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Chapter

Workplace Health and Its Impact on Human Capital: Seven Key Performance Indicators of Workplace Health

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Abstract

Health, a state of complete physical, mental and social well-being according to the World Health Organization, is a critical issue in the workplace as it is directly related to human capital, the most important and expensive asset of an organization. When it comes to workplace health, there are seven key performance indicators to consider. These include physical fitness, physical comfort, physical nourishment, cognitive well-being, social well-being, emotional well-being, and environmental well-being. Various environmental attributes in these seven KPIs in the workplace affect not only health but also performance and engagement of employees via their physical, mental, and social interactions within the environment. For instance, ergonomics, acoustics, lighting, thermal comfort, and olfactory comfort address the overall physical comfort while biophilic components contribute to employee cognitive functions as well as their capacity to cope with mental stress and fatigue. These seven KPIs of workplace health ultimately contribute to five positive organizational outcomes, including healthy organizational culture, higher productivity, improved individual health and safety, financial savings, and enhanced reputation of the organization. This chapter discusses critical health factors in the workplace and their contributions to the capacity of human capital at the individual as well as organizational levels.

Keywords: KPIs of workplace health, PROWELL, human performance, physical fatigue, mental restoration, organizational health outcomes

1. Global health epidemics

We now often hear that chronic diseases are the great health epidemics of our times. This expresses critical concerns about rapidly growing and spreading chronic diseases across the world. Chronic diseases have been blamed for over 60% of all deaths and are expected to grow to nearly 75% by 2020 [1]. The main driver behind this trend is a shift from physical labor-intensive primary industries to knowledge-intensive industries and a technologically advanced lifestyle, which led to physical inactivity, sedentary lifestyle, and unhealthy dietary behaviors. These factors are the causes of intermediate risks such as overweight and obesity, which explain incidents of the majority of chronic diseases such as heart disease, stroke, and diabetes.

The World Health Organization (WHO) statistics reveals that obesity across the world has nearly tripled since 1975 with 39% of adults being overweight, body mass index (BMI) 25 and over, while nearly 13% obese, BMI 30 and over, worldwide [2]. The urgency of these health issues is even prevalent in the US where nearly 70% of adults are overweight and 35% obese based on the WHO statistics. The criticality of the problems with overweight and obesity lie in their links to many illnesses including asthma, musculoskeletal disorders, cardiovascular disease, stroke, type 2 diabetes, osteoarthritis, and certain cancers [3]. Along with physical health issues, mental health issues have also increased due to financial instability, higher demands at job, work-life imbalance, and social isolation. The WHO speculates that a quarter of the world populations experience some sort of mental health issues in their life time with depression being the fourth leading cause of the disease worldwide [4].

With globally prevalent health epidemics of chronic illnesses, various disciplines have joined forces to seek and implement interventions beyond the medical and public health realms. In addition, multi-disciplinary approaches are sought as more desirable in tackling such a complex problem in a collective, systematic way, bringing professionals together in environmental design, food science, health science, neuroscience, and policy. A recent action plan from the WHO to increase physical activity clearly exhibits this approach by calling for strategies in four areas: social culture, physical environments, people's activities, and systems support [5].

The role of physical environment is gaining more traction than ever before in terms of increasing physical activities, changing behaviors, and controlling environmental toxins and pollutants for occupant's health. The sustainable building communities in particular are emphasizing occupant health to mitigate negative environmental impacts on human health. More stringent systems for healthy materials have been developed such as Health Product Declaration and Living Building Challenge Red List. Health and well-being building certification systems have emerged such as Facility Innovations toward Wellness Environment Leadership (FITWEL)® and WELL Building Standard™. Various green building rating systems such as LEED™, BREEAM® and Nabers are evolving to include more occupant health-related criteria to respond to these global epidemics.

2. Workplace health

As global concerns on health epidemics of chronic illnesses prevail, workplaces have become the center of attention in two regards: (1) the relationship between employee health and astronomical costs associated with it, and (2) a unique role of workplaces being a main source of health issues as well as a central place to implement health interventions more effectively.

2.1 Workplace health and its costs

Healthy employees are an important issue as an organization not only for higher productivity and economic benefits but also for organizational culture. People are the most important asset, human capital, to any organization. The majority of the costs related to doing business are attributed to people costs including salaries and benefits. Thus, means to support their optimal performance are important to organizations. Health in the workplace has become critical as organizations have learned that health conditions significantly affect the performance of their employees.

Employee health affects an organization in various ways, sometimes as direct costs such as healthcare costs and workers compensation claims but other times as indirect costs such as productivity, absenteeism, presenteeism, and engagement.

Healthcare costs have been the most troublesome concern in the US workplaces due to a huge amount of healthcare costs imposed on employers. The concerns with rising healthcare costs in the workplaces are also growing in Europe. And even bigger concerns exist with humongous indirect costs associated with unhealthy workforce: higher absenteeism and presenteeism, decreased productivity, and lower engagement.

In the EU, adult obesity accounts for 6% of direct healthcare costs and 12% of indirect costs [6]. Among these indirect costs are sickness absenteeism, being absent at work due to illness. There have been abundant studies on sickness absence, especially, in the public health realm for the last couple decades due to a clearer and simpler methodological advantage. In a study, sickness absence was speculated to cost UK employers over £600 per employee [7]. In more recent studies, the intangible but more impactful costs associated with presenteeism, being present at work but not productive, has become at the center of attention. A conservative calculation of the cost of presenteeism tells us that presenteeism may be nearly twice as high as absenteeism [8].

Productivity and engagement are also indirect costs frequently associated with health issues in the workplace. Productivity loss due to mental health issues explains 3–4% of GDP in the EU [9], and Gallup surveys show a close relationship between unhealthy workforce and low engagement as well as a positive relationship between engagement level and productivity level [10]. While it is important to understand the impact of health in the workplace on absenteeism, presenteeism, productivity, and engagement, we must be cautious in interpreting intangible indirect costs associated with workplace health to actual dollar amounts. This is because of discrepancies observed among the studies as well as credibility of assumptions and reliability of data used for calculations of these impacts in dollar amounts.

2.2 Workplace as a source of health issues and a place to cure them

Workplaces are known as a main source of many health issues in the contemporary society, including sedentary workstyle, work-life imbalance, and increased job demands. People spend a majority of their time at work, allegedly 2/3 of their waking time [11]. Due to the contemporary work settings prevalent in knowledge-intensive industries, sedentary work settings have become the main workplace environment where people tend to have a sedentary posture for a prolonged period. The sedentary work settings have shown an association with overweight and obesity as people who spent longer working hours in the workplace exhibited a higher body mass index [12]. In addition to physical health, the workplace is also a major source of mental health issues. Stress, depression, and anxiety were the number one cause of all absences at work and accounted for nearly half of all reported work-related illnesses [13]. Stress, especially, was the second highest among all reported work-related health issues [14].

While workplaces are a main source of health issues, workplaces also hold an advantageous situation in tackling people's health in a large group setting rather than working with individuals. Workplaces have been sought as a practical place to implement health interventions by health professions to change the prevalent health epidemics for the past several decades. This is because the workplace is where people spend a substantial amount of their time, so it naturally becomes a central place to not only easily implement health programs in social settings with necessary social supports but also reach larger groups of people to effectively control and prevent the health epidemics.

Addressing health issues in the workplace has been a long battle in the public health domain over several decades, especially, for chronic disease prevention and

health promotion. Leading health organizations, including the WHO, the European Network for Workplace Health Promotion (ENWHP), and the US Centers for Disease Control and Prevention (CDC), have introduced a concept of workplace health promotion or health-promoting workplaces more than a decade ago targeting four areas: physical exercise, healthy diet, mental health, and healthy lifestyle in the workplace. Since then, various workplace health promotion programs have been suggested, implemented, and shown positive outcomes.

3. Environmental health in the workplace

There are currently growing efforts to integrate environmental health issues into the realm of public health as a comprehensive approach to tackle workplace health. Health in the physical environment of workplaces has two approaches to workplace health: environmental design to promote physical movement, healthy diet, mental health, and healthy lifestyle at work; and environmental control and monitoring of harmful toxins, pollutants, and irritants as well as provision of human comfort factors. Health-promoting environmental design focuses on environmental interventions such as spatial layout for physical movement, stair use, fitness spaces, spatial features for conscious eating, or biophilic design that integrates nature into the workspaces. Environmental control and monitoring emphasizes proper levels of indoor air quality, comfort factors in temperature, lighting, and acoustics, as well as managing toxic materials and substances in building components.

This section describes both approaches in seven topics called seven key performance indicators (KPIs) of workplace health (7 KPIs of WH). The indoor environmental features, conditions, and design approaches described in this section are derived from various theories and practices, such as biophilic design, environmental preference theory, evolutionary psychological design, and active design, as well as standards and guidelines in the built environment, such as FITWEL®, WELL™, LEED™, BREEAM® and health-related recommendations from the WHO and other relevant governmental agencies. It focuses on the major KPIs of Workplace Health in a comprehensive manner from a design and planning purpose so, further specific issues and items should be discussed in details with experts in each respective field when applying it in practice.

