International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 24 (March 2026) PP. 414-427

INTERNATIONAL JOURNAL OF INNOVATION AND INDUSTRIAL REVOLUTION (IJIREV)
www.gaexcellence.com/ijirev

BIOPHILIC DESIGN IN HEALTHCARE INTERIORS: EFFECT ON HEALTHCARE WORKERS' WELL- BEING

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Article Info:

Article history:
Received date: 28.01.2026
Revised date: 09.02.2026
Accepted date: 17.03.2026
Published date: 29.03.2026

To cite this document:

Muhsein, A. S., & Mustapa, N. D. (2026). Biophilic Design in Healthcare Interiors: Effect on Healthcare Workers' Well-Being. *International Journal of Innovation and Industrial Revolution, 8*(24), 414-427.

DOI: 10.35631/IJIREV.824026

Abstract:

Mental health issues in the workplace have become a growing concern, particularly in rapidly urbanizing countries, including in Malaysia. It is vital by creating a quality healthcare environment that promotes connections with nature through biophilic design to reduce work-related to mental health issues. Since healthcare workers spend most of their time in the hospital, they have limited access to the outdoor restorative natural environments to take a break from their tasks. The use of indoor natural elements in healthcare facilities has also been an effective alternative way to improve the mental health of healthcare workers and promote a healing environment. Based on the systematic review using the PRISMA approach, this paper presents and screens relevant literature on the benefits of biophilic design application in healthcare interior spaces through indirect experiences such as nature images, nature colour, and nature material that affect healthcare workers' well- being. 75 articles published between (2015- 2025) were identified across six online databases (SAGE, Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar), of which 15 were selected for inclusion. The findings provide a foundation for design strategies using indirect biophilic applications to enhance healing in healthcare interiors and outline future research directions to support healthcare workers' mental well- being and sustainable healthcare facilities.

Keyword:

Mental Health, Biophilic Design, Healthcare Interior, Indirect Experiences of Nature, Healthcare Workers

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EISSN: 2637-0972
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Introduction

The mental health issues in workplace have become a growing concern and increasingly important issues that need to be addressed, especially in developing urbanizing countries (Chopra, 2009). This has been found to occur in healthcare facilities also which is in the hospital (Khamisa et al., 2017; Woon & Tiong, 2020; Zakaria et al., 2022). The healthcare workers who are the front line at the hospital, including the doctor, nurses, pharmacists and occupational therapist, who are struggling with mental health problems in healthcare context (Woon & Tiong, 2020; World Health Organization, 2022). Healthcare workers are often exposed to long working hours, emotional unstable work schedules, long- term work stress, high responsibilities for patients and extreme work demands that put them in higher risk of experiencing mental health problems such as burnout, depression, anxiety and fatigue (West et al., 2018; Lai et al., 2020; Pappa et al., 2020; Jin et al., 2023). The mental health problems among healthcare workers will affect their quality of life, productivity and job performance. Mental health problems are not only a risk to healthcare workers, but also to patients. For example, burnout among healthcare workers can increased rates of medical error and hospital associated infection (Shanafelt et al., 2010; Woon & Tiong, 2020). While the risks that involve staff, overtime work, lower job satisfaction, increasing number absenteeism and turnover rates and impact on the quality of patient care (van der Colff & Rothmann, 2009; Woon & Tiong, 2020; Khamisa et al., 2017; Zakaria et al., 2022). Therefore, mental health problems among healthcare workers have received attention as a primary concern and have become critical issues that cannot be ignored. Since healthcare workers are the foundation of the healthcare workers by ensuring their mental health and wellbeing is essential.

To overcome the mental health problems among healthcare workers through the initiatives by create a good physical environment. Substantial studies have found that physical design of healthcare that bring a sense of comfort and healing plays an important role in preventing work-related to mental health (Jin et al., 2023; Karanikola et al., 2020). Numerous studies have demonstrated that *direct experiences of nature*; indoor plants, view toward nature, natural lighting, natural ventilation and green areas, meanwhile for *indirect experiences of nature*; biomorphic forms and patterns, nature material, nature images and nature colour can create environment that engage multiple sense, healing and restorative environment to enhance relaxation and beneficial to mental health and well- being. Healthcare workers' perceived levels of work-related stress, fatigue, and health outcomes were found to be negatively affected by lack of exposure to nature. Hence, it is essential to create an environment that support the healthcare worker’s needs since they are the backbone of the hospital and often spend their time in the hospital, besides that can contribute to sustainable building strategies to improve indoor air quality and make a healthier environment.

