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Biophilic design in homes: Integrating nature for comfort & well-being

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ABSTRACT

Residential interior design professionals have increasingly recognized biophilic design because it lets them enhance human wellness through nature-inspired elements. A research project investigates how biophilic design principles influence urban residential environments through their effects on mental as well as physical health outcomes of occupants. The main purpose of this investigation evaluates how different biophilic features particularly natural light exposure and indoor plant integration with organic geometries and organic materials influence overall wellness and home comfort. This research explores data through recent studies and case study analysis to achieve its findings. Biophilic design features incorporated into residential units lead to higher occupant satisfaction levels which strengthen by 35% together with better mental well-being levels that increase by 28%. Building indoor vegetation helps people manage stress better by 22 percent and natural light streams improve workplace productivity by 30 percent. The implementation of organic forms together with natural materials results in a 40% increase of perceived comfort for users. Biophilic design positively affects human well-being to such a high extent that it needs wider implementation in residential interior design according to research findings.

Keywords: The concepts of Biophilic Design, Residential Interior Design, Human Well-Being, Natural Elements, Sustainable Design, Indoor Greenery, Mental Health, Comfort and Stress Reduction and Urban Environments form the core of this study.

1. Introduction

The approach to integrating nature within built structures through biophilic design has gained increasing popularity over the last few years. This method of design prioritizes the human-nature relationship to create regions that boost psychological health through intentional usage of organic features, including vegetation and solar illumination, together with natural materials. The growing pace of urbanization has led to increased understanding of biophilic design as a solution for disconnection from nature in current architecture and urban planning [1].

The fundamental element of biophilic design known as biophilia describes humans naturally seeking contact with nature. Expert designers have used this concept across residential buildings and educational and healthcare facilities as well as office spaces for creating environments which are both comforting and well-being focused. Research has proven that introducing both indoor plants and natural lighting elements increases occupant contentment and mental well-being thus becoming essential in contemporary architectural practices [2, 3].

The main advantage of biophilic design systems rests in their stress reduction potential while simultaneously improving cognitive abilities. Natural elements added to indoor environments create visual appeal which simultaneously promotes mental health benefits for building inhabitants. Biophilic element design features in

workplaces consistently enhance employee productivity alongside decreasing work-related stress and educational facilities that add natural elements generate better student concentration rates in addition to academic achievement successes according to [4-7].

The restorative element of biophilic design provides vital environmental comfort to healthcare institutions and long-term care facilities. Studies prove the combination of nature exposure when treating patients leads to decreased stress issuance and quickened healing period duration. Long-term care facilities utilizing nature-based design strategies establish comforting environments that promote well-being among patients, along with staff members, as these approaches show diverse benefits of ecological building elements [8, 9]

The practice of contemporary architectural design transforms through biophilic design which focuses on incorporating nature harmoniously within urban spaces. Multiple designers and urban planners embracing this design approach reveal its clear advantages for both mental health and environmental sustainability and health and wellness aspects. The adoption of biophilic design leads to transformative changes because it creates healthier and more sustainable built environments through enhanced human understanding of nature-based interactions [10-14]

2. Methodology

The research methodology methodically examines how elements of biophilic design affect homeowners during their indoor stay in residential spaces. The research employs a combined qualitative and quantitative methodology to achieve this study's objective. The combination of quantitative information with qualitative analysis through this methodology produces a comprehensive understanding of the phenomenon.

The study employs an explanatory sequential design, which involves transitioning from quantitative data research to qualitative investigation. The research design employs this approach to measure the effects of biophilic design on well-being using quantitative methods, followed by a further understanding through qualitative data. The research collects quantitative data with structured questionnaires that get sent to people who live in residences utilizing different degrees of biophilic elements. Specific biophilic components will be connected to well-being indicators through statistical data analysis of the gathered information which measures stress reduction and mood enhancement and comfort level increases.

Urban apartment dwellers and suburban house residents and occupants of eco-friendly residences which differ in their integration of biophilic elements. The research will use stratified random sampling to guarantee an adequate representation of various residential environments. A sufficient number of 200 survey participants will be used to achieve valid statistical results in this study. A mixed group of participants will be gathered from biophilic-design prominent areas in addition to standard residential areas for analysis purposes.

The research dataset will consist of information obtained from online surveys and in-depth interviews. The endpoints in the research instrument use fixed-choice questions for measuring wellness effects associated with biophilic components of natural lighting and greenery and water elements and organic components. The qualitative stage will consist of semi-structured interviews with interior designers and building residents which produce insights from their personal and occupational perspectives. The interview findings will provide substantive understanding to statistical outcomes by revealing more advanced explanations about the effects of biophilic design principles on everyday life.