3.1 Seven key performance indicators of workplace health

Workplace health relevant to the environment can be addressed in seven dimensions within three health domains defined by the WHO: physical, mental, and social domains. Since health is defined as a state of complete physical, mental and social well-being [15], workplace health can be categorized into seven dimensions of well-being states: physical fitness, physical comfort, physical nourishment, cognitive well-being, social well-being, emotional well-being, and environmental well-being. These are essentially seven key performance indicators (KPIs) of workplace health (7 KPIs of WH) when it comes to the environment. Physical fitness, physical comfort, physical nourishment, and environmental well-being fall under the physical domain; cognitive well-being and emotional well-being under the mental domain; and social well-being under the social domain of health (**Figure 1**). This model is called PROWELL. The list of 7 KPIs in the PROWELL model delineates a comprehensive approach to workplace health to accomplish the overall health promotion in the workplace as various factors influence one another in the complex layers of workplace health. The 7 KPIs of WH contribute to overall five positive organizational outcomes: healthy organizational culture, higher employee productivity,

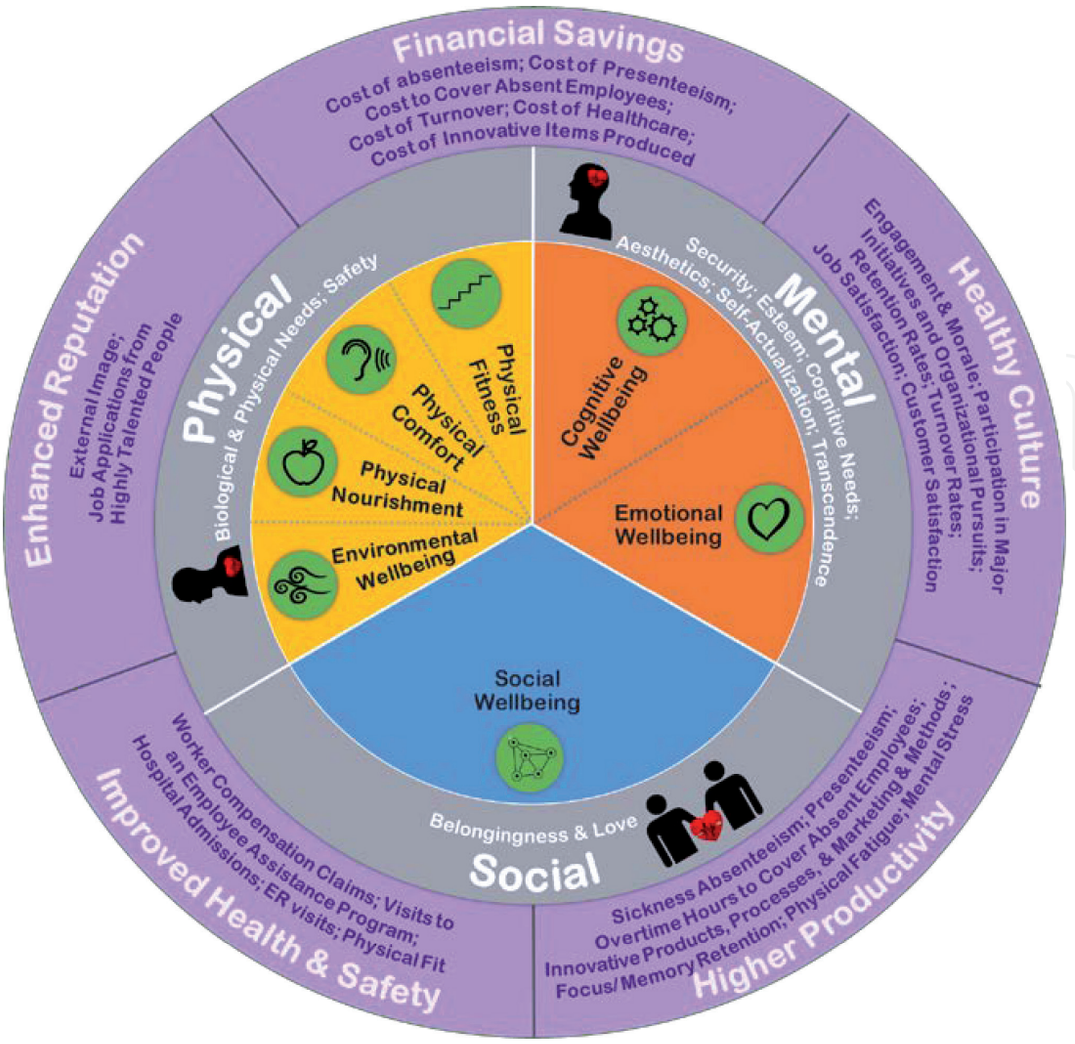


Figure 1.
Seven KPIs of workplace health in three domains and their benefits in the PROWELL model.

improved individual health and safety, enhanced company reputation, and financial savings. Health-enhanced workplaces by the 7 KPIs of WH contribute to healthy organizational culture by promoting engagement and morale, increasing retention rates, decreasing turnover rates, and increasing job satisfaction; higher productivity by reducing sickness absenteeism and presenteeism, decreasing overtime hours to cover absent employees, producing more innovative outcomes, enhancing focus and memory retention, and decreasing mental stress as well as physical fatigue; improved health and safety by reducing workers compensation claims, lower visits to an employee assistance program as well as hospital admissions and emergency visits, and better physical fit; enhanced company reputation by improved external image and increased job applications from highly talented candidates; and financial savings from cost of absenteeism and presenteeism, cost to cover absent employees, cost of turnover, healthcare premium, and financial returns from more innovative items produced by healthy employees (**Figure 1**). This section explains the role of these KPIs and focuses on principles and basis of strategies to achieve each KPI in workplace health.

3.1.1 Physical fitness

The physical fitness (PF) dimension focuses on the workplace environmental features that contribute to promoting and maintaining physical fitness by creating physical movements and providing spaces for physical activities in the workplace.

This is parallel to the principles of active design that recognizes the built environment as a critical venue for promoting physical activities through the design and layout of the physical environment [16]. Established to develop built environments to increase physical activities to stop the rising level of obesity in the UK, the major agendas of active design involve active travel (or transport) that promotes the use of public transport; active buildings and interiors that integrate physical activity-promoting designs of buildings and indoor spaces; and active outdoor and public spaces that increase physical activities [17]. As sedentary postures and inactivity are prevalent in contemporary workplaces, various design and spatial resolutions can be integrated to promote physical movement and activity.

Interior active design offers various health-promoting opportunities for workplace health via interior spatial planning and design elements, behavioral change encouragement, and available physical exercise spaces. Interior layout and circulation planning can stimulate physical movement by providing choice of spaces for people to work from other types of workspaces than only individual workstations. These choices allow them to break their sedentary workstyle and more frequently move around. It can also incorporate design strategies for the mystery patterns to evoke a sense of mystery to compel employees to explore and move around in the spaces (**Figure 2**). As one of the predictors of the environmental preferences, a sense of mystery triggers a strong pleasure response within the brain comparable to the response in an anticipatory situation [18], which leads to curiosity and interest to further explore spaces that evoke a sense of mystery. A good strategy to creating mysterious environments is obscuring spatial boundaries and a part of the focal object [19, 20].

Interior stairs use is a well-known method for interior active design. The use of interior stairs can facilitate more frequent physical movement in the workplace via three elements: stair design, visibility, and accessibility. People are more likely to be motivated to use stairs instead of elevators when stairs are designed as a focal point with pleasant design elements; clearly visible from the main entrance and even located before elevators; and easily accessible from the major workspaces and



Figure 2.
The American Society of Interior Designers (ASID) Headquarters, Washington, DC, USA. LEED platinum-certified and WELL-platinum-certified. Photo credit: Eric Laignel.

during the regular business hours to all employees. In addition, the use of signage/message board can be an effective means to encourage employees to take stairs instead of elevators by especially posting it next to elevators. A post motivating people to use stairs can significantly increase the use of stairs, four times higher likelihood of using stairs when stairs are visible [21].

Using interior design elements is a great way to motivate employees to be willing to walk more often to other parts of workspaces by creating a pleasant ambience using visual and auditory elements around stairs: art and installations; natural elements such as green plants, plant wall, water feature, or daylight; and pleasant music or nature sounds. Lastly, providing the onsite fitness space and equipment would be a vital way to encourage people to be engaged in physical exercise and activity in the workplace. Onsite physical exercise activities can be further enhanced if a combination of exercise equipment are available for both cardio-respiratory and muscle-strengthening exercises in the space. The WHO recommends adults between 18 and 64 years old be engaged in a minimum of 150 min of moderate aerobic activity (or a minimum of 75 min of vigorous aerobic activity or a combination of both) and a minimum of two times of muscle-strengthening activities a week [22]. When providing a fitness/exercise space and equipment, it is also necessary to provide shower and locker facilities for people to be able to clean themselves after workouts.