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Although average studies have widely acknowledged that nature elements in the outdoors can create healing and recovery (Jiang, 2015), access to these spaces is limited by healthcare workers. Consequently, the interior healthcare becomes the primary spaces where the healing occurs. The indoor settings rely heavily on indirect experiences of nature which is the artificial environments, including nature shapes and patterns, nature images, nature color, and nature material that can contribute to reduce stress, fatigue and well-being (Vincent & Mccubbin, 2010; Lankston et al., 2010; Nejati et al., 2016b; Yuniati et al., 2018; Uwajeh & Ezennia, 2018; Elqahtani & Elgizawi., 2015; Muslimi et al., 2021; Mollazadeh & Zhu, 2021; Hettiarachchi & Perera, 2022; Tekin et al., 2023; Totaforti, 2018; ChongX. Y et al., 2023; Williams & Riches, 2023; Shiner et al., 2024; Bates, 2018). Therefore this paper review on the indoor healthcare facilities that use biophilic design elements through indirect nature strategically applied to improve healthcare workers well- being.

Literature Review

Nature as a Healing in Healthcare Facilities

In general, "healing" was defined how humans have understanding on health, recovery, belief systems, science and environment (Elendu & Chukwuka, 2024). Coping with stress through the design of healing spaces that connected with nature are important for healing and recovery. Nature has provided human needs, food, water, shelter and material (Ismail & Hussain, 2003). Nature is crucial for human's psychological, cognitive, physiological, social, spiritual, tangible well- being (Browning et al., 2014). Healthcare environment also received attention in terms of how design can influence mood, stress levels, and satisfaction for users, including healthcare workers (Pragarati et al., 2021). "Healing environment" in healthcare settings is thoughtfully designed physical and psychological spaces that support recovery and well- being hospital users, including the healthcare workers (Tülbentçi & Arcan, 2021; Faraj et al., 2024). The application a variety of nature into both indoor and outdoor settings has been found can create positive experiences for healthcare workers (Parsia et al., 2018; Hastuti & Lorica, 2020). Connection to nature can help to alleviate burnout, reduce stress, improve mental health and job performance and this aligns with the biophilia hypothesis that emphasizes the emotional and psychological benefits to human and nature interaction (Kellert, 2008). Since they are the backbone of the healthcare systems, it is crucial to prioritize their mental well- being through the biophilic design as healing environments that improve job performance, quality of life and positive impact to their patients.

Previous study cited by Ulrich et al. (2008) stated healthcare facilities design has play an important role by helping reduce stress and overcome the work- related to mental health among healthcare workers, by provide a healing and recovery environment, since they spend most of their time in indoor healthcare (Valipoor & Bosch, 2021; Gregory et al., 2022). Subsequently, providing a better workplace for healthcare workers positively impact the way they treat their patients. Many previous studies before shown the application of natural elements through biophilic design as healing environment in both indoor and outdoor spaces of healthcare facilities can have positive effect on health benefits, reduce stress among healthcare workers and create a sustainable environment. Although the importance of natural elements in indoor and outdoor healthcare has been emphasized, healthcare workers do not have the opportunity and have limited time to access nature in outdoor spaces, and nature elements through direct (such as plants, natural lighting, ventilation, water and view) are not always accessible to users, due to safety issues, infection control and depending on weather, time and location. Therefore,

this review focused on indirect of nature in indoor healthcare facilities, since the elements of the indirect are relevant and realistic to be applied comprehensively, easy to control and safe, and indoor spaces are the main environment most often inhabited by users, including healthcare workers. This aligns with suggestions by Kellert (2018) and Browning & Ryan (2020) which emphasize that the connection between humans and nature can occur even without the physical presence of the actual nature.