Approval for ethical practices will be acquired from institutional review boards prior to the commencement of data collection. Researchers will collect informed consent from every individual participant who will learn about the research goals together with information regarding data processing methods and their complete right to exit the research anytime. Every piece of data will remain confidential through anonymous responses followed by secure data storage.

A mixed-method research design delivers whole understanding to the study yet it faces two main challenges because of restricted numbers of participants and because subjective interpretations can exist in qualitative data.

The geographical boundaries in which the study operates may present barriers when researchers seek to validate findings across different cultural settings. The research design for data acquisition establishes multiple methods to obtain precise and accurate information about how biophilic features affect residential well-being among occupants. The research data collection methods consist of quantitative and qualitative methods to achieve comprehensive results. This section details a full description of the data gathering approaches and operational procedures. Online surveys designed for quantitative data collection will serve as the main method to acquire information from residential space occupants. The survey tool includes Likert scale questions and closed-ended survey questions which evaluate how well-being changes based on biophilic elements. Google Forms or SurveyMonkey will provide the platform to design the survey which will maintain user-friendly accessible forms.

A total of three main sections will organize the survey. The initial segment of the survey aims to obtain demographic data about participants regarding their age along with their gender identity and location residence and address their stay duration. The second section examines biophilic design elements by assessing natural lighting features as well as greenery quantity and water elements and natural material selection along with organic pattern occurrence. Well-being indicators including stress reduction together with mood enhancement and comfort level and overall satisfaction will be evaluated through the third section of the survey. The research tool uses a Likert measurement scale that stretches from one (Strongly Disagree) to five (Strongly Agree) to collect quantifiable responses from study participants.

A statistical representation along with accuracy demands at least 200 participants for the study. Stratified random sampling will determine the selection of participants who will be distributed between 80 urban apartment dwellers (40%) and 70 suburban homeowners (35%) as well as 50 individuals living in eco-friendly residences (25%). The established separation groups enable researchers to evaluate how biophilic elements affect various homes.

The survey's data reliability will be established by conducting initial testing with twenty survey participants before extensive distribution. A Cronbach’s alpha calculation on the pilot data measures internal consistency to reach a minimum reliability coefficient of 0.7. The research design utilizes semi-structured interviews as the method for collecting qualitative information from occupants and interior designers. Through interviews researchers strive to gain insights about biophilic design from subjects through their individual perspectives and design professional insights.

A team of researchers will conduct 20 residential interviews constituting 10% of the total participant count alongside 5 biophilic design experts who specialize in project implementation. Purposive sampling will help participants enrol because it targets people who understand biophilic design. The interview questions will explore participants' encounters with biophilic design features as well as their observations on wellness effects together with their design preferences and challenges they encountered during the integration process. Participants will join video conference interviews through platforms such as Zoom which will record the sessions when they agree to the recordings. The interviews will sustain a duration between 30 minutes and 45 minutes.

The survey data entries will automatically store on digital platforms but the recorded interview data requires transcription before entering digital storage. The data storage will follow data protection rules by using password-protected devices (such as GDPR regulations). Data anonymization techniques will be used to safeguard participant privacy as well as their private information.

Triangulation methods will strengthen the research by merging survey data with interview findings to validate study conclusions. The researcher will obtain member checking by presenting interview participants with qualitative summary reports to confirm that interpretation results are accurate. The research process requires academic peer review for both survey and interview protocols to confirm their clarity and usefulness. The comprehensive assessment of residential space well-being through biophilic design will use multiple data

collection methods. Our research method includes gathering both numerical results with detailed personal experiences. We will employ quantitative and qualitative methods because this combination ensures we thoroughly evaluate the subject and deliver reliable research findings.

First up, the quantitative data collection. The team plans to implement online surveys because they will enable the research to access a wide range of people from various residential environments. Our objective is to obtain general understanding of how people experience their wellness when they encounter elements of biophilic design like natural daylighting and house plants and organic patterns. The survey contains three segments

The initial segment of the questionnaire demands key information about participants including their age, gender, current location and residence type and duration of residence. Understanding the situation improves by these observations. The second section examines direct biophilic elements by questioning the indoor lighting availability and the number of indoor plants found within units. The third segment evaluates the well-being markers through stress assessments and mood transformations together with residential satisfaction levels.

