WELL Building: Key design features for office environments

Article · April 2023

DOI: 10.1061/JAEIED.AEENG-1544

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ABSTRACT

This study aims to explore the key design features that support office building occupants from the adverse effects on health, well-being, and productivity (i.e., the three aspects in the WELL Building Standard). To achieve that aim, the objectives are to: (1) identify the key design features that support health, well-being, and productivity; (2) compare the key design features; and (3) analyze the interrelationships between the key design features. Information from a systematic literature review and semi-structured interviews with twenty-three office building occupants were used to develop a questionnaire survey consisting of thirty-three design features. Mann-Whitney-U test, Kruskal-Wallis H test, normalized mean score ranking technique, overlapping analysis, and Spearman's correlation analysis were used to analyze 206 valid responses. The findings highlighted eleven key design features that simultaneously support office building occupants' health, well-being, and productivity. The design features are air quality, clean drinking water, comfortable artificial lighting, adjustable workstation, comfortable temperature, sufficient space, security systems, safety at parking lots, cleanliness, efficiency in building services, and safe design. From those, the last six key design features are absent from the existing WELL Building Standard. The study findings provide new insights to the body of knowledge on WELL building. Industry practitioners can use the findings in designing, planning, and maintaining office buildings that support health, well-being, and productivity. Additionally, policymakers can establish an alternative rating tool for evaluating office buildings.

Author Keywords: WELL Building; key design features; health; well-being; productivity.

Practical Applications

The study aims to explore the key design features that support building occupants' health, well-being, and productivity in office buildings. Building occupants' health, well-being, and productivity are the three aspects that can be defined as WELL as per the WELL Building Standard. The poor indoor environment of office buildings can negatively impact health and well-being as well as decrease employee productivity, which results in organizational losses. Hence, design features that support building occupants' health, well-being, and productivity should be considered for office buildings. In this study, eleven key design features have been identified to support occupants' health, well-being, and productivity for office buildings: air quality, clean drinking water, comfortable artificial lighting, adjustable workstation, comfortable temperature, sufficient space, security systems, safety at parking lots, cleanliness, efficiency in building services, and safe design. With reference to the key design features, clients can stipulate requirements for WELL office buildings, and design consultants can comprehensively integrate the key design features into office buildings. The study also raises public awareness about the value of WELL building in delivering a quality lifestyle overarching human health, well-being, and productivity.

INTRODUCTION

Working long hours in poor office environments have a substantial impact on human health (Forooraghi et al. 2020; Tekce et al. 2020); well-being (Dreyer et al. 2018; Roskams and Haynes 2019); and productivity (Agha-Hossein et al. 2013; Wu et al. 2020). The office environments comprehend the architectural and functional features that define the office settings and significantly impact office employees (Danielsson 2005). The features include air, light, noise, thermal, office type, workplace design, window view, and indoor plant, which may negatively impact employees in different respects, such as health status, well-being, and productivity (Kamarulzaman 2011; Danielsson 2008). The poor office environment can act as a stressor for building occupants. Examples of stressors that affect health are uncomfortable temperature, poor air and lighting quality, excessive noise, and constraint space (Clement-Croome 2015; Al-Ghamdi et al. 2017; Bluyssen 2019). These stressors can result in an elevated heart rate, migraine, difficulty breathing, fatigue, and muscle tension (Clement-Croome 2015; Al-Ghamdi et al. 2017; Bluyssen 2019). The stressors can also disrupt brain rhythms that lead to mood shifts, which results in poor well-being, decreased productivity, and organizational losses (Clement-Croome 2015). These prior works have posited that the poor office environments are grievously impacting the building occupants. Therefore, identifying key design features that enhance office buildings is vital to support building occupants. The design features can play a notable role in sustaining building occupants from unfavorable indoor office buildings that consequence in ill health, poor well-being, and reduced work performance.

A vitality survey conducted by AIA (American Insurance Association) has revealed that building occupants are having many adverse effects of health complications, well-being issues, and productivity loss (AIA 2019). The results highlighted that 32% of building occupants have serious health risks such as high blood pressure, high cholesterol, diabetes, kidney problems, heart disease, or cancer. Other health issues include musculoskeletal disorders, poor eating diet, obesity, and feeling fatigued every day. A shocking and undeniable finding from the survey revealed that mental health issues are on the rise. As a result, the prolonged negative implications of office buildings have caused substantial losses to individuals and organizations. Organizations are losing approximately USD 4.2 million annually due to presenteeism and absenteeism from ill health (AIA 2019). This predicament has alerted the need for office buildings to relieve building occupants from unnecessary negative impacts. Thus, positive actions are critical for mitigating unfavorable consequences of office buildings through design features that support health, well-being, and productivity among building occupants (WELL 2018).

Different standards have been established for enhancing office buildings in the last few decades. However, initiatives to address health, well-being, and productivity among building occupants have received little consideration in the development of building standards (WELL 2017). Thus, the practical solution is to examine the key design features for office buildings as different building types may require different or additional design features. For example, the primary function of office buildings is to provide a setting that comes with office equipment such as computers, laptops, photocopy machines, printers, and projectors. Hence, the information technology (IT) capacity to support office equipment for productivity is a demand to be satisfied in an office building. In addition, office equipment produces a higher concentration level of indoor pollutants than other enclosed spaces and may require a higher performance of filtrations and maintenance (Destaillats et al. 2008). And, distinct groups of building occupants may require specific design features for supporting their task performance. For instance, office building occupants have high prevalence rates of musculoskeletal pains in the neck, back, and shoulder due to long hours sitting and using computers confined at their workstations (Mahmud et al. 2012). Furthermore, the lack of movement contributes to the risk of obesity (Gates et al. 2006). As such, research that examines design features of office buildings that supports occupants' health, well-being, and productivity is necessary, as different aspects may require similar and different design features. Also, an in-depth investigation of the three aspects to discover any additional design features is vital.

To address the negative impacts in office buildings, this study takes the opportunity to explore key design features that influence the health, well-being, and productivity of office building occupants The second edition of the WELL Standard (2018) defined WELL as a “holistic view of health, not only free of disease but also the enjoyment of productive lives from which humans derive happiness and satisfaction.” Hence, this study aims to explore the key design features to support office building occupants from the adverse effects on health, well-being, and productivity (i.e., the three aspects in the WELL Building Standard). To achieve that aim, the objectives are to: (1) identify the key design features that support health, well-being, and productivity; (2) compare the key design features; and (3) analyze the interrelationships between the key design features. The identified key design features will lay a foundation for relevant regulatory bodies to establish a local WELL building standard for office building assessments. The standard can be used as a benchmark in developing project briefs to ensure that WELL benefits are delivered to building occupants. And also, the standard can raise awareness about the value of WELL buildings.