Active workstations such as treadmill desks or portable desk pedals, a combination of a desk and a treadmill or a bike pedal to facilitate physical movement while working, can also be integrated to encourage physical movement. However, it is important to note that this is not a means for fitness exercise or weight control. While those who use active workstations are overall more engaged in physical movement than those who do not use them as they tend to break more often sedentary workstyle habits, the amount of exercise is neither enough to meet the recommendations of the WHO as a fitness activity nor to lose weight as a weight control mechanism [23].

3.1.2 Physical comfort

The physical comfort dimension addresses comfort issues in major human senses and body systems. This includes comfort issues in four major senses: *visual, auditory, thermal*, and *olfactory* as well as in the overall body system: *Ergonomics*. Human comfort issues have always been the focus of green buildings. Especially, lighting (visual sense), acoustics (auditory sense), and temperature and humidity (thermal sense) have led major discussions in providing human comfort in green buildings. Smell (olfactory sense) is recently recognized as a human comfort issue in the workplace due to not only unpleasant odors but also recent awareness on toxic chemicals embedded in everyday products used in the workplace such as air fresheners or scents.

Visual comfort strategies for workplace health mainly address lighting for visual acuity, glare control, and quality of lighting. To provide proper lighting for visual acuity, it is necessary to provide sufficient lighting level, 300 lux for general areas and 300–500 lux for computer workstations [24]; control options for light level such as task lights for individual desks and multi-zone lighting control systems with a minimum of several different lighting levels; and availability of light switches and controls within the same space as the lights to be control. Glare control for interior ambient lighting can be addressed through types of lighting fixtures by employing light diffusers to spread the angle of beams wider and indirect up-light fixtures to point lights upward; lighting planning that orient lighting fixtures perpendicular to individual workstations/computer monitors to prevent potential hot spots and glare

in monitors; and a coordination with interior finishes as non-reflective matte, light to medium colored interior wall finishes helps to address the overall discomfort with artificial lighting for computer users [25].

Solar glare control strategies have been frequently emphasized in green buildings. Solar glare has become problematic in green buildings as an increased amount of vision glass, glass lower than 7 feet, has been used in office buildings to introduce a higher amount of daylight into the workspaces, coupled with a design intent relevant to the architectural esthetics of glass towers which has driven higher window-to-wall ratios (WWR) in office buildings. Several major strategies to control solar glare include incorporating window shading devices such as interior blinds or curtains, exterior shading systems, variable opacity glazing, interior light shelves, and reflective film of micro-mirrors on windows; meeting WWRs between 30 and 40% [26]; and limiting the amount of direct sunlight that can potentially cause glare discomfort by calculating/simulating the Annual Sun Exposure (ASE). ASE measures the floor area that receives minimum 1000 lux from the sun for at least 250 occupied hours a year, and the recommended ASE is no more than 10% of the total floor area for visual comfort [27].

The strategies to achieve the quality of lighting involve providing proper color rendering of light bulbs through color rendering index (CRI) for the realism of colors in objects; light reflecting property of interior finish materials with light reflectance value (LRV); and brightness contrast level between monitors and immediate surroundings including desk surfaces. The European Standard (EN 12464-1) recommends a minimum CRI of 80 for R_1-R_8 colors for architectural lighting in offices. While only R_1-R_8 colors are considered for CRI ratings, the importance of considering R_9 in selecting architectural lighting has been emphasized as many LED lights in the market have shown poor scores in R_9. With the technological advancement in LED lighting, it is advised to consider various color rendering-related factors simultaneously including fidelity, gamut and correlated color temperature of a light source. LRV recommendations for interior finishes in the office environment vary between the standards and guidelines; more narrowly ranged in the recent green building and high-performance building standards and guidelines for the purpose of energy conservation with a range of 80–90% for floors, 50–70% for walls, 50% for cubicle partitions, and 20–25 for floors [28, 29], but more broadly defined as 70–90% for floors, 50–80% for walls, and 20–40% for floors for visual comfort, specifically, in the office environment [30]. However, LRV is not only related to the amount of light available in the space but also visual ergonomics for visually impaired. It has been noted an association between a lack of contrast between interior finish materials and increased visual fatigue as well as loss of concentration [31]. Visual disability codes and guidelines prescribe the contrast ratios of architectural surfaces and details as follows: a LRV difference of 30 points between two contrasting areas in the British Standard: BS 8300:2009 + A1:2010 and a contrast ratio of minimum 70% between the LRV of the lighter area and the LRV of the darker area in the Americans with Disabilities Act (ADA). Lastly, brightness contrast ratio not exceeding 1:3 should be provided between the monitors and desk surfaces and between the immediate surroundings and the background areas in the office environment to prevent visual fatigue and eye strains [32].

Auditory comfort has been a major discussion in the contemporary workplace. Open-plan offices have become a prevalent office type in the contemporary workplace due to efficient real estate management and encouragement of interactions and collaborations among employees. The importance of open environments has been emphasized to facilitate interactions and collaborations in the innovation economy. The innovation economy is a relatively recent economic theory that emphasizes economic growth through entrepreneurship, technological

interventions, and innovations [33]. As seen in successful innovative companies, an open environment that facilitates interactions for fruitful collaborations and innovative outcomes has become the most frequently adopted office type in the innovation economy. However, the downside of an open environment is excessive noise that causes annoyance, stress, and physical fatigue, not to mention loss of concentration and productivity. As noise means unwanted sounds by its definition, when and what is noisy is subjective by individuals based on their workstyles, required tasks at the time: concentration vs. casual mode, and personality attributes. Personality attributes play a significant role in the noise sensitivity issue as people with neuropsychiatric personality tend to be more annoyed by noises and negative people are more significantly influenced by noise annoyance [34, 35]. People who are less extroverted and conscientious might also be more associated with noise sensitivity [36]. *Auditory comfort* in the workplace can be achieved by four major strategies: space planning principles; technical measures; sound masking systems; and sound mitigating construction methods. While many technical strategies and measures are suggested and relied on to mitigate noise issues and provide speech privacy, providing *auditory comfort* in open-plan offices is not an easy task by all means. Thus, these strategies must address a comprehensive approach through space planning and design, technical measures, and workplace policy for successful *auditory comfort*.

Space planning principles provides a basis of noise control in the workplace and include grouping similar types of spaces; placing buffer spaces to separate noisy spaces; avoiding room shapes causing sound to reflect or focus in specific spots; staggering doorways to avoid a straight path for noise; and placing quiet spaces away from noise sources such as major traffic roads and copy rooms (**Figure 3**). Various technical measures can be employed for internal noise control via three typical principles of soundproofing: sound absorption, sound blocking, and sound masking. These technical measures include sound absorption coefficient, noise criteria (NC), reverberation time (RT), sound transmission class (STC), and sound masking systems in open-plan offices. Sound absorption coefficient is a measure that is based on the sound absorption of materials and can assess sound absorption of either individual materials: noise reduction coefficient (NRC) or rooms: design coefficient (DC). As a rule of thumb, a NRC of 0.7–0.8 in ceilings and walls/partitions is considered as a good solution for private offices and meeting/conference rooms, and a NRC of 0.9 or higher for spaces requiring a higher level of speech privacy and open-plan offices [28, 37]. However, the total coverage of the materials applied in an area would determine the overall performance of sound absorption in the space. In addition, the NRC of ceiling materials will be more important than the NRC of wall materials in open-plan offices. It should be noted that NRC is to be replaced by a similar rating system called sound absorption average (SAA). DC is also related to sound absorption of materials but rather assesses the overall sound absorption of a room by considering both the area and NRC ratings of materials in the area.

NC is a sound pressure-based measure and typically used to measure the background noise such as the heating, ventilating and air conditioning (HVAC) systems as this type of noise can be annoying and disruptive in the workplace. A NC of 45-40 is considered appropriate for open-plan offices, multi-occupant spaces and common spaces; a NC of 35-30 for conference and meeting rooms with normal speech privacy, a NC of 25 for conference and meeting rooms with high speech privacy, and a NC of 20-25 for teleconference rooms [37, 38]. According to Noise Rating (NR), a NC equivalent in Europe, NR 35 is recommended for open-plan offices and 30 for general offices. RT in a room is measured by the amount of time it takes for sound to decay by 60 decibels (T60). A RT of 0.5–0.6

