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Editorial

Special Issue: Well-Being in the Built Environment

The COVID-19 pandemic has clearly raised public awareness of the significant impact of indoor built environments on human health. However, the true health *and well-being* impacts are much more substantial and long lasting than those stemming from infectious diseases.

Health and Well-Being in a Holistic Manner

Good building design is linked to well-being, productivity, performance, employee recruitment, and retention and also helps to reduce health risks, absenteeism, as well as associated costs [1]. Poorly designed or controlled indoor environments are linked to some of the nation's greatest public health concerns, such as obesity, cardiovascular diseases, diabetes, asthma, and depression [2–5] as evidenced by studies on sick building syndrome (SBS), respiratory distress, discomfort, stress, and anxiety [6–9]. The literature is unequivocal: indoor environmental quality (IEQ) impacts health and well-being [10]. As illustrated in Fig. 1, IEQ includes indoor air and ventilation, temperature, moisture and humidity, light and color, glare, sound, ergonomics, privacy and enclosure, spatial organization and interior design, and so on. [10–14]. These factors affect the quality of human life, stress, job satisfaction, and productivity. For example, slightly lower temperatures are associated with higher task accuracy and reduced sick leaves [15]; access to temperature control increases worker productivity [16]; daylight and windows as well as views of nature positively impact mental and physical health [17]; daylight helps regulate the circadian system (waking and sleeping hours) [18–21]. On the other hand, poor air quality and inadequate ventilation are linked to SBS and adverse health outcomes among building occupants [22–25] and to poor productivity [13]; exposures to indoor air pollutants cause irritation of eyes, nose, and throat, as well as headaches and fatigue [26]; damp and moldy environments are associated with respiratory illnesses, allergies, and skin problems [27]; and poor acoustics lead to low performance and distraction and negatively impact mood [28]. Figure 1 shows IEQ factors that impact well-being and are related to building design and engineering.

The aforementioned literature clearly illustrates how the buildings affect occupant thermal comfort, productivity, and overall satisfaction. Yet how the built environment, that is, the indoor environment and outdoor built structures, affects occupant physical, mental, and social well-being jointly has received much less attention. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being". Clearly, to improve health, a more systematic and holistic understanding is needed.

Recent "Ten Questions" Papers on Well-Being

Several recent "Ten Questions" publications, authored by experts in relevant research and practicing fields, provide key insights on the state-of-the-art of well-being in a built environment. Altomonte et al. [29] discussed this topic from the design and operation perspective. Their "Ten Questions" paper illustrated how individual indoor environment attributes, including lighting, acoustics, indoor air quality, and thermal comfort, affect occupant well-being. This article advocates for a paradigm shift. There is a need for new schools of thought to promote next-generation design and operation strategies, for instance, (1) shifting from minimizing the negative design to promoting the positive design; (2) shifting from siloed individual attribute considerations to multisensory integration (for example, considering lighting, acoustic and air quality altogether); (3) shifting from maintaining static indoor attributes (for example, constant temperature or lighting) to dynamic attributes (for example, varying comfort parameters over time or on the demand); (4) shifting from satisfying the illusive "average" occupant to allowing personalized control and customization.

Understanding the impacts of buildings on occupant health is the focus of the "Ten Questions" paper by Awada et al. [30]. Many perspectives that connect health and buildings are reviewed in this article, which range from typical questions such as how buildings affect health; how health is monitored and assessed to unique perspectives such as the impact of socioeconomic status and the economic impact of unhealthy buildings; and how extreme events such as COVID-19 affect health in buildings. Similar to Ref. [29], breaking the current siloed viewpoints and practices to allow a holistic understanding is strongly advocated.

The existing literature has mostly focused on how the built environment affects physical well-being. Yet how it affects mental well-being, a critical challenge of modern society, is rarely studied. The "Ten Questions" paper by Hoisington et al. [31] provides a timely review on this topic. Despite limited studies, nearly all indoor environment attributes, including lighting, acoustics, thermal, air quality, and so on, have an impact on mental health. Though much more research is needed to fully understand the connections, some of the underlining biological mechanisms are illustrated in this article: for instance, how poor air quality causes chronic low-grade inflammation, which further triggers stress-related psychiatric disorders.

These recent publications highlight the urgency and the significance of understanding how the built environment affects well-being. The most imperative challenge pointed out by all of these recent publications is the need to promote an interdisciplinary collaboration among scientists, engineers, architects, and health professionals to catalyze a paradigm shift in building design, operation, and evaluation practices during the entire life cycle of a building. Long-term and multiscale studies are needed to better understand the physical, social, and mental health implications of the multisensory stimuli from the built environment. These understandings need to then be translated into building protocols, codes, standards, best practices, as well as new technologies, sensors, and tools. Moreover, the financial and societal benefits of healthy buildings must be better communicated with the business community and the public to gain their support.