BACKGROUND

In recent decades, many green and sustainable building standards have been established to meet the trends toward environment-friendly and energy-saving conscious buildings (Pushpakumara and Thusitha 2021). While the green and sustainable paradigms have improved energy efficiency and carbon reduction, the advancements have received little attention and concern on human WELL. For example, Leadership in Energy and Environmental Design (LEED) is a set of rating systems accessed based on eight concepts: location and transportation; material and resources; water efficiency; energy and atmosphere; sustainable sites; indoor environmental quality; innovation and design process; and regional priority credits (USGBC 2014). The Building Research Establishment Environmental Assessment Method (BREEAM) includes ten cost-effective concepts for mitigating the environmental impact of new buildings throughout their life cycle (BREEAM 2018). These standards have included design features like air, water, light, thermal, acoustic quality, and material. However, the key design features supporting humans, such as nourishment (nutritious food access), mind (to sustain mental health), movement (to promote physical activity and fitness), and community (to encourage social interaction), are absent from the existing green or sustainable assessments (Dovjak and Kukec 2019).

As other standards focused on green and sustainable paradigms, the WELL Building Standard (v1) was established by the International WELL Building Institute (IWBI) in 2014 to improve WELL among building occupants. The standard plays a pioneering role in harnessing the built environment to benefit human health, well-being, and productivity (WELL 2018). Several revisions have been made since 2014, and in 2018, the latest WELL Standard (v2) was published. The revised edition incorporates active designs and strategies to promote a healthier, more active lifestyle. The WELL standard (v2) organized the design features into ten concepts: air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community. There are 120 design features associated with these concepts. Every design feature is attributed to the human body (WELL 2018). As the current WELL Building Standard is universal, there is still a gap for in-depth study to explore new design features to support WELL in a particular building type. The physical characteristics and conditions of different building types vary considerably. Additionally, different building types serve distinct tasks and occupy specific groups of occupants that may require varying degrees of attention and support. Therefore, it is vital to identify the unique design features of different building types to support the occupants' WELL. Furthermore, as developing countries have different health, socio-economic, cultural, and climate conditions, the WELL standard may need to be tailored for developing nations. As a result, a gap exists in developing countries that need to be filled.

Prior works have compared the WELL Building Standard to local laws and norms. Landmark (2019) demonstrated WELL's compliance with Swedish regulations and standards for accessing office building facilities. Luddi (2018) and Dekkers (2017) compared the WELL Building Standard with other built environment standards, such as green rating for office building assessment. Fujisawa (2017) proposed a WELL index for office buildings based on two existing standards. In other words, these precedence works focused on the existing legislations and standards. Other researchers discretely explored design features supporting office building occupants' health, well-being, or productivity based on a comprehensive literature review and existing data. When the execution method is confined to the existing data, there are possibilities for certain key design features to be left unidentified. As a consequence, any design features that are paramount for sustaining WELL in office buildings may have been neglected. Hence, this study uses a questionnaire survey aggregated from interview data and a systematic literature review to capture the physical design features of office buildings that are vital for WELL. By doing so, this study fills in the gaps pertaining to the design features of WELL office buildings.

Research Gap & Positioning of this Study

In summary, precedence works have comprehended physical office buildings' design features supporting occupants' WELL based on data such as systematic literature review, legislation, regulations, and existing standards. As a result, any key design features essential for sustaining WELL in occupants may have been overlooked. Furthermore, the prior works were conducted in developed countries. The situations in developing regions vary in terms of their health conditions, socio-economic status, cultural practices, and climate may give rise to a variety of key design features required. To address this drawback, this study attempts to bridge this knowledge gap by integrating all associated key design features of WELL office buildings according to the nation's development in providing an optimized indoor office building to sustain occupants' health, well-being, and productivity.

METHODOLOGY

Survey Development

The study employs a questionnaire survey to discover the key design features to support health, well-being, and productivity (the aspects of WELL) in office buildings. A questionnaire survey systematically collects quantitative data from a large sample size (Chua 2012). A large number of responses increases the confidence in the data obtained to generalize the study findings. In other words, an overall pattern of design features to support WELL in office buildings can be discovered. The questionnaire survey approach is frequently employed to elicit direct responses from participants in built environment research (Radzi et al. 2022; Darko et al. 2017; Mao et al. 2017). For this study, the survey consists of a list of office building design features generated from interview data and journal articles. The subsequent subsections provide the details of developing that list.

First, an in-depth interview with office building occupants was conducted to explore design features that support health, well-being, and productivity. The snowball sampling approach is used to solicit participants. The data collection process ended when data saturation was reached at 23 participants (Tan et al. 2022). The two-way communication of the semi-structured interviews allows freedom to express opinions from the respondents' perspectives. Thus, giving insights to explore design features that may be absent from prior works and beyond the existing data (Chua 2012). Thematic analysis was employed to deduce design features from the interview data obtained (Tan et al. 2022).

In addition to the interview data, the design features were further explored through a systematic literature review (SLR). SLR is a powerful method for developing frameworks and conceptual theories by examining published works (Schryen et al. 2015). It is commonly adopted to explore topics and issues related to built environment research (Chan 2020). Hence, this study uses SLR to identify office building design features that support health, well-being, and productivity. An SLR search was performed using Scopus academic database to explore a list of design features from prior works. The search was not limited to any period as this study aims to explore all design features of office buildings from prior works. Scopus was used among other databases because it covers a broad range of scientific publications and has the highest number of indexed manuscripts (Owusu et al. 2020).

A comprehensive search was initiated under "T/A/K (title/abstract/keyword)" using the keywords: "Office Building" AND "Employee Health" OR "Employee Well-being" OR "Employee Wellbeing" OR "Employee Wellness" OR "Employee Productivity" OR "Employee Performance." The search resulted in the acquisition of 211 journals. The search targeted journals because journal manuscripts are more scientifically valid due to thorough review processes (Olanipekun et al. 2017). The final search string was: (TITLE-ABS-KEY (office AND building)) AND ("employee health" OR "employee well-being" OR "employee wellbeing" OR "employee productivity" OR "employee performance" OR "employee wellness") AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")).

The identified design features from the interview data and SLR were reviewed, and those with similar meanings were merged. The finalized 33 design features are shown in Table 1. From those, twelve design features of office buildings were discovered which are absent from the WELL Building Standard (v2, 2022) include workstation privacy, sufficient space, office layout, security system, safety at parking lots, individual control systems, building automation system, cleanliness, efficiency in building services, IT infrastructure, Wireless Fidelity (WiFi) risk mitigation, and safe design. The descriptions of these twelve design features are provided in Table 2. The 33 design features were transcribed into a digital survey platform. The survey contained two sections. The first section was the respondent's profile working in an office building. Prior to further analysis, this section serves to screen and determine the validity and reliability of the responses. The second section contained questions on the identified design features, measured on a 5-point Likert Scale ranging from '1 – Not Significant at All' to '5 – Very Significant'. The five-point Likert scale was used because it is straightforward and easy for respondents to communicate their answers (Miller 1956). The last question is an open structured question that invites respondents to provide additional design features to improve health, well-being, and productivity.