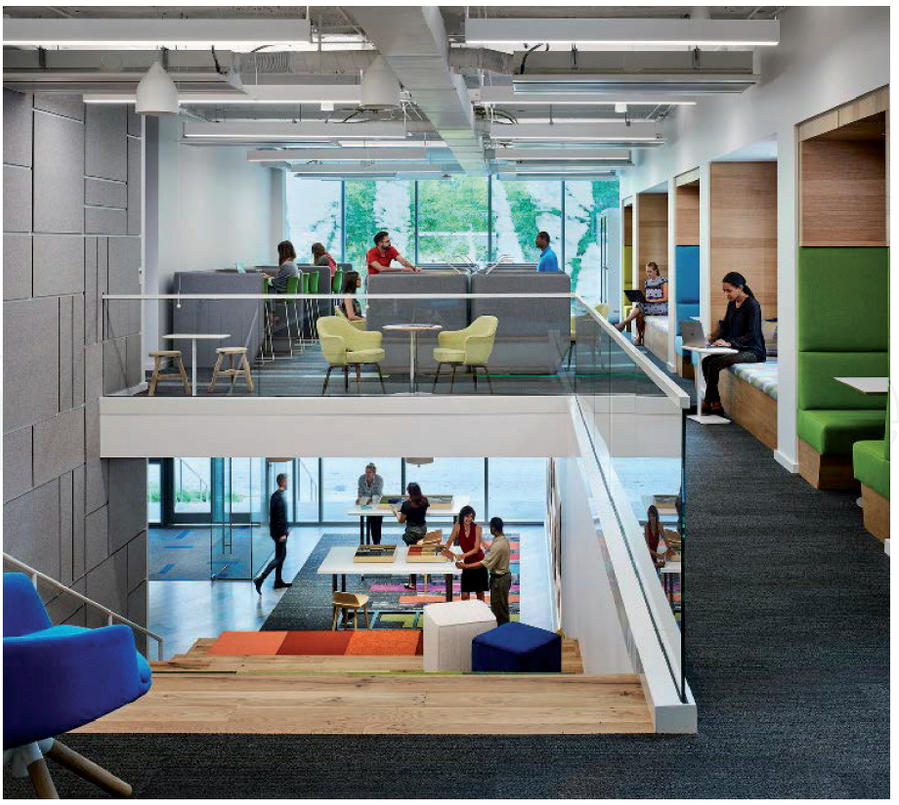


Figure 3.
Interface Headquarters in Atlanta, Georgia, USA. A combination of acoustic solutions used: separate acoustic zoning, quieter background noise from chilled beam system, mechanical sound tuned to sound masking pitch, and interior finishes and furnishings with acoustic properties. LEED platinum and WELL silver certifications pending. Photo courtesy: Nick Merrick, Hall + Merrick photographers.

is considered for private offices, meeting/conference rooms, and teleconference rooms, and a RT of 0.8 for open-plan offices [37, 39]. The overall performance of RT in a room will be determined by sound absorption of materials and the volume of the space as it gets longer with less sound absorption and a larger volume.

STC, as a laboratory test - based rating for sound blocking and isolation, measures the degree of sound attenuation of a wall partition in adjoining areas, commonly ranging between 30 and 75 [40]. STC 40 is considered a threshold for a sense of privacy and higher numbers are required to provide speech privacy and noise isolation. A minimum of STC of 45 is required between standard offices to block loud speech and 50 between meeting rooms, conference rooms, and hallway to isolate louder sounds [28, 39]. Sound Reduction Index (Rw), instead of STC, is used in Europe to measure sound insulation levels by calculating the reduction in the intensity of sound through a partition. Rw 45dB means when loud speech is audible but unintelligible through a wall and, RW 50dB and over when loud speech is difficult to be audible. A field test version of Rw, Sound Level Difference (Dw) with NR together is often used to determine Acoustic Privacy in Europe. A privacy rating of 75 is considered as a good acoustic privacy level and, 85 a high level of acoustic privacy where loud speech is barely audible and intelligible. Sound masking is a vital acoustic system for sound privacy in open-plan offices by adding background noise. An electronic sound masking system typically used in open-plan offices generates ambient background noise that matches the frequency of human speech. This makes conversations in open environments unintelligible to nearby coworkers, providing sound privacy. Various masking sounds such as white noise and pink noise have been explored to reduce the intelligibility level of speech from adjacent co-workers in open-plan offices. While high acoustic variation such as music can affect emotion positively, it tends to distract people's concentration and disrupt

with short-term working memories and cognitively demanding functions. Among nature soundscapes, water sounds with limited acoustic variation have shown more effectiveness than high acoustic variation such as bird songs. Sound mitigating construction methods help decrease sound travel and increase sound isolation via the details during the construction, including constructing interior walls/partitions with staggering gypsum board seams; completely sealing interior walls at the top and bottom; using a door with a non-hollow core, gaskets all around door perimeters, and door sweeps for meeting rooms, conference rooms, and private offices; using sound isolation hardware, such as resilient channel clips or floor isolation hardware.

Thermal comfort is the source of one of the most frequent complaints in the office environments. In periodic facility satisfaction surveys, being hot and being cold have consistently been top two complaints about office environments [41]. *Thermal comfort* is one of the most difficult challenges in meeting expectations of occupants as it is determined by (1) environmental factors: air temperature, air velocity, radiant temperature, and relative humidity; (2) personal factors: clothing and metabolic rate, and (3) work-related factors including work demand. In addition, other biological and physiological factors also affect thermal sensation among various people. Women tend to prefer higher temperatures, preferably 2.5°C higher, than men [42, 43] and are more sensitive to temperature than relative humidity while men are the opposite [44]. Similar to noise sensitivity, some people have thermal sensitivity, showing lower tolerance to undesirable thermal conditions. Due to individual and biological differences in thermal sensation, thermal comfort in the workplace needs to be sought in spatial planning, work settings, and policy support beyond technical and mechanical approaches.

Thermal comfort in the workplace can be addressed via fundamental thermal comfort measures and advanced temperature control through ventilation systems. Fundamental thermal comfort measures focus on thermal comfort issues in an integrative way by considering environmental factors, flexible work settings, and policy together: providing individual thermal comfort devices such as fans and protective clothing or blankets; allowing a flexible workstyle for employees to be able to move to another space with a desirable temperature or shift to another type of task requiring a different level of metabolic heat; providing spaces with various temperatures for employees to choose from; providing cabinets, lockers, or cloak room for people to store extra layers of personal clothing or blankets; separating heat-generating equipment and devices from major workspaces; maintaining 30–60% of relative humidity (up to 65% for mechanically ventilated spaces); and policy to conduct an occupant survey to ensure that at least 80% of people at work are satisfied with temperature and humidity as prescribed in ANSI/ASHRAE 55-2013 [45]. Advanced temperature control via ventilation systems can be an expensive investment and, thus, requires consultancy with experts to carefully determine pros and cons of systems, adequacy to address thermal comfort in the particular environments, and the return on investment. These systems include operable windows with outdoor air monitoring system in a mechanically ventilated office; natural ventilation system or passive cooling; radiant heating system; dedicated outdoor air system; and displacement ventilation system such as underfloor air distribution system or low-side wall air distribution system.

Olfactory comfort concerns not only unpleasant odors but also toxic chemicals used to create pleasant odors. Unpleasant odors in the workplace can come from various sources such as food, garbage, bathrooms, and storage. In addition, there is an issue of chemical sensitivity in the workplace for those who are allergic to certain chemicals used in fragrance, scents, air fresheners, and cosmetic lotions. A recent study shows that nearly 20% of people have chemical sensitivity to chemicals used in everyday products and over 90% of people with multiple chemical sensitivity have

fragrance sensitivity [46]. This raises a caution to daily chemicals used in the workplace. There is also a general concern with harmful chemicals used in cleaning agents in the workplace. To prevent strong odors from the spaces where the sources exist, the following strategies help to alleviate the problems and enhance *olfactory comfort*: providing self-closing doors; deck-to-deck partitions; separate exhaust; negative pressurization; a buffer space such as an interstitial room, vestibule or hallway separating spaces generating strong odors from major workspaces. In addition, having a workplace policy regarding fragrance sensitivity and the use of other daily products with toxic chemicals such as air fresheners is a good way to enhance *olfactory comfort*.

Lastly *furniture ergonomics* provides a support for the overall physical bodily comfort. Due to the efficiency-oriented work settings and longer working hours in the contemporary workplace, a sedentary workstyle has caused adverse health issues. A significant amount of work-related musculoskeletal disorders (WMSDs) is a well-known issue in the workplace and a critical reason for the need of ergonomic furniture. WMSDs are injuries or disorders in muscles, spinal discs, nerves, tendons, joints, and cartilage caused by the work environment or certain work conditions such as repetitive movement or forced awkward postures [47]. Typical WMSDs include back pain, sprains, strains, tears, and carpal tunnel syndrome. WMSDs are not only causing an annoying pain, that is often chronic, to manage for employees but also a significant amount of costs to employers in the forms of compensation costs, absenteeism, increased healthcare cost, and lost productivity [48]. *Furniture ergonomics* is critical to properly support the human body systems and reduce the risks of WMSDs. Many standards and guidelines related to ergonomics of workplace furniture can be easily found in the literature from the Occupational Safety and Health Administration (OSHA) of the US Department of Labor, the Human Factors and Ergonomics Society (HFES), and the Business and Institutional Furniture Manufacturers Association (BIFMA).