The Biophilic Design

At the beginning of the 21st century, nature design was introduced from the biophilia hypothesis. Biophilic design was defined from the "biophilia" coined by Erich Fromm in 1964 that describe the "love of life". The biophilic design can integrate the nature elements into built environment in both indoor and outdoor context (Zhong et al., 2022). There are three main frameworks of biophilic design: 2 dimensions 6 elements and 72 attributes (Kellert, 2008), 3 experiences and 25 attributes of biophilic design (Kellert, 2018) and 3 categories and 14 patterns of biophilic design (Browning & Ryan, 2020). The most commonly used frameworks by many researchers are Kellert (2018) and Browning & Ryan (2020) since the biophilic framework are complement each other. Kellert (2018) framework include direct experiences of nature, indirect experiences of nature and experiences of space and place. On the other hand, Browning & Ryan (2020) framework includes nature in the space, natural analogues and nature of the space.

These design patterns have various application for indoor and outdoor environments that illustrate the relationship between human biology, nature and built environment. Most of the previous studies refer to the biophilic design application under the direct experiences of nature (nature in the space) and indirect experiences of nature (natural analogues) by Kellert (2018) and Browning & Ryan (2020) since the biophilic elements and patterns under the framework are easy to identify and understand in the context of healthcare facilities. However, there is mapping and overlapping of the elements or attributes and classification are still being debated. Also, some of the elements in the framework are uncertain and difficult to measure (Zhong et al., 2022). The Experiences of Space and Place and the Nature of the Space are rarely given focus because the elements and patterns are complicated to find and easy to understand. This review has focused on the biophilic framework by Kellert (2018) because it provides a more comprehensive and fundamental theoretical basis for the human relationship with nature in built environments and is suitable for focusing on indirect experiences of nature in healthcare contexts where direct exposure to nature is limited.

Indirect Experiences of Nature

Indirect experiences of nature (Natural Analogues) can be known as the imitation of nature that deals with the resurrection of organic, non- living to nature (Kellert, 2018; Browning & Ryan., 2020). The objects, material, colour, shapes, form and pattern found in nature, manifest artwork, ornamentation, furniture, décor and textiles in the built environment. Furniture with organic shapes, mimicry of shells and leaves that have been process or extensively altered. Each elements provide an indirect connection with nature; while them real, they are only analogous of the items in their natural state. In healthcare context, indirect of nature can enhance sensory experiences, aesthetic value to the space, healing and recovery for users, including healthcare workers.

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Table 1: Indirect Experiences of Nature (Natural Analogues) Patterns and Elements with Explanation Used as A Reviews

Category	Patterns	Elements	Explanation
Natural analogues (indirect experiences of nature)	Biomorphic forms And patterns	Forms Shapes Patterns	Symbolic to contoured, patterned, textured or numerical arrangements that persists in nature
	Material connection with nature	Nature material Colour Textured	Material and elements from nature- through minimal processing, reflect to local ecology or geology and create distinct sense of place
	Complexity and Order	Example	Rich sensory information that adheres to a spatial hierarchy similar to encountered in nature

Source: Biophilic Framework Kellert (2018); Browning & Ryan (2020); Zhong et al., (2022)

Methodology

This systematic review was conducted by using the PRISMA 2020 guidelines. The review focuses on analysis of indirect experiences of nature elements in healthcare interior. A literature review search from six databases, including SAGE, Scopus, Web of Science, PubMed, Science Direct and Google Scholar. Search terms comprised the following twelve keywords; mental health, healthcare workers, indoor healthcare facilities; nature; biophilic design; indirect experiences of nature; colour; nature material; nature images; VR; nature texture and patterns; related journals were identified. The following inclusion criteria were applied at this stage: (1) the publication between 2015 and 2025 inclusive: (2) peer- reviewed journal: (3) the full text that available in English language. By using Microsoft Words containing the author, application of indirect nature, characteristics of indirect elements and the effect to healthcare workers well-being. Two eligibility criteria were applied at this stage: (1) application of biophilic design through indirect indoor healthcare, (2) use of secondary data obtained from peer-reviewed papers through a literature review approach. A total of 75 articles published between 2015 and 2025 were identified, and 15 were selected for inclusion. The review highlights the benefits of biophilic elements to healthcare well- being, since they spent most of their time in indoor healthcare facilities.