Lastly, a pilot study was conducted to assess the survey's relevance and viability (Radzi et al. 2020). Six individuals were invited to the pilot study. The survey was appraised by a sustainable consultant and two architects (i.e., built environment experts) with experience in office building projects to ascertain the survey. In addition, three professionals that are unrelated to the built environment and working at office buildings were also invited to review any difficulty in understanding the survey. Based on the comments received, amendments were made to improve the structure and clarify of the survey, especially for individuals unrelated to the built environment. First, definitions for the terms health, well-being, and productivity were added before having respondents measure the design features. Second, technical jargons were substituted with much simpler terms without altering the original definitions of the design features Also, examples were provided for several design features, where necessary, based on the comments received. However, detailed definitions were not provided for all design features to avoid a lengthy survey as it can reduce the reliability of the collected data (Herzog and Bachman 1981; Chua 2012; Alwin and Beattie 2016; Peytchev and Peytcheva 2017). Nevertheless, this approach of not providing detailed definitions was also used in prior works, including on identifying user requirements for building facilities (Abdul-Rahman et al. 2015); homeowner perception of energy usage (Barry et al. 2016); and occupant satisfaction with their residential environment (Sanni-Anibire et al. 2016). The final version of the survey was validated by the six professionals on the clarity of the amendments. Through this process, the survey is believed to be valid and understood by respondents (Barry et al. 2016; Sanni-Anibire et al. 2016; Venkataraman and Cheng 2018; Rangaswamy and Ramamurthy 2021). Appendix A shows the simplified version of the final survey.

Data Collection

The data collection used a non-probability snowball sampling technique to collect data from potential respondents (Chua 2012). Non-probability sampling effectively collects extensive data when the sampling frame is unavailable (Patton 2002; Radzi et al. 2022). The snowball sampling recruits initial participants willing to participate in the survey and share through their referrals (Noy 2008). This approach is commonly applied in building research (Farouk et al. 2021; Radzi et al. 2022). The survey was administered online to target samples working in Malaysian office buildings. To ensure the credibility of the data, the study targeted respondents from high-rise office buildings. The Building Dictionary defines a high-rise as a building with eight-story and above (Maclean and Scott 1993). High-rise office buildings consist of homogenous characteristics such as lifts, staircases, centralized ventilation systems, sanitary and plumbing systems, fire protection systems, security systems, and parking lots (Yik and Lai 2005). The study aims to target respondents working in office buildings; hence respondents were asked at the start of the survey if their office is in a building eight stories and above.

360 respondents participated in this survey. The respondents include diverse professions categorized into two groups; built and non-built environments professionals. However, 91 respondents were removed because their offices were not in high-rise office buildings; and 50 respondents were discarded due to incompleteness. Lastly, the remaining

responses were checked against the standard deviation. Out of 218 responses, 12 were omitted as their standard deviation is 0 between answers, indicating the responses were unreliable for analysis as one scale of an answer was applied throughout the entire survey. The screening process has resulted in 206 valid data from 128 office buildings.

Respondent profile

Table 3 illustrates the profiles of respondents. According to the valid data, respondents were fairly distributed between built and non-built environment professionals at 48.5% and 51.5%. Examples of built environment professionals include architects, engineers, construction project managers, contract managers, property managers, building suppliers and specialists, interior designers, and others. The non-built environment professionals come from diverse industries such as information technology, banking, finance, accountancy, law, sales and marketing, insurance, and others. Most respondents have spent more than one year working in office buildings. 47.6% have worked between 1 to 5 years, and 47.5% for more than five years. 39.8% of the respondents spend at least 8 hours in an office daily, while 48.1% work for longer hours. Hence, the respondents are qualified to provide reliable answers for the survey.

ANALYSIS AND RESULTS

Reliability Analysis

The Cronbach's alphas were computed to test the survey's consistency and reliability when adopting the Likert Scale (Field 2005; Nunnally and Bernstein 2007). Cronbach's alpha values are between 0 and 1. A value of 0.7 is considered acceptable, and 0.8 or higher indicates good internal consistency (Pallant 2016). In this study, Cronbach's alpha values for productivity, well-being, and health are 0.955, 0.962, and 0.959. Hence, the collected samples are of excellent reliability at the 5% significance level and are suitable for further analysis (Hinton et al. 2014).

Additionally, the two-standard deviation (SD) technique was employed to screen any potential outlier (data that differ from the norm) that might affect the results significantly. The method involves calculating the means, SDs, and two SD intervals of the design features. Design features with mean values outside the two SD intervals are identified as outliers (Radzi et al. 2022; King et al. 2021). Hence, in this study, 'hall for function' (F23) and 'space for exercise' (F10) were detected as outliers for health and productivity. Well-being includes two outliers: 'hall for function' (F23) and 'space for exercise' (F10).

The non-normality data is confirmed by the Kolmogorov-Smirnov test resulting in non-parametric tests being used in further analysis. The Mann-Whitney U test was performed to identify any significant differences in the ranking of design features between two independent groups. This study's null hypothesis (H_0) is "no significant difference in ranking between the two independent groups." The null hypothesis (H_0) should be rejected if the significance level is less than 0.05 ($p < 0.05$) (Hinton et al. 2014). The Mann-Whitney Test has a probability p-value of all design features greater than 0.05, except 'security system' ($p = 0.048$) in the health aspects, indicating overall, the results have minimal to no significant differences between the built and non-built environment professionals. Similarly, there are no significant differences between respondents that have heard of and not heard of the WELL Building Standard, as the group's probability p-value is greater than 0.05. Thus, these groups are not differentiated in subsequent analyses.

Mean Score Ranking Technique

The mean score ranking technique with normalization was used to determine the relative ranking of the design features. The normalization technique yields an accurate interpretation of the data; hence it was employed in this study for identifying key design features. Prior works have adopted this approach to identify key factors (Lee et al. 2020; Radzi et al. 2022). The normalized values are calculated using the following formula:

$$Normalized\ value = \frac{Mean - Minimum\ mean\ value}{Maximum\ mean\ value - Minimum\ mean\ value}$$

Here, the technique transforms the minimum mean value to a normalized value of 0 and the maximum mean value of 1. Other mean values were converted to normalized values between 0 and 1. Design features with normalized values of at least 0.50 are identified as the key design features. In this technique, design features with identical mean scores were ranked based on their standard deviations, where those with smaller standard deviations were ranked higher. Table 4 shows the means, standard deviations, and normalized values of the design features. The results shows that there are seventeen, twelve, and twenty key design features for health, well-being, and productivity.

Overlap Analysis

The overlap analysis was used to discover whether the key design features are pillared to support health, well-being, and productivity, either discreetly, in between them, or all simultaneously. The overlap analysis is a decision-making technique to identify similarities and differences between two categories (Heberle et al. 2015). Variables shared by groups are found in the overlapping area of two or more circles. Prior works, including on drivers for design-build implementation (Lee et al. 2020) and pandemic impacts on construction projects (King et al. 2021), have used this technique to identify overlapping variables.

Fig. 1 illustrated eleven key design features that are crucial to support health, well-being, and productivity simultaneously for WELL office buildings are 'air quality,' 'clean drinking water,' 'comfortable artificial lighting,' 'adjustable workstation,' 'comfortable temperature,' 'sufficient space,' 'security systems,' 'safety at parking lot,' 'cleanliness,' 'efficiency in building services,' and 'safe design.' 'Healthy food access' is an additional key design feature that requires attention to sustain health. 'Natural air ventilation,' 'natural daylight,' 'glare control,' 'comfortable humidity level,' and 'non-toxic material' are the key design features in parallel to optimize health and productivity. 'IT infrastructure' is a key design feature supporting well-being and productivity. In addition, 'quiet environment', 'office layout', and 'easy access' are the key design features for supporting productivity.