The fundamental ergonomics for workplace furniture include providing individual workstations with ergonomic sizes and clearances; ergonomic conditions of individual workstations in open-plan offices; and ergonomic chairs for individual workstations. Ergonomic sizes and clearances of individual workstations include: a minimum desk surface of 20 inches (50 cm) between a seated person and a monitor and a minimum of 30 inches (76 cm) to place both a keyboard and a monitor; height-adjustable desk between 20 inches (50 cm) and 28 inches (72 cm) for seated tasks; height-adjustable desk to accommodate standing tasks; sufficient under-desk clearance, minimum width of 20 inches (50 cm) and a minimum depth of 15 inches (38 cm) for knees and 24 inches (60 cm) for feet. Ergonomic conditions of individual workstations should address: perpendicular placement of desks to window panes to reduce glare and brightness contrast issues; matt finish on desk surfaces to reduce glare; 24–27 inches wide desk surface edge to accommodate armrests of chairs; and round front edge of desk to avoid contact stress of wrists. Ergonomic chairs for individual workstations should have such attributes as height- and depth-adjustable seat; seat with a minimum width of 18 inches (45 cm) and the length between 15 inches (38 cm) to 17 inches (43 cm); rounded, waterfall edged front of the seat; height-adjustable armrests; armrests with tilting capability (inward and outward from the user); backrest with reclining capability, a minimum of 15 degrees; backrest with a minimum height of 15 inches (38 cm) and a minimum width of 12 inches (30 cm) with a lumbar support; and chairs in different sizes/fit available for people with a particularly small height (5′2″ and lower) or tall height (6′3″ and above).

3.1.3 Physical nourishment

The science clearly tells us how physical activity and diet issues go hand-in-hand together in human health. According to the WHO, poor diet, especially, consuming a

significant amount of foods and beverages high in calories but low in nutrients, is the main culprit of overweight and obesity along with physical inactivity [49]. A medical condition called metabolic syndrome or insulin resistance syndrome, a combination of metabolic disorders showing the symptoms of obesity, high blood pressure, and diabetes is a particular concern of public health related to chronic diseases. Dietary factors significantly contribute to both the development and control of metabolic syndrome. Metabolic syndrome as well as cardiovascular disease (CVD) and certain cancers can be improved and prevented by certain dietary factors, including consuming healthy fats, consuming fruits and vegetables, eating whole grains, and limiting sugar intake and overall excessive calories [50]. In addition to dietary factors, professionals in the workplace design, planning, and management have also started developing strategies through environmental attributes, choice architecture, and workplace policy to support healthier diet and behaviors in the workplace. In this capacity, the built environment professionals are expanding their traditional roles to facilitate and orchestrate the overall workplace health, working with other professionals in nutrition, diet, genetics and neuroscience, as well as human resources to tackle such a complex problem through multi-disciplinary interventions. This section focuses on providing *healthy food amenities* as environmental strategies and encouraging *health-conscious eating habits and behaviors* through the method of choice architecture.

The strategies to support healthy eating via *healthy food amenities* include providing onsite food-related amenities for employees; and enhancing onsite eating space features. Onsite food-related amenities include cold food storage, cabinets and storages available for personal food items that employees bring, food heating-up appliances such as microwave, and dish washing supplies and sink. Enhancing onsite eating space features encourages employees to use the space to prevent eating alone or at individual desks and rather socialize with colleagues during lunch time. Eating in a social setting has several benefits. It slows eating speed down, preventing people from eating too fast and consequently overeating. It also makes people more mindful of the type, amount, and contents of food they consume, compared to eating alone or eating while working. And there is a benefit of increasing social well-being while conversing and socializing with others. Desirable features of eating spaces include various types of seating arrangement available; daylight; art and design elements available such as paintings, plants, water features, or music; and being sufficiently large enough to accommodate at least 25% of employees at once.

The main strategies to encourage *health-conscious eating habits and behaviors* involve the concept of choice architecture. Choice architecture is a practice of presenting choices to consumers at points-of-decision with strategies to influence their decision toward desirable options in behavioral economics. This influence on people's decision is called nudging. Choice architecture has been practiced in commercial food industry for a while. The same principles and strategies are now suggested to influence people to make healthier food choices. These strategies can be divided into two groups: food-related and non-food-related. Food-related choice architecture strategies include proximity of healthy foods—placing healthier food choices close to people's point-of-decision or purchase point; portion control—smaller portioned food options available; promotion of healthier choices—use of more appealing packing, appearance or display of healthier foods; and healthy default—providing healthy default side dishes with bundled meals. Non-food-related choice architecture strategies are ambience—using environmental design elements, such as lighting, colors, or spatial features, to highlight healthier food choices; pricing—providing reduced prices for smaller portioned options or healthier options; prompting—providing nutrient information and use of messages or signage at points-of-decision or purchase point; and convenience—providing an expedited checkout options for foods marked as healthy food options.

3.1.4 Cognitive well-being

The cognitive well-being dimension emphasizes environmental supports to enhance cognitive mental processes of attention, memory, problem-solving, reasoning, and thinking for occupational functions. Cognitive domain mainly focuses on the mental capacity related to thinking process, acquiring knowledge and associated behaviors, while emotional domain focuses on the feelings that affect moods, attitudes, and consequently behaviors. However, human mental domain is a complex territory that is intertwined and influential among the components within themselves. It is often seen that a positive emotional mood is associated with enhanced cognitive performance. Thus, cognitive well-being in this section mainly concerns on how to enhance mental capacity related to job functions through the environment, and the emotional well-being section, on workplace environmental attributes to create positive moods and attitudes in its own dimension.

A cognitive performance-conducive environment in the workplace is an age-old discussion since job performance in the contemporary knowledge workplace is mainly related to employees' cognitive functions. Many studies in organizational behavior and management have explored how to create work environments conducive to employees' creative and innovative ideas and problem-solving under the innovation economy. As entrepreneurship, technological interventions, and innovations have become important for economic growth under new financial challenges and downturns, specific workplace strategies have been sought to enhance employees' cognitive performance in the knowledge workplace. Cognitive performance and well-being has also been discussed in cognitive and organizational ergonomics. As a study of human-system interactions at work, when applied to the environment, cognitive ergonomics focuses on environmental supports for mental process of information and memory, while organizational ergonomics, on organizational structures and policies [51]. Cognitive well-being strategies comprise three major themes to reduce cognitive overload and increase support systems: providing appropriate *types of spaces*; *flexibility and flow* in the major workspaces; and *acoustic privacy*. In addition, crowding and density, proximity, and visuospatial information process affect cognitive performance and well-being at work. Thus, environmental supports are necessary to provide appropriate space planning and sensory balanced environments to reduce cognitive overload, stress, and errors, and assist with better attention and decision-making.

According to the literature in organizational management, choices and autonomy in the workplace contribute to organizational creativity and innovation by building trust, transparency, and even engagement. Allowing employees to be able to find appropriate *types of spaces* for the tasks that they need to accomplish is critical to support their job functions. There are four types of work modes in the knowledge workplace including socialization, externalization, combination, and internalization [52]. Typical spaces necessary to support these four types of knowledge work modes are spaces for focus, socialization, and collaboration. Collaboration spaces can accommodate various needs and modes of collaboration such as formal vs. informal and scheduled vs. impromptu. These collaborative spaces can also be either technology-enhanced in various degrees or technology-free depending on the purpose of the tasks and outcomes. When providing these spaces, it is important to offer various degrees of settings for sensory balance. For instance, the workplace can identify best settings for spaces with higher privacy vs. spaces for interaction, quiet spaces vs. noisy spaces, and various lighting levels and thermally variant spaces to accommodate physical comfort to enable their best cognitive performance. Along with these spaces, various furniture settings can also be provided: formal setting vs. informal/casual settings, and high ergonomic settings for focused mode and longer stay vs. low ergonomic settings for casual and shorter stay.

Respite or recharge spaces are a fourth type of spaces necessary for employees to mentally cope with stress, work demand, and physical fatigue. Contemporary workers are frequently cognitively overloaded, receiving more information every second than their conscious brain can digest. This causes a constant mental fatigue and blocks that adversely affect their performance. There are multiple studies that highlight the benefits and the power of breaks and respite on physical and mental restoration. When taking micro-breaks, especially, engaging in relaxation and socialization activities throughout a day, employees tend to be less stressed by work demands and better recover from negative affect from work-related stress [53]. They also tend to have a higher level of focus, a greater creative thinking capability, and a substantially increased sense of health and well-being [54]. Respite or recharge spaces, intending to provide a short mental break and cognitive restoration, consist of play spaces, solitude spaces, social spaces, and designated outdoor respite spaces (**Figure 4**). Play spaces are provided for physical activities and games with supportive equipment. Solitude spaces are for personal lounging, reflection, contemplation, meditation, or religious practice. Social spaces are for social interactions and gatherings. Designated outdoor respite spaces include outdoor lounge areas, outdoor garden, balconies, or rooftop hangout places. If there are not designated outdoor respite spaces associated with the workplace, having access to public respite spaces is another great way to offer employees outdoor respite spaces.