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EISSN: 2637-0972
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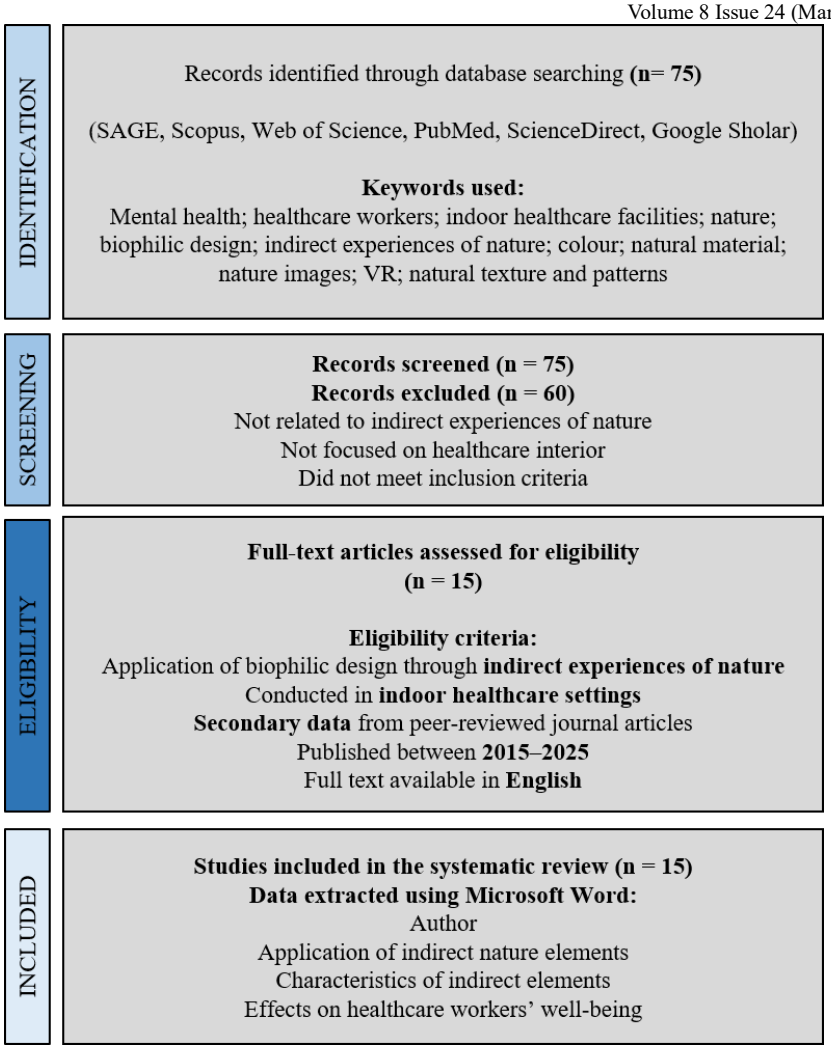

Figure 1: Systematic Review PRISMA Diagram

Source: Author

Analysis and Discussions

Indirect Experiences of Biophilic Design in Healthcare Interior

This review explains that previous studies on the indirect biophilic design that have been applied in healthcare interior, and how the elements positively benefits to healthcare workers well- being (Vincent & Mccubbin, 2010; Lankston et al., 2010; Nejati et al., 2016b; Yuniati et al., 2018; Uwajeh & Ezennia, 2018; Elqahtani & Elgizawi., 2015; Muslimi et al., 2021; Mollazadeh & Zhu, 2021; Hettiarachchi & Perera, 2022; Tekin et al., 2023; Totaforti, 2018; ChongX. Y et al., 2023; Williams & Riches, 2023; Shiner et al., 2024; Bates, 2018). In addition, this review has been categorized into biophilic elements, follow with nature images, arts, VR, colour and nature material.