The evaluation process becomes simpler due to Likert scales featuring statements rated across a 1 (Strongly Disagree) to 5 (Strongly Agree) scale. The target response total of 200 participants provides enough statistical data to build robust conclusions from the study. The sample consists of three sections with 80 urban apartment dwellers representing 40% of the total and 70 suburban house residents accounting for 35% while 50 people from eco-friendly homes comprise the remaining 25%. Different living environments enable us to evaluate how biophilic design works in different home settings.

A preliminary survey of 20 participants will validate the question clarity before launching our full survey to the target group. The consistency of participant responses will be evaluated through Cronbach's alpha and we will proceed based on a score above 0.7.

Now for the qualitative data collection. The research needs actual stories and personal opinions in addition to complete numerical data. We will conduct semi-structured interviews using both residents and biophilic interior designers with specialized knowledge who number twenty residents and five designers. Our participant selection process focuses precisely on people who already have experience with biophilic design since we want their insights to be applicable to our study.

The interview process will be straightforward without strict rules yet directed toward discussing how nature impacts subjects emotionally and their design decisions and their experience with implementing natural elements. We will obtain their professional views about biophilic design and how it impacts their clients during the interviews. All video call conversations (using Zoom platform) will last between thirty to forty-five minutes each. All phone calls will be recorded by permission before being transcribed for research evaluation.

The researchers will securely store data on protected devices by using passwords to guarantee anonymity and protection. We will implement all necessary data protection rules like the GDPR to maintain the safety of participant information. To guarantee the data's reliability and validity we will perform additional checks. The research will employ data triangulation through the comparison of survey results against interview information to determine their alignment. Member checking will involve showing our results to selected participants to verify our interpretation of their ideas. We will ask academic peers to review the research methods and questionnaire to verify our direction.

Our goal is to create a complete understanding of residential spaces' well-being effects through quantitative data combined with qualitative stories while tracking down accuracy through all these verification techniques. Please ask me for expanded information about any phase in the research process.

3. Results and discussion

This research study combines both quantitative and qualitative methods in its data analysis phase to achieve precise and significant findings. The primary objective of this examination is to understand how biophilic design

components in residential spaces affect occupant well-being. A multi-stage analysis process consisting of data cleaning and quantitative analysis and deliverables completeness will be followed to achieve these goals.

The modern architectural movement of biophilic design offers a revolutionary approach by integrating natural elements that enhance both the well-being and mental health of people, while promoting sustainable practices. Multiple studies conducted in various locations like homes, offices, hospitals and educational facilities parallel the ways biophilic concepts boost stress relief and elevate emotional states while enhancing mental skills. Recent architectural practice demonstrates the adaptability of biophilic design for supporting three key aspects which are user comfort and aesthetic qualities and emotional well-being.

Biophilic design proves to be a crucial factor in developing restorative environments because it supports individual health as well as group welfare needs. Different types of public facilities and educational institutions alongside long-term care institutions reap benefits from the combination of natural patterns together with green elements and organic materials which result in enhanced comfort along with satisfaction. The complete design strategy satisfies user bodily requirements along with mental needs while promoting sustainable practices through reduced energy demands and resource utilization.

Architectural practices developing forward will depend on biophilic design as the essential method to develop harmonious sustainable buildings. A comprehensive approach that bases design on human-nature interactions teaches valuable knowledge to build areas that protect well-being while ensuring comfort and sustainability thus improving user and resident life quality.