Kruskal-Wallis Test

Kruskal-Wallis test was applied to compare differences between two or more groups of non-parametric data (Kruskal and Wallis 1952). In this study, the test evaluated whether there were any differences in design features supporting the aspects of health, productivity, and well-being. Design feature with a $p > 0.05$ indicates that the design feature has the same viewpoint in supporting occupants' WELL.

Table 4 shows the p-value of Kruskal-Wallis's test results for key design features. Eight out of the eleven overall key design features crucial to support health, well-being, and productivity simultaneously have no significant differences in the means at $p > 0.05$. The eight design features include 'air quality,' 'comfortable artificial lighting,' 'adjustable workstation,' 'comfortable temperature,' 'sufficient space,' 'cleanliness,' 'efficiency in building services,' and 'safe design.' Although 'clean drinking water,' 'security systems,' and 'safety at parking lot' are the key design features to support the three aspects simultaneously, they have statistically different means. The mean of 'clean drinking water' is significantly higher to support health than well-being and productivity. 'Security systems' (F25) and 'safety at parking lot' are more vital to support well-being, with the means for well-being being significantly higher than the means for health and productivity. 'Natural air ventilation,' 'natural daylight,' 'glare control,' 'comfortable humidity level,' and 'non-toxic material' are vital to support health and productivity, have no significant differences in their means. Lastly, 'IT infrastructure' is a key design feature supporting well-being and productivity has a significantly higher means for productivity compared to well-being.

Spearman Correlation

Spearman's correlation analysis evaluated the relationship strength of two ordinal variables. The coefficients' strength ranges from 0.00 to 0.29 as no correlation; 0.30 to 0.49 as low correlation; 0.50 to 0.69 as moderate correlation; 0.70 to 0.89 as high correlation; and 0.90 to 1.00 as very high correlation (Asuero et al. 2006). This technique was used to calculate the correlation coefficients between the design features.

The analysis shows that ‘safety at parking lot’ and ‘security systems’ are highly correlated for health (0.875), well-being (0.805), and productivity (0.847). Hence, a well-plan security system should cover the entire building, including parking lots, to prevent injury and accidents. To support health, ‘air quality’ is highly correlated (0.701) with ‘natural air ventilation;’ additionally, ‘cleanliness’ is highly correlated (0.714) with ‘safe design.’ To support better performance in productivity, ‘comfortable temperature’ is highly correlated (0.733) with ‘comfortable humidity level.’ ‘Cleanliness’ and ‘efficiency in building services’ is highly correlated to provide support for both well-being (0.702) and productivity (0.735).

DISCUSSION

Key design features for Supporting Health, Well-being, and Productivity

Air quality (F01) and comfortable temperature (F11). Prolonged exposure to indoor air pollutants poses a severe threat to health. A high level of air pollutants will also decrease the occupants’ comfort and affect their well-being (Roskams and Haynes 2019; Mansor and Sheau-Ting 2020). In addition, poor air quality with a carbon dioxide concentration greater than 700 ppm and thermal comfort exceeding 30–40°C leads to lower productivity (Kaushik 2020).

Clean drinking water (F03). A clean drinking water supply should be available at the workplace to encourage occupants to have a sufficient intake of clean water and prevent dehydration (Tan et al. 2022). Dehydration may cause body discomfort. Furthermore, consuming contaminated water with harmful pathogens can affect employees’ health, consequently impacting organizational performance. Besides that, clean water is required in cooling or heating systems and bathroom appliances against the risk of Legionella infections (CDC 2016). Therefore, a clean water supply in office buildings is crucial for adequate consumption and preventing health risks associated with contaminated water.

Comfortable artificial lighting (F06). Prior works have discussed that good lighting quality can improve health, well-being, and productivity (Roskams and Haynes 2019; Al Horr et al. 2016). Good visual lighting, which includes glare and reflection control, is necessary to prevent impaired vision and eye strain. Besides relying solely on artificial light, allowing daylight illumination is vital for health. Unlike artificial lighting, employees usually prefer to have daylight in their workspace (Veitch 2005). Hence, a good glazing system should be carefully designed to permit sunlight into office buildings, considering the effect of heat and glare.

Adjustable workstation (F09) and sufficient space (F19). Prolonged sitting positions and bad sitting postures could cause musculoskeletal disorders among office occupants, including lower back, shoulder, and neck pains (Mahmud 2014). These prolonged pains can impair the well-being and productivity of individuals (Mansor and Sheau-Ting 2020). Thus, providing an active-design workstation is necessary for individuals to permit flexibility in physical movement and alleviate the constraint effect in an office setting (Alfonsin et al. 2018; Karakolis and Callaghan 2014). Space, including workstations, discussion rooms, storages, lifts, and other common areas, should be adequate for occupants' comfort and ease of movement in the office buildings (HSE 2013).

Security systems (F25) and safety in parking lots (F26). High crime rates can affect occupants' well-being, such as a sense of insecurity and fear when working in office buildings (Tan et al. 2022). Parking lots are usually isolated areas located in the basement of a building, giving a sense of insecurity to occupants. Moreover, it creates a potential scene for crime to take place. Violent actions from crime incidents may lead to physical injury and mental health distress. Injuries sustained due to criminal actions may impact health and affect work performance. The best strategy to deter crime in a building is to develop a preventative measure (Ghani 2017) with security features through active (security systems) and passive design (building layout) extended to the parking lots to ensure safe walking from the parking lots to the office.

Cleanliness (F29) and efficiency in building services (F30). Ineffective maintenance and lack of cleaning to eliminate dust, pollutants, and contaminants from indoor office buildingscan cause discomfort, raise health risks and impair work effectiveness (Passarelli 2009). Unfortunately, developing countries lack the resources and expertise to maintain building services to sustain occupants' health (Poh 2019; Au Yong et al. 2014). Therefore, the emergence of cleanliness and efficiency in building services features is necessary to address the shortcomings of office building maintenance.

Safe design (F33). Poor design in an office building often leads to frequent injuries and accidents, affecting occupants' health; and incurring productivity loss to organizations. Moreover, working in a dangerous environment creates a sense of insecurity. For example, the most prevalent type of accident in office buildings are linked to falls on staircases, resulting in hip fractures and brain injuries (Mansor and Sheau-Ting 2020). Hence, prioritizing safety in design is critical to supporting health, well-being, and productivity.

Key design features for Supporting Health and Productivity

Natural air ventilation (F02). Several prior works have discussed that occupants who work in naturally ventilated offices have fewer reported illnesses than occupants who work in air-conditioned offices (Seppänen and Fisk 2002). An adequate fresh air intake can lower carbon dioxide concentration and air pollutants, which minimizes the Sick Building Syndrome (Syazwan et al. 2009), resulting in improved productivity (Kaushik 2020). In addition, fresh air aids in alleviating odors in an enclosed space.

Natural daylight (F07) and glare control (F08). Natural daylight fosters a healthy circadian rhythm within office buildings, promoting good sleep, memory, body metabolism, and immune response (Altomonte et al. 2020). It stimulates occupants' innovation and collaboration performance at work (Göçer et al. 2019). Glare control aids in preventing visual discomfort from excessive light and offers better visuals for task performance (Tekce I. et al. 2020). Therefore, good lighting design features should be outlined to promote eye health, visual comfort, alertness, and work effectiveness in office buildings.

