes support human health by contributing to food digestion, training the immune system, modulating neurotransmitters to support mental health and protecting skin from penetration by harmful microbes. A small percentage, however, are pathogenic (disease-causing) microbes.

Understanding the intersection of buildings, indoor microbes and humans is not simply theoretically interesting; it is an urgent topic for everyone, especially hospitalized patients. Healthcare associated infections (HAIs), often from antibiotic resistant bacteria, are claiming the well-being and lives of hundreds of thousands of patients every year in the U.S. alone.

How much does the design, operation and management of the hospital building contribute to this HAIs epidemic?

New information is emerging from studies that correlate patient HAI rates, indoor climate (temperature, humidity, carbon dioxide, outdoor air,

and so on) and building design, and the indoor microbiome. Evidence suggests the microbial communities in mechanically ventilated buildings are both less diverse and more closely related to pathogens when compared to microorganisms outdoors or in buildings with operable windows.

Another startling finding is that buildings with indoor relative humidity (RH) below 40 per cent contain more infectious microbes, as well as more occupants suffering from infections and psychological stress. Conversely, indoor climates with RH between 40 and 60 per cent have the greatest number of health-promoting microbes and healthy, productive human occupants.

Studies on the relationships between the built environment, indoor microbial communities and occupant health in other building types are yielding similar results.

How can this be?

Ambient conditions with RH less than 40 per cent promote infectious pathogens, while simultaneously hampering people's ability to combat disease.

Dry air contributes to this disastrous combination for several reasons: indoor communities of microbes are less diverse and skewed toward pathogenic species; infectious aerosols coughed or shed from occupants shrink and are transmitted farther and longer in tiny desiccated droplets, capable of reaching more vulnerable secondary hosts through inhalation or skin exposure; when water vapour is low, the actual virility or infectivity of many viruses and bacteria is greater, though for reasons still not understood; and human physiological barriers and natural immunity are impaired when water vapour is lacking.

These findings offer new tools to control patient infections, reducing avoidable suffering, death and healthcare costs.

This is not entirely new information, though. A 1985 study found that RH between 40 and 60 per cent was advantageous to humans and decreased pathogenicity of microbes.

So, why aren't buildings that are occupied by humans humidified?

In short, there's worry about water condensation within walls in cold climates and increased energy costs from running humidifiers. And then there's the issue of ongoing maintenance.

The best course of action is to design buildings with adequate envelopes and insulation to contain healthy water vapour (humidity) levels while preventing the dew point from being reached in interstitial spaces such as walls. Building codes must be updated to protect human occupants, not simply to prevent immediate disasters like fires and to keep energy consumption down.

It's now known that proper humidification does not necessarily mean higher energy consumption. When the RH in operating rooms is maintained at 40 per cent, fewer infectious aerosols settle into the sterile field compared to a RH of 20 per cent. For this reason, room air change rates can be reduced because infectious particles settle down rather than being resuspended in dry, turbulent air. Another energy-saving benefit comes from decreased evaporation of moisture from the skin of occupants. This results in people feeling comfortably warm at thermostat settings several degrees lower than temperatures needed for comfort in dry air.

Ultimately, maintaining proper water vapour between 40 and 60 per cent RH will achieve cleaner environments with healthier occupants. Research across multiple building types and climactic regions consistently show that adequate water vapour must be provided for all occupants.

To motivate building owners to create indoor spaces that truly support human health, return on investment models must be developed to capture the financial benefits of healthy and productive building occupants. When building engineers and medical professionals learn to work together, united in ongoing research and implementation of proper indoor humidification systems, building occupants will benefit from fewer infections and other diseases exacerbated by the built environment. ■

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