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Table 2: Indirect Biophilic Elements in Indoor Healthcare Facilities

Indirect Nature Elements	Author	Characteristics in Study	Effect on Healthcare Workers
Nature colour	Totaforti (2018) Uwajeh &Ezennia (2018b) Elqahtani & Elgizawi Muslimi et al. (2021) Hettiarachi & Perera (2022) ChongX. Y et al. (2023) Tabanejad (2024)	Colour in general Colour in general Colour in general Lavender and soft purple, earthy tone, soft white and cream and accent colour Shaded green Grey Pop colour Bright and harsh colour Muted tone colour	• Emotional and psychological well-being • Create visual effect • Enhance brightness and clarity • Reduce stress, anxiety, depressions • Bring calming and relaxation • Enhance focus • Positive work environment • Enhance job satisfaction and performance • Improve morale, satisfaction and functionality
Nature images	Vincent et al. (2010) Lankston et al. (2010) Totaforti (2018) Uwajeh & Ezennia (2018b) Muslimi et al. (2021)	Prospect image Refuge image Hazard image Prospect- refuge image Landscapes, trees, water, Blue skies, flower Landscape Greenery Nature view Depict serene landscape Flora and fauna Nature textures Water scene Seasonal imagery Abstract nature	• Bring healing and therapy • Create calming • Promote relaxation • Reduce stress • Improve well- being • Visual experience • Stimulate positive psychology

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Virtual reality	Yuniati et al. (2018) Mollazadeh & Zhu (2021) William & Riches (2023) Shine et al. (2024)	Graphic images Virtual reality environment (VRE) Augmented Reality (AR) Stimulated Natural Environment (SNE) Multisensory Environment (ME) Virtual reality Virtual reality	• Enhance experiences • Promote healing • Support therapeutic • Increase focus and creativity • Provide peace • Positive impact to well- being
Nature Material	Muslimi et al. (2021) Totaforti (2018) Tekin et al. (2023)	Wood and stone Timber Timber	• Support well- being • Create welcoming and relaxation atmosphere • Enhance visual comfort • Positively affect olfactory • Enhance aesthetic • Improve healing and therapeutic
Nature art	Lankston et al. (2010) Bates (2018)	Paintings Photographs Drawings Murals Video/ films Sculpture Visual art Painting Mural Patterns	• Improve morale • Positive effect on healing • Create calm and atmosphere • Support well- being • Positive impact to psychology • Strengthen multisensory and emotional

Nature Colour - The choice of colour in healthcare design are important based on functional and specific spaces to give positive impact to emotional and psychological well- being for users including healthcare staff. Study by Muslimi et al. (2021) stated the *lavender and soft purple* use for relaxation area; *earthy tone* for staff lounges that create warm and inviting atmosphere; *soft white and creams* enhance brightness and clarity for hallways and *accent colour, teal and coral* for staff break rooms that create visual effect. Next, study by Hettiarachchi & Perera, (2022) the shaded green, followed with study by ChongX. Y et al. (2023) that emphasized the preferred colour in nurse stations, example the grey colour that provide calm and neutral, and for pop colour would signify as a focal point that people can quickly response when they need

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help. The use over bright and harsh colour need to balance with muted tone that contribute more positive work environments Elqahtani & Elgizawi. (2015). Therefore, the choice of colour is important in indoor healthcare to create a healing environment and impact to healthcare workers well- being.

Nature Images - Nature image based on the concept of nature can be used on the walls and floors in healthcare design that bring healing and therapy for healthcare users. Study by Muslimi et al. (2021), the nature image such as depicts serene landscape, flora and fauna, nature texture, wildlife, water scene, seasonal imagery and abstract nature can create calming atmosphere. Then studies by Lankston et al. (2010) have shown the nature images such as landscapes, trees, water, blues skies and flower images. While studies by Totaforti et al. (2018) and Uwajeh & Ezennia, (2018) have emphasized the nature images like landscape and greenery view. Then study by Vincent & Mccubbin,(2010) emphasized the nature images have been categorized to Appleton's prospect- refuge theory, such as *Prospect Image* that provide expansive views (landscape, mountains and fields) by incorporating windows with a view of natural landscapes or mural depicting wide- open space; *Refuge Image* that depict sheltered or enclosed spaces (forest, garden and cosy nooks) was designed that mimic refuge; *Hazard Images* that perceived as threatening (rocky cliffs or stormy seas) should be applied carefully because of hazard; and *Prospect- Refuge Image* combination of both elements, prospect and refuge (meadow with mountain) have utilizing artwork or digital display.