Comfortable humidity level (F12). Malaysia is a hot and humid country; high humidity and indoor dampness promote bacteria and fungi growth; contribute to workplace adverse health effects (Mansor and Sheau-Ting 2020). Moreover, when the humidity level is high, occupants easily sweat and perspire, impairing their effectiveness at work (Roskams and Haynes 2020). The recommended relative humidity range for achieving a performance of more than 95% is 50% – 68% (Wu et al. 2021). Therefore, an optimum relative humidity feature specification is necessary to provide a reference for cooling system design that focuses on office building occupants' health and productivity.

Non-toxic material (F14). Toxic building materials such as asbestos and volatile organic compounds (VOCs) materials (paints, adhesives, coatings) present various health threats, from respiratory problems to chronic lung disease (EPA 2017). For instance, asbestos has been linked to several diseases, including lung cancer. However, asbestos is often used as insulation material and ceiling panels; and is still manufactured and marketed legally in several countries (Poh 2019). Thus, emphasizing the non-toxic material feature is vital to limit the amount of hazardous material installed in the indoor office buildings.

Key design features for Supporting Well-being and Productivity

IT infrastructure (F31). This study reveals that IT infrastructure is the most voted design feature to support productivity in office buildings. A well-equipped IT system enables collaborative work, information access, data processing, visualization, innovative services, and product development. Besides supporting organizations' work performance, IT infrastructures function to automate building systems that respond to the comfort of building occupants (Murali et al. 2019; Papagiannidis and Marikyan 2020). The specification of IT Infrastructure design features in design may include a raised floor system with a proposed height for convenient routing of mass wiring and cables to computer equipment and electronic devices.

Key design features for Supporting Health

Healthy food access (F04). Nutritional food intake can significantly influence occupants' long-term health (AG 2016). Hence, providing adequate and comfortable eating facilities is the utmost way to foster a healthy eating culture at work. In addition, kitchen electrical appliances, such as refrigerators, toasters, and microwave ovens, should be provided to allow employees to prepare simple and ready home-cooked meals at the office.

Key design features for Supporting Productivity

Quiet environment (F13). The World Green Building Council (WGBC, 2014) revealed that office workers' performance declines by 66% when exposed to distracting noise. Distractions from environmental noise sources, such as background conversation, can impact work concentration, job satisfaction, and performance (Jahncke et al. 2011). Thus, an outline of sound prevention measures to control sound exposure internally and externally in an office building is essential to sustain productivity.

Office layout (F20). Many works have highlighted that a well-designed office layout with an allocation of space for breaks, communications, and collaborations has significantly improved productivity levels (Mansor and Sheau-Ting 2020; Göçer et al. 2019). A functional office layout must understand the demand of the work processes (Al Horr et al. 2016; Haynes et al. 2017). Thus, the design feature of office layout outlining the implementation of flexible workspaces is a practical approach to promote collaborative and concentrative work (Zoltan 2014).

Easy access (F24). Poor access resulted in time-consuming navigating around and within a building. Furthermore, the inconvenience of access creates a barrier to disabled people from seeking employment (WHO 2011). It could have caused organizations to miss the opportunity to recruit potential and talented candidates despite their disabilities. A work conducted by Accenture (2018) reported that organizations embracing employment with disabilities had increased productivity levels, resulting in a 30% increase in profit margin compared with their peer competitors. Hence, building design should be friendly to disabled users in accessing and navigating an office building. The accessibility design features should be outlined in the standard to ensure convenient mobility for all occupants in office buildings.

The provision may include clear signage, maps, and symbols; audio and visual devices; ramp access with a handrail and an automated door with a width allowance for wheelchair access.

Comparison with Existing Standards

Table 5 illustrates the comparison of the key design features to the current US WELL Building Standard (v2, 2022), BREEAM (UK), LEED (USA), and GBI (Malaysia). The comparisons reveal that the current standards still lack essential design features to support occupants' WELL, particularly in office buildings. For instance, 'healthy food access' to sustain health and adjustable workstations to promote comfort in the working environment are absent from the green and sustainable guidelines. Although the 'water' design feature is available under BREEAM, LEED, and GBI, the focus is on water efficiency and water reduction usage. The emphasis on supplying qualified 'clean drinking water' for building occupants' consumption is absent from these standards. Similarly, the 'material' design feature specified in BREEAM and GBI aims to ensure the material is sustainable and recyclable for a better environment. The focus is not on minimizing human exposure to harmful and hazardous materials installed or constructed in a building that impacts health. 'Sufficient space,' 'office layout,' and 'IT infrastructure' design features are not outlined in the BREEAM, LEED, and GBI guidelines to generate a healthy working space and promote productivity. When it comes to 'safe design' design features, only BREEAM identifies hazards within a building to ensure occupants' safety. The WELL Building Standard incorporates all essential design features. However, key design features like 'sufficient space', 'office layout', 'security systems,' 'safety in parking lots,' 'cleanliness,' 'efficiency in building services,' 'IT infrastructure,' and 'safe design' are not available to assess health, well-being, and productivity comprehensively in office buildings.

From this study, the key design features discovered can be referenced by a governing body to establish a comprehensive standard for office buildings. Building owners can specify the brief requirements by the standard for designers to transform a design of an office building, specifically focusing on occupants' WELL. After completion, the local governing body can employ this standard as a tool to evaluate the WELL of an office building. Additionally, the findings contribute insight and raise awareness among built environment stakeholders and the public on the importance of a WELL office building.

Theoretical Implications

This study contributes insight into key design features to provide a valuable guideline for policymakers in developing a local WELL standard for office building assessment. Furthermore, this study suggests additional design features should be studied to develop a comprehensive standard for the specific type of building in a holistic approach. According to the WELL Building Standard, v2 (2018), every design feature is dedicated to supporting the human body's systems. Hence, specific and unique design features should be adopted to support a particular group of occupants performing specific tasks in the building. Office buildings, for instance, demand high-performance information technology systems to perform service-based business effectively. Apart from the building types, the key design features may be differed and be influenced by climate, culture, socio-economic, government policy, and statutory of a country. Therefore, identifying key design features to establish a WELL Standard based on the local context to address the negative impacts of the indoor physical office buildingsis crucial for sustaining occupants' WELL, especially in developing nations. The findings also provide insights to educate the public and built environment stakeholders on how pivotal WELL's key design features are to benefit human life.

Managerial Implications

With the tailored list of key design features, clients can specify requirements for WELL office buildings during the inception stage, and design consultants can incorporate the key design features into the design development. With the insights, clients and design consultants can also draw up a suitable design and optimal solutions for their office building. In terms of budgeting, a WELL project's costs can be accurately estimated. Consequently, clients can secure adequate finance early, assuring the project's viability for completion (Venkataraman and Cheng 2018; Ahmad et al. 2021). Upon completion, government agencies can efficiently assess the WELL office building using scores established in the standard. The scores will determine if the building has successfully met the requirements of the WELL standards.