IN2WIBE and Its First Workshop

Responding to the growing awareness of the necessity for collaborative and convergent research in the field of well-being in the built environment, IN2WIBE (An International Network of Networks for

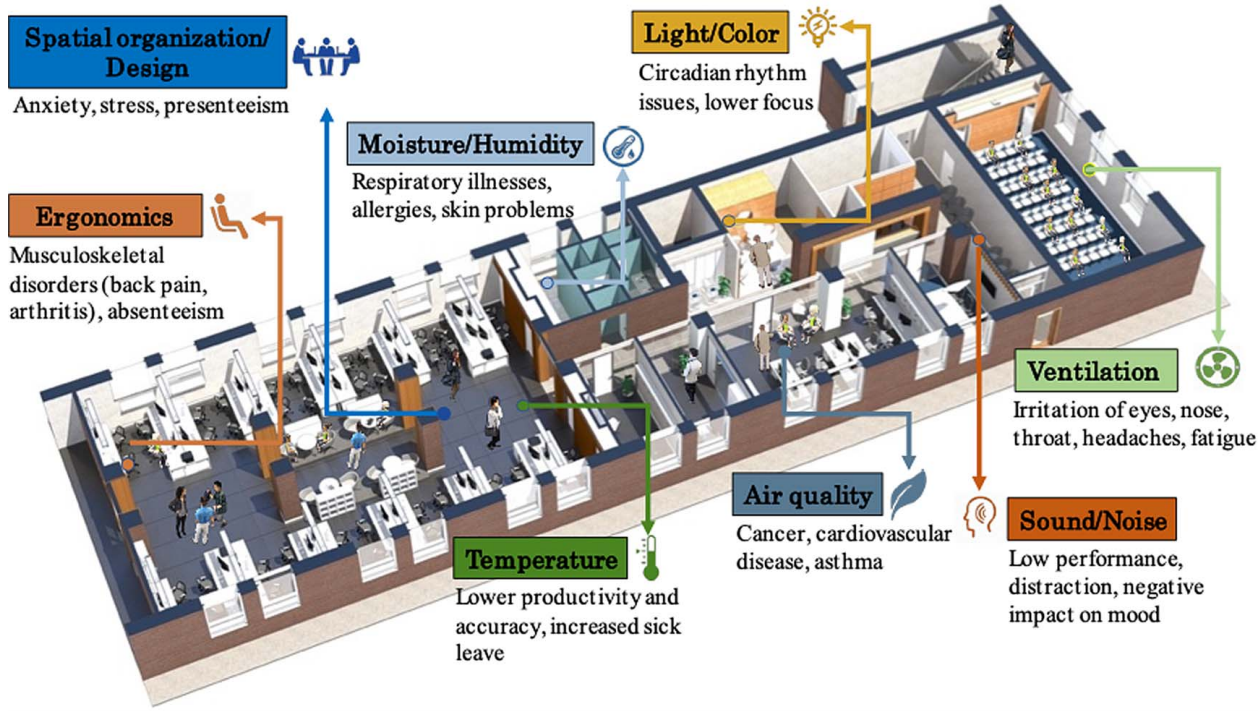

Fig. 1 Environmental quality factors and well-being in the built environment (source: https://in2wibe.net)

Well-being in the Built Environment, funded by the National Science Foundation, https://in2wibe.net) aims at providing an opportunity to unite disciplinarily, culturally, and geographically diverse networks around the world. A kick-off workshop in March 2021 included participants from diverse backgrounds including four keynote speakers representing experts in Medicine, Public Health, Engineering, and the Building Industry. The first workshop laid the foundation for fostering interdisciplinary discussions on the definition, needs, gaps, and future research directions in the field of well-being in the built environment.

Contribution of This Special Edition

Inspired by the IN2WIBE kick-off workshop, this special edition solicits studies that examine well-being from holistic and comprehensive perspectives.

It includes two survey studies to understand how the home environment affects physical, social, and mental well-being especially during the COVID-19 quarantine period: Questionnaires were designed with the multisensory stimuli in mind. The survey results were analyzed to provide guidelines for future building design and operation standards.

(1) "*Associations Among Home Indoor Environmental Quality Factors and Worker Health While Working From Home During COVID-19 Pandemic*": This is a national survey with 988 responses. It extensively focuses on the relationship between satisfaction with IEQ factors and health (both mental and physical) issues.

(2) "*How Work From Home Has Affected the Occupant's Well-Being in the Residential Built Environment: An International Survey Amid the COVID-19 Pandemic*": This is an international survey with 1,137 completed responses from 35 countries. Compared with Paper 1, a wider array of residential building attributes are considered, which include home size, layout, location, and so on.

Moreover, this special edition also demonstrates the complex interplay of factors that affect human health and well-being. It includes a study that examines the relationships among outdoor weather, discomfort, and energy trends (spatial and temporal) for multiple regions in North and South America:

(3) "*Climatology and Trends of Heat Index, Human Discomfort Index and Energy per Capita for Conus and Meso-America*."

In response to the need to understand the financial impacts of well-being, one of the studies in this special edition examines the productivity from the perspective of monetizability:

(4) "*Statistical and Qualitative Evaluation of Human Productivity Metrics in the Indoor Environment From the Perspective of Monetizability*."

The editors hope that this special edition will inspire continuous and long-lasting interdisciplinary dialogues, which lead to the paradigm shift for a healthier built environment.

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