Flexibility and flow of major workspaces are necessities to supporting cognitive functions by providing flexible spatial capacity and flow to aid various tasks and numbers in team/group as well as to capture the flow of ideas. The success of a knowledge workplace depends on successful organizational knowledge management. And knowledge management ability relies on how an organization can capture, share, manage and deliver information in real time to make faster but accurate



Figure 4.
Interface Headquarters in Atlanta, Georgia, USA. A respite, social space with biophilic/evolutionary psychological design features, highlighting high IAQ and non-toxic materials. LEED platinum and WELL silver certifications pending. Photo courtesy: Nick Merrick, Hall + Merrick photographers.

decision-making [55]. *Flexibility and flow* of major workspaces can be achieved by four strategies: providing expandability, versatility, and convertibility of major workspaces, and implementing non-hierarchical spatial planning. Expandability addresses a capacity to accommodate growth with expansion such as a space with movable partitions to open up the space to accommodate bigger groups. Versatility refers to a capacity to accommodate several different activities as multifunctional spaces such as a space with various settings of furniture to accommodate different activities in the same space. Convertibility means a capacity to change in function through the conversion of spaces such as a space that can easily be modified to change its purpose to serve another function. Non-hierarchical spatial planning is spatial planning that blurs the traditional power structure at work through different space allocation or layout from the traditional planning such as assigning spaces by the best use of the spaces or types of furniture by the functions of the person instead of the hierarchy of the organizational structure. Non-hierarchical organizational structure tends to promote an organizational culture that encourages individual views and participation, informality, and freedom, which is crucial to innovative performance and outcomes [56].

Acoustic privacy is one of the major problems in open-plan offices. *Acoustic privacy* can be achieved through spatial options and behavioral change: providing separate, designated focus/concentration spaces away from open workspaces; providing a phone booth type of small private rooms for confidential or private conversations or calls; conducting an early assessment, identification, and space planning to establish quiet zones separately from noisy/interaction zones; and workplace policy for office etiquettes. It should be noted that the major sources of noises in the workplace are people-related issues. People's conversations with others nearby or via phone and telephone left ringing being most disruptive, significantly worse than noises from office equipment and outside the building [57]. Thus, workplace etiquettes promoting courteous behaviors for others who might be sensitive to noises can be an impactful way of mitigating noise issues at the root of noise sources through workplace policies and achieve *acoustic privacy*.

3.1.5 Social well-being

The social well-being dimension focuses on enhancing *social connectivity* and support social systems in the workplace. While many conversation in the built environment revolves around physical and mental well-being, research suggests that social well-being has huge impact on both psychological and physical health as well as longevity [58, 59]. The intangible impact of social well-being can be even more significant, affecting longevity more than smoking, drinking, and obesity [60]. Thus, it is important to address how to promote *social connectivity* via workplace design and planning. Spatial layouts significantly affect how people interact and have been used to predict social interaction patterns and behaviors in the built environment.

Providing *social connectivity* between people in the workplace through space planning and design features can enhance not only social bond and inter-personal relationship between colleagues but also interactions and communications necessary for job functions. When communications increase in the workplace, people tend to also talk about task-related conversations, which then promote feedback, conflict reduction, and increased motivation [61]. Socialization activities at work have shown to reduce work demand-related stress and negative affect at the end of workday [53]; increase cohesion; and decrease employee turnover [62].

Enhancing *social connectivity* through spatial layout and planning can be done in four ways: providing social spaces; increasing visual connectivity; establishing core

interaction networks; and implementing cross-pollination space planning practice. Social spaces include impromptu meeting spaces at corners, along the hallways or major paths of traffic to increase serendipitous interactions and meetings; central or local open lounge areas; food/beverage spaces such as café, snack bar, or pantry; and breakrooms. Visual connectivity can be achieved via either horizontal or vertical visual connectivity. Horizontal connectivity can be enhanced through the use of lower partitions than 42 inches (1 m) high or transparent materials for partitions and enclosed spaces. Vertical connectivity can be achieved by creating a vertical openness using inter-floor stairs or atrium. Establishing core interaction networks is a vital way to increase social connections. An organization is defined as connected points of people that create the pattern of communication or information exchange among them, acting as a network in an organization, and social networks play a critical role in generation innovative outcomes [63]. Core interaction networks can be established by placing individuals who are the core interaction networks within a department/team along the core circulation paths for easy access and increased exposure for others. Furthermore, cross-pollination space planning practices can promote social interactions by connecting core circulation paths to the informal or impromptu meeting and social spaces where colleagues in different departments/teams can frequently meet and gather informally.

3.1.6 Emotional well-being

The emotional well-being dimension mainly concerns workplace environmental features providing individual emotional state of happiness and satisfaction. Emotional well-being is a dimension above the first two basic human needs: biological and physiological need and safety need in Maslow's hierarchy of needs that explains behavioral motivation [64]. Emotional well-being is a critical dimension to the overall quality of life, and can be addressed via three major topics related to environmental features in the workplace: *biophilic design*, *art and design elements for pleasure*, and *personalization and control*.

Biophilic design refers to environmental design strategies and features to enhance human's innate bonding with nature. It has been long recognized human's strong instinct responsive to natural forms and patterns, and their desire to integrate those into their habitats and lifestyle. Restoring this bond, once broken due to industrialization and modernization, is now emphasized as a critical component to human mental well-being. Nature has been highlighted for its therapeutic benefits on improved moods, reduced stress, and restoring human adaptive resources [65–67].

Biophilic design strategies consists of three major topics: providing sensory stimulation by nature and integrating natural elements; views and circadian lighting support; and accommodating evolutionary psychological design.

Sensory stimulation by nature and integrating natural elements are related to visual, auditory, and olfactory sensory experiences with natural elements as well as their components expressed in design elements. There is a plethora of studies that provide evidence of multiple benefits from the power of seeing or contacting with nature on human mental capability coping with physical healing, stress and fatigue reduction, and faster cognitive restoration. In addition, using vegetation or plants in interior spaces can be an effective strategy to reduce noise, provide privacy, and decrease negative feelings of crowding, which also contribute to health and well-being in the workplace. Recently, organizations have started paying attention to the positive relationship between natural elements and employee's enhanced cognitive function and performance, and, thus, potential organizational benefits from increased productivity as well as engagement. Providing sensory stimulation by nature and integrating natural elements can be achieved by presence of green

vegetation; water elements; 2D or 3D artwork depicting natural elements or scenes; sounds of nature; smells of nature; shapes and forms of nature in workspaces or materials; patterns of nature applied to the spatial design; materials of nature; colors of nature.

Circadian lighting is a recent focus among lighting professionals to provide human-centric lighting by supporting human innate body clocks, circadian rhythms, that synchronize human physiological functions with the approximate 24-h day-night solar cycle. As a type of neuron in the retina of eyes, the intrinsically photosensitive retinal ganglion cells (ipRGCs), sends information on the time of day to an area in the brain called the suprachiasmatic nucleus which synchronize clocks in peripheral tissues and organs in human body, the role of light has become more than providing visual functions. Circadian lighting is known to regulate various hormones such as growth hormone, melatonin, and cortisol that affect sleep, mood, stress, and eating and diet habits. Imbalance in circadian rhythms can cause adverse health consequences such as sleep disorder, obesity, diabetes, cardio-metabolic diseases, and even memory and productivity [68–70].

Views to outdoors and circadian lighting support can be incorporated through non-obstructive views and no tints on the windows; minimum two lines of sights to vision glass in the primary workspaces; views of natural elements outside the windows such as plants, skies, etc.; non-obstructive views within the distance; locating at least half of the primary workspace (or regularly occupied spaces) within 40 feet (12 m) of windows or atriums. Furthermore, using a technical metric, either circadian stimulus (CS) or melanopic lux (ML), to assess the amount of circadian light can assist the enhancement of circadian impactful lighting (**Figure 5**). However, when it comes to design solutions for circadian lighting, a cautious approach is necessary. While there is a sufficient amount of research indicating the impact of light on our body clock, it is still too early to be conclusive on what solutions are truly desirable and effective. In addition, daylight is a complex issue as it can create other undesirable problems: glare, overheat, and higher cooling loads. It is worth noting an approach suggested by the US General Services and Administration (GSA) called daylight ecosystems that require a comprehensive approach to daylight solutions by integrating daylight design for daylight penetration strategies, interior design for choices of finish materials and desk orientations, and human factors to support user behaviors [71].

Evolutionary psychology is an approach to the study of human behaviors that explains how the brain works and behaviors form based on biological reasons. Prospect-refuge theory, similar to mystery theory discussed in the active design section, explains many aspects of human visual and environmental preferences in nature and their psychological comfort, security, and safety related to these preferences. According to the theory, people feel secure, safe, and comfortable in a space with an open view: prospect for easy surveillance to detect hazards, and a space protected from behind and above: refuge to safeguard themselves from unexpected hazards. Prospect-refuge theory has many implications especially in open-plan offices. These implications include visual access to activity hubs or similar central spaces from individual workspaces with lower partitions and transparent materials; dropped ceiling and/or elevated floors in areas with high ceilings; quiet spaces covered by three sides such as reading nooks, booths, or alcoves; operable or adjustable translucent screens or semi-opaque partitions; clusters of workstations; freestanding planters or vegetated partitions in circulation paths between clusters of workstations; and retreat spaces looking out to outside views.