Global Implication

In a global context, the findings enable other developing regions with similar characteristics to Malaysia to adopt the key design features. Additionally, the key design features can be benchmarked against those of developed nations. The differences in design features can be further examined, compared, and views exchanged by researchers from different regions to develop a more accurate WELL Building Standard. Furthermore, the insights may enlighten various international health and safety organizations in the buildings' health and hazard risk assessments. On merit, the key design features can be aligned harmoniously with other global green or sustainable standards to deliver a holistic building that pays attention to human WELL while also performing green and sustainable functions.

Limitations and Future Work

Despite the significance of the findings, this study has some limitations which can be explored in future research. First, this study is based on individuals working in high-rise office buildings, including non-built environment professionals. Therefore, some respondents might not have sufficient knowledge on the impact of the design features on health, well-being, and/or productivity. However, the Mann-Whitney test shows minimal significant differences between the built and non-built environment professionals. Furthermore, the study findings focus on identifying the key design features rather than ranking them. Therefore, the results can be analyzed as a whole and are reliable. Second, this study is confined to high-rise office building types with eight-story and above homogenous characteristics. Different building types accommodate distinct groups of occupants and functions, that may demand specific design features. Therefore, future research may extend the research to other building types. Third, the survey used in this study was limited to design features associated with the internal environment of office buildings. On the contrary, external building environments (e.g., building location, surrounding amenities, infrastructure facilities) and government-level strategies (e.g., policies, programs) were excluded from the survey. These exclusions enable the study to focus on exploring design features that can be controlled by industry professionals. Thus, future research may explore design features of external environments and government-level strategies. Finally, this study is contextualized in a local setting. Therefore, future research can be undertaken in different geographical locations to identify new or divergent findings that enable worldwide comparisons.

CONCLUSION

Based on 206 valid responses, this study highlighted the significant high-rise office building design features that support WELL concerning health, well-being, and productivity. The ranking results demonstrate that the key design features for supporting health, well-being, and productivity are prioritized differently. For instance, 'IT infrastructure' scored first and foremost for productivity, yet, it is not significant for health, ranking twentieth. The overlapping analysis identifies eleven key design features of office buildings that are pillared to concurrently promote occupants' health, well-being, and productivity: air quality, clean drinking water, comfortable artificial lighting, adjustable workstation, comfortable temperature, sufficient space, security systems, safety at parking lot, cleanliness, efficiency in building services and safe design. The finding also revealed that green or sustainable standards play a major role in energy savings and environmental carbon reduction but may not play a complete role in promoting and supporting building occupants' WELL. The current WELL Building Standard is universal to all types of buildings. Therefore, additional distinctive design features are necessary to adequately support and sustain the WELL in a particular building. The key design features play a significant role in forming a foundation for establishing a WELL tool tailored to the local context for accomplishing the desired results of a WELL building that benefits the human WELL. The key design features synchronize to project a conducive environment for work performance while sustaining the building occupants' WELL.

ACKNOWLEDGEMENT

This work was supported by Universiti Malaysia Pahang [PDU213001-1]. The authors would like to thank the participants for their time and participation in the survey to make this study possible.

DATA AVAILABILITY STATEMENT

Some or all data, models, or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions (e.g., anonymized data).

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Table 2 Click here to access/download;Table;Table 2.docx

Table 2. Design features identified from the interviews and SLR absent from the WELL Building Standard.

Code	Features	Interview data from respondents' perspective	Description from SLR
F18	Workstation privacy	"A considerate space layout planning that gives privacy to the employee can reduce the stress level."	Refers to visual (view) privacy and acoustic (sound) privacy (O'Neill and Carayon 1993).
F19	Sufficient space	"There should be a sufficient space provision for documents and files. Otherwise, the cluttered files may interrupt the movement of staff and are difficult to locate when in need."	
F20	Office layout	"Space planning for office layout is important to support productivity; layout design may directly influence employees' interaction in brainstorming and work as a team or vice versa."	The physical office space arrangement (Lee 2010).
F25	Security system	"Tight security system with access card control, and video surveillance systems to prevent any improper conduct or intrusion in the office building; makes the building users feel more secure."	
F26	Safety at parking lots	"Brightly lit car park and clear signage to ensure the safety of the building occupants."	
F27	Individual control systems		The devices allow individuals to adjust their workplace environment to the desired level of comfort at any given time (Bauman et al. 2015).
F28	Building automation system	"Sensor can adjust the suitable temperature, ventilation, lighting, etc. for human comfort, which can minimize sicknesses."	Bas integrates wireless sensor networks of control devices to govern the operation of mechanical and electrical systems in a building (Salsbury 2005).
F29	Cleanliness	"Upkeep the cleanliness through maintenance and sanitation; for example, carpet should be frequently vacuumed and cleaned with the wet vacuum cleaner to prevent dust accumulation."	The hygienic environment involves cleaning activities in buildings (Mansor and Sheau-Ting 2020).
F30	Efficiency in building services	"Efficiency of building services to support occupant's productivity. For example, a good speed lift allows faster movement for employees who need to travel several floors to complete a task."	The building services performance includes ventilating, heating, lighting, lift, plumbing and sanitary, access, parking, landscaping, and others (Myeda et al. 2011).
F31	IT infrastructure	"High speed of internet for smooth connection of communication for video call, online meeting, etc."	The system consists of computers, software, and all components of telecommunication necessary to facilitate efficient data transfer and management (Enakrire & Onyenania, 2007).
F32	Wireless Fidelity (WiFi) risk mitigation	"Wireless network is extensively used in an office building; the building shall be able to deflect the risk of Wifi signals radiation wave."	A wireless network is linked to the internet consisting of a series of computers or laptops and other wireless devices that communicate with the Wi-Fi antenna (Pall, 2018).
F33	Safe design		The design process in securing a safe working environment in office buildings to reduce accidents and injuries (Mansor and Sheau-Ting 2020).

Table 1. List of design features identified from systematic literature review and interview data.