Virtual Reality of Nature - The use of Virtual Reality as a biophilic design approach in healthcare facilities has been widely used (Mollazadeh & Zhu, 2021; Williams & Riches, 2023; Shiner et et al., 2024). There are some of VR that mentioned in study Mollazadeh & Zhu (2021) can enhance experiences, promote healing and support therapeutic outcomes, such as Virtual Reality Environment (VR) that stimulate natural setting (forest, beaches, garden); Augmented Reality (AR) that overlays virtual natural elements (plants and landscapes); Simulated Natural Environments (SNE) screens or projections display soothing natural scenes (flowing water and wildlife) and Multisensory Environments (ME). Then study by Shiner et al. (2024) have proven that healthcare workers have a positive response towards VR used and believe it can be beneficial to their well-being. The use of plant graphics such as Epipremnum Aureum (pothos) have been printed and pasted in indoor areas that act as a visual symbol of nature. Even it not realistic, VR technology and graphic images do not require frequent maintenance and have a positive impact to healthcare workers well-being

Nature Material - Nature materials such as wood and stone play an important role in supporting healthcare workers' well- being (Tekin et al., 2023). A study by Muslimi et al. (2021), the use of nature material such as timber should be maximize in healthcare design that create welcoming and relaxing atmosphere and need to avoid the materials that detract from comfort, such as plastic seat. Besides that, the use of essential wood oils can enhance visual comfort by absorb the light, positively affect olfactory comfort Totaforti et al. (2018). The timber material usually applied in various spaces such as warded, staff areas and waiting areas to enhance aesthetic, improve healing and therapeutic environments.

Arts of Nature - Art have potential positive benefits in healthcare and recognized by artist and healthcare professionals. Study by Lankston et al. (2010) focused on the three different hospital that focused on visual art including paintings, photographs, drawings, murals and video films through nature- themed for indoor healthcare. On the other hand, the use of complex abstract is not suitable cause discomfort to healthcare users, including healthcare workers. Then a study

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by Bates (2008) discusses the use of natural visual art as part of humanistic design in hospitals, which is a design approach that aims to make the hospital environment more friendly and humane, especially in a hospital environment filled with technology through painting, murals and patterns such as trees, gardens and landscapes.

Indirect Experiences of Biophilic Design in Healthcare Interior that Effect on Healthcare Workers Well- being