Art and design elements for pleasure addresses human innate desire for esthetic pleasure. Esthetics used to be a domain of psychology but neuroscientists are currently also exploring the answers for why humans develop esthetic adjustment and appraisal by examining the human brain. The approaches to *art and design elements*

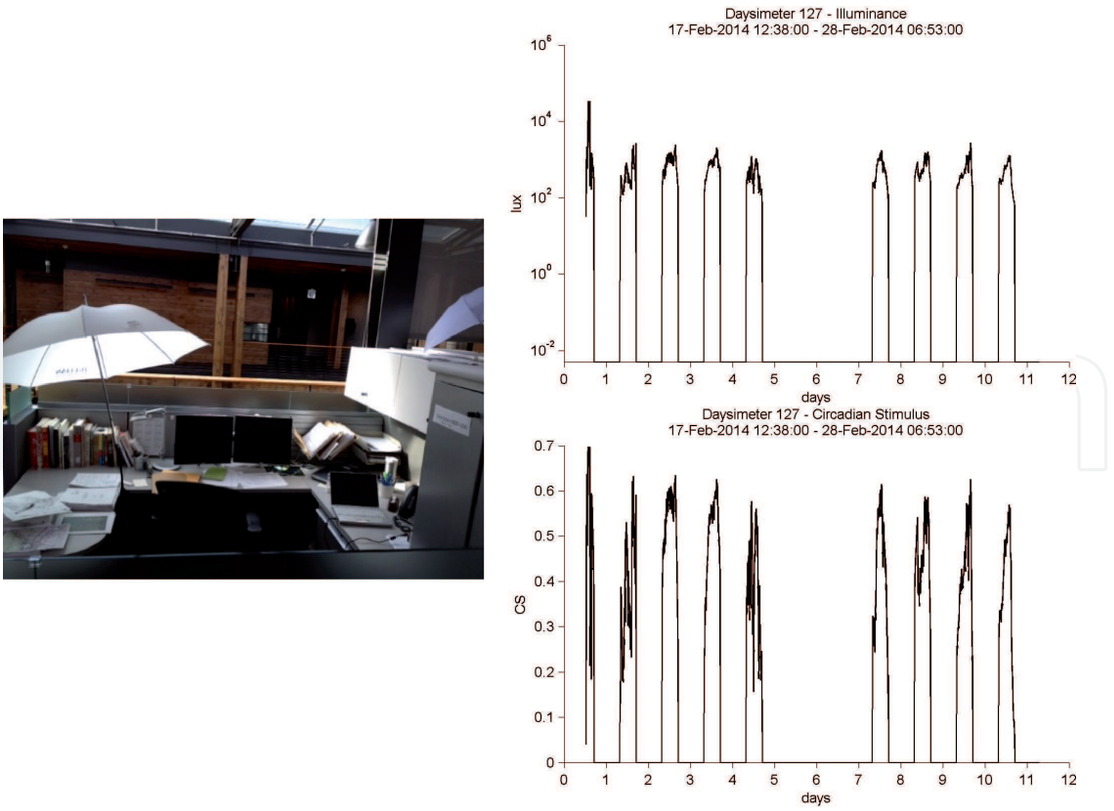


Figure 5.
Circadian stimulus measured at a desk with an umbrella improvised by employee to block too much sunlight and glare from the skylight, the US GSA Federal Center South building. Photo courtesy: the US General Services Administration.

for pleasure are composed of three topics: incorporating art and design elements; sensory engagement in common or open spaces; and relaxing settings.

Art is known to have not only emotional impact but also cognitive and psychological stimulation. In addition, the literature suggests its healing power shown through positive physiological improvements related healthy symptoms [72]. Art and design elements deal with conventional artwork and installation as well as unconventional design components in the workplace. According to the organizational management literature, ease and laughter in the organizational culture in the workplace is one of the critical elements contributing to less stress, cognitive release, and social cohesion. These concepts can be expressed by fun, whimsical, unconventional design features that we have witnessed in successful tech companies and creative industries as part of their effort to create an ambience of ease [73]. Art and design elements for pleasure include artwork, designwork or installation in major common spaces and regularly occupied spaces; interior components with unconventional functions and shapes; unconventional use of finish or furnishing materials; and fun and unique decor such as whimsical signage, ornaments, or similar items.

The sensory engagement in common or open spaces involves three common sensory systems: visual, auditory, and olfactory as well as another sensory system that is typically expressed in interior design elements: tactile. Sensory engagement comprises visual elements utilizing colors and patterns; auditory elements, music or sounds of nature; olfactory elements, smell or scent such as smell of coffee or herbs; and tactile elements, various levels of soft and hard textiles and textures. These sensory stimulations tend to influence emotional states and also raise mental awareness and cognitive engagement. There are, in general, more design strategies to create visual stimuli utilizing colors and patterns than other types of sensory stimuli. This

is due to the human neurophysiological condition that 30–40% of human cerebral cortex is allotted to vision, making vision the most dominant sense in the human body, while the cerebral cortex for auditory sense is only 3%.

Relaxing settings create an ambience of positive state of mind and ease. Relaxing settings are related to expanded experiences in the workplace that are associated with the first place (home) and the third place (café) beyond the second place (workplace). The attributes of the first place bring psychological comfort to the workplace, and the attributes of the third place, a sense of community and social activities as an anchor in the community. Home-like settings, especially, enhance such organizational cultures as freedom and autonomy which contribute to flattened hierarchy and nonconformity that are critical to employees' mental well-being. In addition, certain successful start-up companies have seen a significant role of such a home-like environment as a work environment in increased creative and innovative outcomes. This is because such an environment enhances organizational cultures vital to business success such as less hierarchical structure, more social connections between colleagues, and shared visions and goals. Sensory engagement in common and open spaces can be enhanced by providing furniture/furnishing types associated with the first place or the third place; and spaces emulating residential setting or the third place.

Personalization and control is an essential component for workplace health in open-plan offices. Numerous studies support the positive impact of personalization of work spaces and furniture arrangement as well as personal control over the environment on job commitment, motivation, engagement, job satisfaction, and performance. Personalization is a critical mechanism for employees to express their emotions, manage stress, and control their workspaces [74]. This tends to be more important to women as women personalize their spaces more than man and more frequently rearrange their workspaces [75]. The strategies for personalization and control in open-plan offices consist of allowing employees to display physical personal items such as artwork, plants, photos of people in individual workspaces; display personal items such as personal photos digitally through computer screensavers; adjust/reconfigure the settings in individual workspaces; and choose the layout of their individual workspaces.

3.1.7 Environmental well-being

The environmental well-being dimension concerns providing non-toxic and clean environment for employee health. There has been a plethora of research conducted in this topic, and many technical standards and guidelines have been established to protect human health in the built environment. While an extensive list can be sought to battle the problems related to toxins, chemicals, and cleanliness in work environments, this section discusses four main sources that are typically found in the workplace: *indoor air quality (IAQ)*; *drinking water quality*; *chemical control*; and *cleanliness and maintenance*.

IAQ is one of the strongest predictors of workplace health as well as performance. Poor *IAQ* has been linked to both physical, psychological, cognitive health symptoms: tiredness, loss of concentration, loss of control, depression, anxiety as well as physical conditions: irritation of skin, respiratory tract, asthma, allergic reactions to pollutants, infectious diseases and even cancers [76]. In addition, poor *IAQ* problems are known as one of the leading causes of distractions and decreased productivity [77]. *IAQ* in the workplace can be controlled, maintained, and enhanced through three themes of major strategies to provide good quality air: removing or preventing chemicals, pollutants, and irritants in the air; providing air filtration system; and employing *IAQ*-enhancing features. To remove or prevent

harmful and hazardous toxins and irritants, the following strategies need to be sought. Indoor smoking should be banned. A minimum of 10 feet long entryway system needs to be implemented in building entrances to remove and prevent outside dirt and particulates from entering into the building. Sources of chemicals and pollutants need to be controlled in the janitor closets, bathrooms, copy/print rooms, and storages for products containing harmful and hazardous chemicals by using a combination of self-closing doors, deck-to-deck partitions, exhaust rate of minimum 0.5 cubic feet per minute (cfm) per square foot (0.15 $m^3/min/m^2$) with no air recirculation, and negative pressure at least 5 Pascals on average and 1 Pascal at a minimum when the door of the room is closed.

Volatile organic compounds (VOCs), organic chemicals that easily evaporate at room temperature due to a high vapor pressure, cause irritations in eye, nose and throat, headaches, nausea, and damage to human organs and central nervous system. VOCs must be controlled and limited in various building, interior, and cleaning products. There are various standards and guidelines in relation to VOCs in the built environment that can be complied with when seeking to purchase particular items in the workplace. These include but not limited to the following: Green Seal Standard GS-36 Paints & Coatings, GS-11 Paints, and GC-03 Anti-Corrosive Paints, ASTM D 2369-10 Standard Test Method for Volatile Content of Coatings, ISO 11890 Paints and varnishes—Determination of VOC content, CRI Green Label Plus Program & Green Label Program for carpet, cushions and adhesives, FloorScore for surface flooring materials, adhesives, and underlayments, and ANSI/BIFMA e3-2011 Sustainability Standard Method for furniture.