Code	Design Features	Source	Design features absent from the WELL Building Standard (v2)
F01	Air quality	Kaushik A. *et al.*, (2020), Mannucci & Franchini (2017), Esfandiari M. *et.al.* (2017), Roskams and Haynes (2019), Göçer *et al.* (2019), Interview data	
F02	Natural ventilation	Mansor R. and Sheau-Ting L. (2020), Al Horr Y. *et al.* (2016), Duan Q. and Wang J. (2019), Liang H.-H. *et al.* (2014), Syazwan *et al.* (2009), Interview data	
F03	Clean drinking water	Interview data	
F04	Healthy food access	Interview data	
F05	Pantry	Interview data	
F06	Comfortable artificial (electric) lighting	Tekce I. *et al.* (2020), Roskams and Haynes (2019), Esfandiari M. *et al.* (2017), Al Horr Y. *et al.* (2016), Interview data	
F07	Natural daylight	Altomonte et al. (2020), Tekce I. *et al.* (2020), Göçer *et al.* (2019), Roskams and Haynes (2019), Veitch (2005), Interview data	
F08	Glare control	Tekce I. *et al.* (2020), Dreyer B.C *et al.* (2018), Al Horr Y. *et al.* (2016), Leder S. *et al.* (2016), Interview data	
F09	Adjustable workstation	Forooraghi *et al.* (2020), Alfonsin *et al.* (2018), Karakolis and Callaghan (2014), Mahmud (2014), Interview data	
F10	Space for exercise	Jensen P.A. and van der Voordt T.J.M. (2020), Al Horr Y. *et al.* (2016), Gates. (2006), Interview data	
F11	Comfortable temperature	Dreyer B.C *et al.* (2018), Geng *et al.* (2017), Esfandiari M. *et.al.* (2017), Göçer *et al.* (2019), Liang H.-H. *et al.* (2014), Interview data	
F12	Comfortable humidity level	Wu *et al.* (2021), Roskams and Haynes (2019), Geng *et al.* (2017), Al Horr Y. *et al.* (2016), Göçer *et al.* (2019), Interview data	
F13	Quiet environment	Esfandiari M. *et.al.* (2017), Leder S. *et al.* (2016), Liang H.-H. *et al.* (2014), Jahncke *et al.* (2011), Interview data	
F14	Non-toxic material	Tekce I. *et al.* (2020), Singh A. *et al.* (2010), Interview data	
F15	Suitable color	Mansor R. and Sheau-Ting L. (2020), Jensen P.A. and van der Voordt T.J.M. (2020), Poursafar Z. *et al.* (2019), Al Horr Y. *et al.* (2016), Kamaruzzaman *et al.* (2010), Interview data	
F16	Connecting to nature (plants)	Mansor R. and Sheau-Ting L. (2020), Jensen P.A. and van der Voordt T.J.M. (2020), Al Horr Y. *et al.* (2016), Smith and Pitt (2011), Interview data	
F17	Outside view	Dreyer B.C *et al.* (2018), Göçer *et al.* (2019), Leder S. *et al.* (2016), Interview data	
F18	Workstation privacy	Roskams and Haynes (2019), Dreyer B.C *et al.* (2018), Leder S. *et al.* (2016), Agha-Hossein M.M. (2013), O'Neill and Carayon (1993), Interview data	✓
F19	Sufficient space	Interview data	✓
F20	Office layout	Tekce I. *et al.* (2020), Göçer *et al.* (2019), Haynes *et al.* (2017), Al Horr Y. *et al.* (2016), Zoltan (2014), Lee (2010), Interview data	✓
F21	Leisure space	Interview data	
F22	Services provider	Al Horr Y. et al. (2016), Jensen P.A. and van der Voordt T.J.M. (2020), Agha-Hossein M.M. (2013), Interview data	
F23	Hall for function	Interview data	
F24	Easy access	Interview data	
F25	Security systems	Interview data	✓
F26	Safety at parking lots	Interview data	✓
F27	Individual control systems	Tekce I. *et al.* (2020), Shahzad S.S. *et al.* (2016), Al Horr Y. *et al.* (2016), Bauman *et al.* (2015), Agha-Hossein M.M. (2013)	✓
F28	Building automation systems	Tekce I. *et al.* (2020), Papagiannidis S. and Marikyan D. (2020), Al Horr Y. *et al.* (2016), Salsbury (2005), Interview data	✓
F29	Cleanliness	Mansor R. and Sheau-Ting L. (2020), Tekce I. *et al.* (2020), Au Yong *et al.* (2014), Passarelli (2009), Interview data	✓
F30	Efficiency in building services	Tekce I. *et al.* (2020), Poursafar G.R. *et al.* (2019), Myeda *et al.* (2011), Interview data	✓
F31	IT infrastructure	Papagiannidis S. and Marikyan D. (2020), Murali and Surya (2019), Enakrire & Onyenania (2007), Interview data	✓
F32	Wifi risk mitigation	Pall (2018), Interview data	✓
F33	Safe design	Mansor R. and Sheau-Ting L. (2020)	✓

Table 3. Respondents' profile

Characteristics	Categories	Frequency	(%)
Group	Built	100	48.5
Years of working in office buildings	Non-Built	106	51.5
	< 1 year	10	4.9
	1 - 5 years	98	47.6
	6 -10 years	61	29.6
	11 - 15 years	22	10.7
	15 - 20 years	11	5.3
	> 21 years	4	1.9
Respondent's office	1 - 10 floors	81	39.3
	11 - 20 floors	81	39.3
	21 - 30 floors	32	15.5
	31 - 40 floors	8	3.9
	41 - 50 floors	2	1.0
	> 51 floors	2	1.0
Average hours spent in the office	< 7 hours	25	12.1
	08 hours	82	39.8
	09 hours	39	18.9
	10 hours	51	24.8
	> 10 hours	9	4.4
The number of respondents who heard of WELL Building	No	153	74.3
	Yes	53	25.7