The application of biophilic design through indirect of nature (Natural Analogues) in healthcare interior play an important role effecting healthcare workers well- being. As discussed in (Table 2) the indirect nature application positively impacts healthcare workers', particularly can help prevent mental health and reduce work- related to mental among them. This review showed that most important elements for healthcare interior, such as nature colour, nature images, virtual reality, and nature material and nature art. Each of the elements prove can enhance their well- being and improve job satisfaction and performances. Since healthcare workers spent most of their time in indoor healthcare facilities and they don't have the opportunity to expose to nature in outdoor environments. So that, the application of biophilic design in healthcare interior significantly addresses mental health problems among healthcare workers through indirect experiences with nature, since each element is realistic and relevant for overall application in healthcare interior. The indoor spaces become the main environment frequently inhabited by healthcare workers, the use of "natural colour" are most crucial elements in indoor spaces (Totaforti et al., 2018; Muslimi et al., 2021; Hettiarachchi & Perera, 2022; Uwajeh & Ezennia, 2018; Elqahtani & Elgizawi., 2015; Tekin et al., 2023). The nature color in interior healthcare design can improve morale, satisfaction and functionality, enhance focus, create visual effect, and improve emotional and psychological well-being. Next is "nature images" such as landscapes, flora and fauna, nature texture, wildlife, water scene, seasonal imagery and abstract nature, reduce stress, improve well-being, enhance visual experiences, stimulate positive psychology, in addition can create calming and relaxation (Vincent & Mccubbin, 2010; Lankston et al., 2010; Totaforti et al. 2018; Uwajeh & Ezennia, 2018; Muslimi et al., 2021). Next for "virtual reality" is a technology and graphic images of nature are also encouraged in indoor healthcare that enclosed spaces and creates indirect experiences that positively affect increasing focus and enhance concentration among healthcare workers (Mollazadeh & Zhu, 2021; Williams & Riches, 2023; Shiner et al., 2024). Next for "virtual reality" is a technology and graphic images of nature are also encouraged in indoor healthcare that enclosed spaces and creates an indirect experience that positively impact on increasing focus and enhance concentration among healthcare workers, and positive impact to well- being. For "nature material", the used of timber need to be maximize in indoor healthcare design that enhance visual comfort, create welcoming, relaxation and aesthetic, in addition can support healthcare workers' well-being (Muslimi et al., 2021; Totaforti, 2018; Tekin et al., 2023). Based on "nature arts" have been emphasized in healthcare design (Lankston et al, 2010), that affect psychological, improve morale, strengthen multisensory and emotional and support well- being (Bates, 2018). Therefore, indoor healthcare design plays an important role by applying natural elements through indirect for healthcare workers; since the elements are not used frequent maintenance, further contribute to their well-being, subsequently can create sustainability environment in healthcare design.

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Conclusion

This paper review highlighted strong evidence for the positive impact of application of biophilic design in healthcare interior through indirect experiences of nature (natural analogues) to contribute healthcare workers well- being. This paper confirmed and agreed that nature elements in indirect is vital to reduce mental health problems that have been facing by healthcare workers. This paper also highlighted the indirect of nature through natural colors, nature images, virtual reality, natural material and nature art benefiting to healthcare workers well- being, in addition to creating a healthcare environment that enhances healing.

The practitioners in the built environments such as architect, interior designer, landscape architect, and healthcare management need to rethink and play an important role by creating the healthcare design through the application of biophilic design in indirect in indoor spaces, where the environment that healthcare workers stayed in long hours. The indirect of nature are relevant and provide alternative way to bring nature benefits into controlled indoor environments, where the direct access to nature is limited. Future research can further explore the context and other indirect nature elements that enhance well- being. Furthermore, the necessity to redefine the healthcare facilities design by nature application as healing environments in indoor is crucial to reduce mental health problems of healthcare workers, also support the sustainable building practices by improving indoor air quality and fostering healthier environment in healthcare facilities. This review has made a strengthen contribution by focus on the indirect biophilic elements in indoor healthcare facilities to improve healthcare workers' well- being.

Acknowledgements: The author would like to thank the Fundamental Research Grant Scheme (FRGS) FRGS/1/2024/SS112/UMK/02/1 under Ministry of Education (MOHE) for providing funding and Universiti Malaysia Kelantan continuous support.

Funding Statement: This research received financial support from Research Grant Scheme (FRGS) under Grant Number [FRGS/1/2024/SS112/UMK/02/1]. The funding body had no role in the design of the study, data collection, analysis, interpretation of results, or the decision to publish this manuscript. (If no, just stated "No Funding")

Conflict of Interest Statement: The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Innovation and Industrial Revolution (IJIREV).

Ethics Statement: Option B (For Studies Not Involving Human or Animal Subjects) This study did not involve any human participants, animals, or sensitive data requiring ethical approval. The authors confirm that the research was conducted in accordance with accepted academic integrity and ethical publishing standards.

Author Contribution Statement:	All authors contributed significantly to the development of this manuscript. Aida Syaqirah Muhsein was responsible for the conceptualization, methodology, and overall supervision of the study. Dr. Nor Diyana Binti Mustapa handled data collection, analysis, and interpretation of results. Dr. Nor Diyana Mustapa contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

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International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 24 (March 2026) PP. 414-427
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