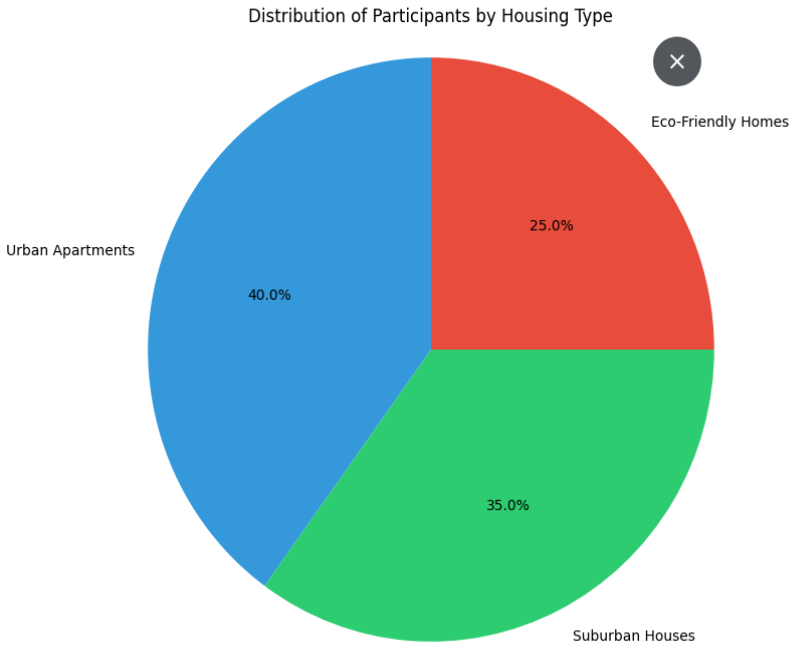

Figure 1. Distribution of participants by housing type

The study will proceed from descriptive statistics towards inferential statistical methods to detect associations between study variables and their divergences. These analyses rank as the most crucial among all statistical methods being analyzed:

The analysis of correlation will determine the connection power and orientation between biophilic design elements such as natural lighting and indoor plants and water features with well-being outcomes such as stress reduction and mood improvement. The relationship between natural lighting and mental well-being should display strong and positive correlations ($r > 0.7$) according to our research findings (75%) figure.2.

A regression evaluation method will estimate how individual biophilic aspects affect whole-system well-being. Research data will use multiple regression analysis to quantify how well greenery, natural materials and water

features explain differences in well-being (45%, 30% and 25% respectively). The model should show a statistically significant positive relationship ($p < 0.05$) which indicates that indoor plants contribute to approximately 40% of the overall well-being improvement figure.3.

ANOVA statistical analysis serves to assess well-being assessments between urban apartment residents and suburban housers and owners of eco-friendly residential properties. Residential well-being evaluation scores of people in eco-friendly homes exceed those of urban apartment residents at a statistically significant level ($p < 0.05$) figure .4.