Table 4. Results of mean ranking technique and Kruskal–Wallis test

		HEALTH				WELL-BEING				PRODUCTIVITY					Statistically difference
Code	Design Features	Mean	SD	NV	Rank	Mean	SD	NV	Rank	Mean	SD	NV	Rank	p-value	No significant difference (p > 0.05)
F01	Air quality	4.286	0.884	0.933[a]	3	4.155	0.818	0.719[a]	7	4.170	0.824	0.843[a]	5	0.070	No significant difference
F02	Natural air ventilation	3.942	1.044	0.589[a]	13	3.883	0.909	0.369	20	3.845	0.929	0.534[a]	17	0.371	No significant difference
F03	Clean drinking water	4.330	0.893	0.976[a]	2	4.184	0.875	0.756[a]	3	4.049	0.941	0.728[a]	9	0.003[b]	Health-Productivity Health-Well-Being
F04	Healthy food access	3.932	1.038	0.580[a]	14	3.883	1.000	0.369	21	3.709	1.042	0.405	23	0.042[b]	Health-Productivity
F05	Pantry	3.796	1.006	0.444	19	3.830	0.960	0.300	23	3.743	1.006	0.438	22	0.628	No significant difference
F06	Comfortable artificial lighting	4.146	0.807	0.792[a]	6	4.141	0.823	0.700[a]	9	4.272	0.817	0.940[a]	2	0.112	No significant difference
F07	Natural daylight	3.961	1.021	0.609[a]	12	3.917	1.026	0.412	19	3.888	1.069	0.576[a]	16	0.810	No significant difference
F08	Glare control	3.985	0.940	0.633[a]	10	3.932	0.913	0.431	17	4.005	0.929	0.686[a]	11	0.627	No significant difference
F09	Adjustable workstation	4.155	0.892	0.802[a]	4	4.180	0.873	0.750[a]	5	4.248	0.856	0.917[a]	4	0.534	No significant difference
F10	Space for exercise	3.350	1.243	0.000	32		-				-				
F11	Comfortable temperature	4.073	0.878	0.720[a]	7	4.136	0.839	0.694[a]	10	4.121	0.878	0.797[a]	6	0.762	No significant difference
F12	Comfortable humidity levels	3.976	0.864	0.623[a]	11	3.942	0.865	0.444	16	3.922	0.907	0.608[a]	14	0.845	No significant difference
F13	Quiet environment	3.840	0.926	0.488	18	3.981	0.872	0.494	13	4.073	0.900	0.751[a]	7	0.023[b]	Health-Productivity
F14	Non-toxic material	4.063	1.161	0.710[a]	8	3.971	1.126	0.481	14	3.835	1.157	0.525[a]	19	0.055	No significant difference
F15	Suitable color	3.563	0.989	0.212	28	3.699	0.903	0.131	27	3.699	0.996	0.396	24	0.238	No significant difference
F16	Connecting to nature	3.660	1.055	0.309	22	3.704	1.019	0.138	25	3.519	1.090	0.225	30	0.167	No significant difference
F17	Outside view	3.587	1.017	0.236	27	3.845	0.970	0.319	22	3.587	1.017	0.290	28	0.009[b]	Health-Well-Being, Productivity-Well-Being
F18	Workstation privacy	3.563	1.141	0.212	29	3.801	1.111	0.263	24	3.767	1.111	0.461	21	0.051	No significant difference
F19	Sufficient space	3.888	1.008	0.536[a]	17	4.063	0.988	0.600[a]	12	4.034	0.985	0.714[a]	10	0.103	No significant difference
F20	Office layout	3.641	0.991	0.290	23	3.927	0.900	0.425	18	3.927	0.910	0.613[a]	13	0.001[b]	Health-Well-Being, Health-Productivity
F21	Leisure space	3.388	1.120	0.038	30	3.597	1.142	0.000	31	3.383	1.149	0.096	31	0.075	No significant difference
F22	Services provider	3.379	1.157	0.029	31	3.704	1.075	0.138	26	3.689	1.087	0.387	25	0.004[b]	Health-Well-Being, Health-Productivity
F24	Easy access	3.670	1.040	0.319	21	3.961	0.915	0.469	15	3.835	0.959	0.525	18	0.019[b]	Health-Well-Being
F23	Hall for function		-				-			3.282	1.058	0.000	32		
F25	Security systems	3.927	1.113	0.575[a]	15	4.218	0.903	0.800[a]	2	3.898	1.061	0.585	15	0.005[b]	Health-Well-Being, Productivity-Well-Being
F26	Safety at parking lots	3.903	1.122	0.551[a]	16	4.184	0.950	0.756[a]	4	3.830	1.093	0.521[a]	20	0.002[b]	Health-Well-Being, Productivity-Well-Being
F27	Individual control systems	3.631	1.100	0.280	25	3.699	1.129	0.131	28	3.626	1.131	0.327	27	0.696	No significant difference
F28	Building automation systems	3.612	1.089	0.261	26	3.626	1.078	0.038	30	3.583	1.082	0.285	29	0.907	No significant difference
F29	Cleanliness	4.354	0.794	1.000[a]	1	4.374	0.759	1.000[a]	1	4.267	0.809	0.935[a]	3	0.327	No significant difference
F30	Efficiency in building services	4.019	0.932	0.667[a]	9	4.155	0.847	0.719[a]	8	4.063	0.963	0.740[a]	8	0.399	No significant difference
F31	IT infrastructure	3.786	1.149	0.435	20	4.063	0.983	0.600[a]	11	4.335	0.921	1.000[a]	1	0.000[b]	Health-Productivity, Well-Being -Productivity
F32	WIFI risk mitigation	3.641	1.103	0.290	24	3.694	1.045	0.125	29	3.631	1.104	0.331	26	0.866	No significant difference
F33	Safe design	4.155	0.913	0.802[a]	5	4.165	0.901	0.731[a]	6	3.985	0.965	0.668[a]	12	0.089	No significant difference

Note: [a] Key design feature (normalized value ≥ 0.50);
[b] The Kruskal–Wallis H test result is significant at the significance level of 0.05 (p-value < 0.05).

Table 5. Comparison with existing building standards

Key design features of office buildings	Key design features in this study	WELL Building Standard (v2, 2022)	BREEAM UK [a] (v3.0, 2018)	LEED USA [b] (BD & C, v4.1, 2020)	GBI MYS [c] (v1, 2011)
Air quality Natural air ventilation	✓	✓	✓	✓	✓
Clean drinking water	✓	✓	* water efficiency	* water reduction	*water efficiency
Healthy food access	✓	✓			
Comfortable artificial lighting, Natural daylight & Glare control	✓	✓	✓	✓	✓
Adjustable workstation	✓	✓			
Comfortable temperature, Comfortable humidity level	✓	✓	✓	✓	✓
Quiet environment	✓	✓	✓	✓	✓
Non-toxic material	✓	✓	*sustainable material	✓	*recycling material
Sufficient space Office layout	✓				
Easy access	✓	✓	✓		
Security systems Safety at parking lots	✓		✓		
Cleanliness Efficiency in building services	✓		✓	✓	✓
IT infrastructure	✓				
Safe design	✓		*hazard identification		

Notes: [a] BREEM (Building Research Establishment Environment Assessment Method);
[b] LEED (Leadership in Energy & Environmental Design);
[c] GBI (Green Building Index);
✓ Feature that is available in the standard;
* Feature that focuses on energy saving or environmental concerns.

Figure 1

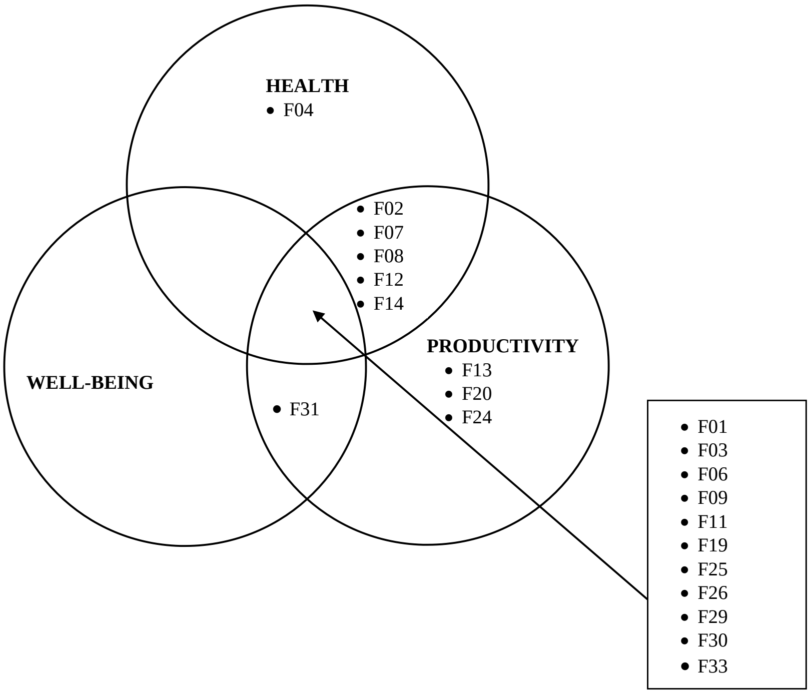

Fig. 1. Overview of the overlap analysis results for the key design features

Notes: F01: Air quality; F02: Natural air ventilation; F03: Clean drinking water; F04: Healthy food access; F06: Comfortable artificial lighting; F07: Natural daylight; F08: Glare control; F09: Adjustable workstation; F11: Comfortable temperature; F12: Comfortable humidity; F13: Quiet environment; F14: Non-toxic material; F19: Sufficient space; F20: Office layout; F24: Easy access; F25: Security systems; F26: Safety at parking lot; F29: Cleanliness; F30: Efficiency in building services; F31: IT infrastructure; F33: Safe design

Figure Captions List

Fig. 1. Overview of the overlap analysis results for the key design features