Air filtration systems are a good means to enhancing *IAQ*. Indoor air pollutants are made of particulate matter typically classified into three groups based on sizes related to their deposit behaviors in human body airways: particulate matter smaller than 10 μm (PM_{10}), 2.5 ($PM_{2.5}$), and 0.1 μm ($PM_{0.1}$). Particles with a diameter greater than 10 μm are less of a concern in IAQ as they tend to be filtered out by human nose and upper airway. Air filter systems in indoors are more concerned with filtering out PM_{10} (coarse particles), $PM_{2.5}$ (fine particles), and $PM_{0.1}$ (ultrafine particles) as they can reach human respiratory system. Air filtration system strategies can be implemented by incorporating in the ventilation system air filters rated with a Minimum Efficiency Reporting Value (MERV) of 13 that filters 90% of PM_{10} and $PM_{2.5}$. The workplace can also employ air purification and disinfection filtration systems to clean indoor air and kill microbes to control pathogens. These systems include carbon filters, ultraviolet germicidal irradiation (UVGI), or photocatalytic oxidation (PCO). Carbon filters are known to filter pollutants and VOCs as well as absorb odors and fumes. UVGI or PCO are recommended for purification and sanitization of air. When employing these filtration systems, it is also important to develop and adopt a policy for a regular filter maintenance program to be able to continuously monitor and sustain the enhanced air quality.

The workplace can further explore other strategies to enhance *IAQ*. Providing a real-time air monitoring display system is a great way for employees to understand the level of IAQ in their spaces by showing the major indoor air pollutants such as carbon dioxide, ozone, and particle count. The workplace can also develop and adopt a green purchasing policy as a procurement policy of products and services to reduce negative impact of *IAQ* on occupant health. Lastly, controlling and monitoring outdoor air delivery and quality can enhance *IAQ*. The workplace can increase outdoor air ventilation rates in all occupied spaces by minimum 30% above the ASHRAE 62.1 requirement and monitor outdoor air contaminant concentrations regulated by National Ambient Air Quality Standards (NAAQS) for the six common air pollutants: carbon monoxide, lead, ground-level ozone, nitrogen dioxide, particulate matter, and sulfur dioxide.

While *drinking water quality* is controlled and managed by the laws and codes for basic human health, there are strategies to further enhance the quality of drinking water in the workplace through water filtration systems. These water filtration systems are employed to clean, sanitize, and screen organic and non-organic pollutants. Sediment filter systems, acting like a net, screen solid particulate transported in water. Reverse osmosis (RO) systems and kinetic degradation fluxion (KDF) filters can remove dissolved hazardous metals such as lead, mercury, and arsenic from water. UVGI and the National Sanitation Foundation filters are sanitization filters to reduce microbes in drinking water.

Hazardous chemicals in building and interior materials need to be controlled. Persistent bio-accumulative and toxic (PBT) chemicals are especially a major concern. PBTs are chemicals that do not easily degrade and cause adverse health impact such as reproductive dysfunction, endocrine disruption, or cancers by accumulating in organisms for an extensive period. There are many green building standards and guidelines that have established what chemicals need to be regulated in building and interior materials for occupant health. The workplace should ensure that there are no human carcinogens such as asbestos, lead, polychlorinated biphenyl (PBTs), mercury, cadmium, perfluorinated compounds (PFCs), halogenated flame retardants, phthalate (plasticizers), isocyanate-based polyurethane, and urea-formaldehyde in building materials; and no urea formaldehyde, mercury, lead, antimony, cadmium, and halogenated flame retardants in furniture and furnishings materials. In addition, the workplace can purchase furniture that is certified by the Scientific Certification Systems (SCS) Indoor Advantage Environmental Certification and interior finishes and furnishings certified by Declare®, Cradle to Cradle®, Cradle to Cradle® Material Health, Health Product Declaration®, Underwriters Laboratories (UL)' Product Lens™, Facts-NSF/ANSI 336, or SMaRT©.

Lastly, *cleanliness and maintenance* should be addressed to sustain the quality of indoor environment that is controlled, monitored, and toxin-reduced. *Cleanliness and maintenance* can be addressed in two ways: cleaning equipment and agents, and cleanliness and maintenance level. The workplace can develop and adopt a protocol for cleaning and maintenance by determining frequency, supplies, equipment, and procedures. Another protocol is also necessary for the cleaning storage to instruct how to handle and store hazardous chemicals such as bleach and ammonia-based cleaning products. Using cleaning agents that are certified by a reliable third party is a good way of practicing how to identify and purchase cleaning agents that do not contain harmful chemicals. These certificates include the US EPA Design for the Environment, UL EcoLogo®, or GreenSeal®. The cleanliness and maintenance level can be addressed by achieving cleanliness and hygiene that is equivalent to Level 2 Ordinary Tidiness as defined in the Association of higher Education Facilities Officers (APPA) custodial guidelines for general office spaces. The Level 2 Ordinary Tidiness indicates when there is no built up in corners or along walls; there is no more than 2 days' worth of dust, dirt, stains or streak; and marks, smudges and finger prints are noticeable only upon close examination. Hygiene-sensitive spaces need additional care. This requires cleaning all countertops and fixtures in the bathrooms and kitchen and shelves and surfaces inside refrigerators with proper hygiene cleaning agents on a regular basis. In addition, a management policy for pest and garbage should be in place to instrument employee to store all non-refrigerated perishable food in sealed containers for pest management and providing garbage cans with a lid or hands-free operation.

4. Conclusion

Promoting workplace health is a complex challenge that requires multi-layers of approaches from various disciplinary solutions in a collaborative manner to increase

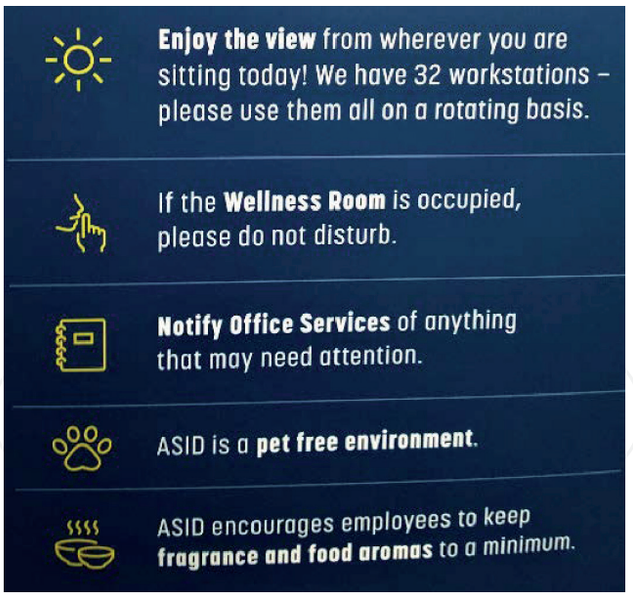


Figure 6.
ASID office etiquette list posted in the open-plan office. Photo courtesy: the American Society of Interior Designers.

physical exercise, healthy diet, mental health, and healthy lifestyle all together to change the current health epidemics. These approaches include not only technical measures but also spatial planning, design strategies, and workplace policies (**Figure 6**). The PROWELL model and its 7 KPIs of WH suggest a comprehensive approach to workplace health to address this. While 7 KPIs of WH address comprehensive topics, WH is not limited to only the strategies and specific measures discussed in this chapter. Other strategies, thus, can be further implemented to increase mental health and social well-being through various assistance programs and workplace policies to provide a balanced health in all three domains of health. Individual workplaces can also seek specific KPIs and strategies to promote a particular target domain or organizational outcomes more desirable to a workplace under specific pursuits and circumstances.

It is worth noting that while many health interventions at work have focused on health impacts at the individual level, companies are more interested in understanding the impacts of workplace health at the organizational level by exploring organizational outcome measures such as the sickness absenteeism, accident rates, work-related injuries, presenteeism, job performance, employee engagement, and retention rates [78]. Through decades-long research in public health, we have learned certain organizational outcome measures are more meaningful to the organization level decisions. For instance, sickness absence analysis tends to be less meaningful as a health measure to organizational decision-making in establishing better health promotion strategies, or motivating employees to engage in healthier behaviors, compared to other types of measures [79].

When looking for workplace health outcomes at the organizational level, it is important to note many discrepancies shown in various studies. These discrepancies are likely due to validity and reliability issues in research designs. The poorer the research methodological quality is, the higher the effects are [80, 81]. Thus, we need to be aware of possibilities of either under- or over-valuation of certain health interventions in research reports instead of trusting the impacts interpreted as exact numbers and dollar amounts. What is important is that there is a consistent discovery of the benefits of workplace health in both employee health and organizational outcomes. At the same time, it is important to develop further proper research methods and designs to yield more accurate results to narrow the discrepancies.

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