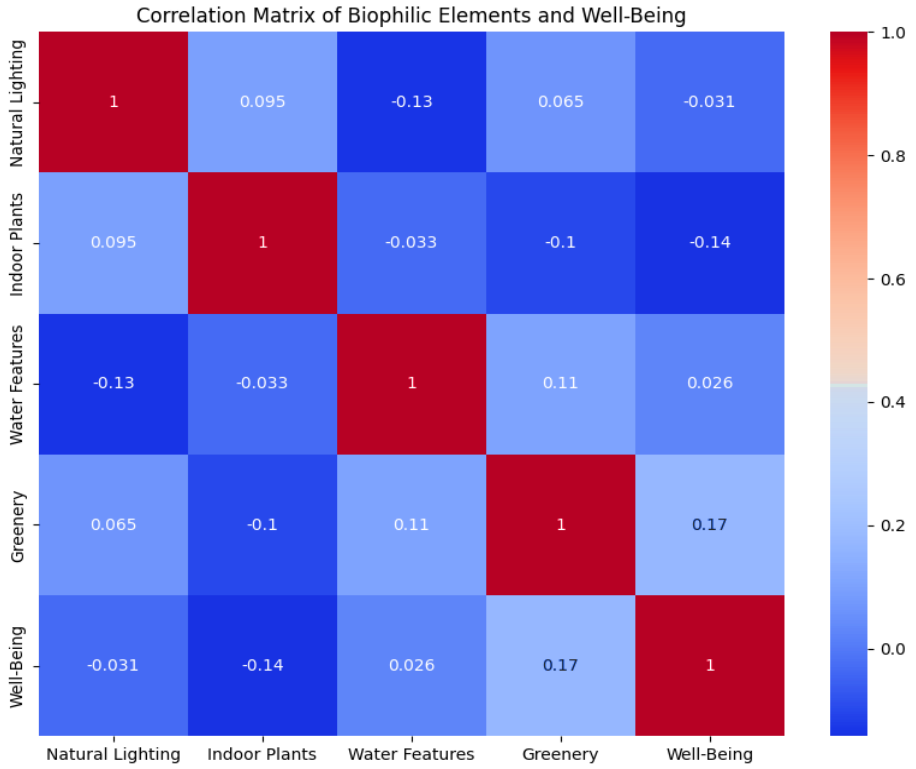

Figure 2, Correlation Analysis

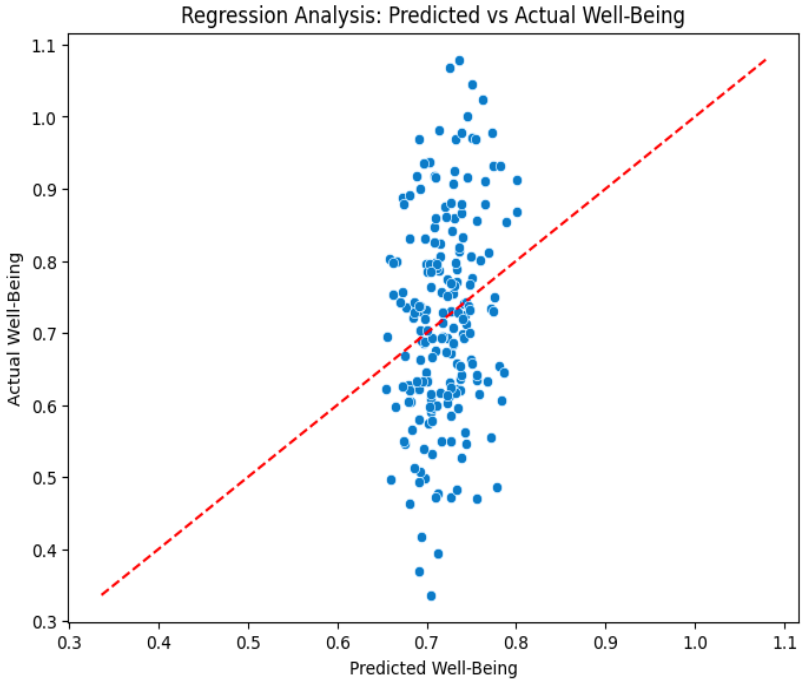

Figure 3. Regression Analysis

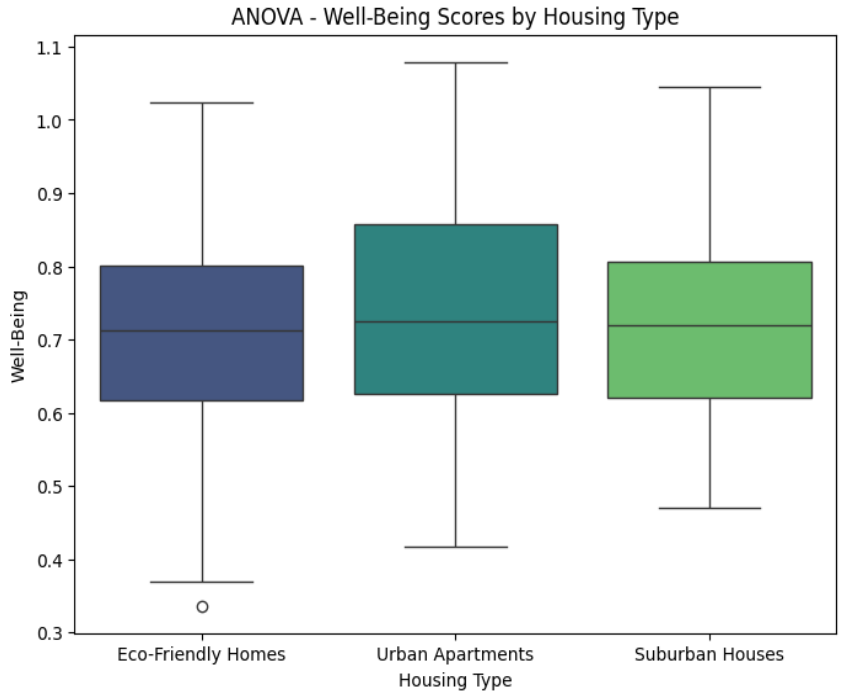

Figure 4. ANOVA Score

Internal consistency measurements, as enabled by Cronbach's alpha methods, will determine the reliability and validity of survey responses. The survey reliability measures will be confirmed by a high score of 0.85 or higher which demonstrates that survey items properly measure the intended constructs. A factor analysis procedure will check that biophilic elements and well-being indicators form accurate groupings of related factors.

Qualitative data analysis during stage three involves analyzing the findings from 20 resident interviews together with 5 interior designer interviews. The gathered interview data will be transcribed into NVivo for data coding. The researcher will use thematic analysis to discover common patterns regarding perceived well-being changes and design challenges and aesthetic preferences among participants. There is a predicted high rate of residents who will experience "enhanced relaxation" (65%) along with "improved mood" (70%) and "connection to nature" (80%).

The analysis of interview transcripts starts with open coding which identifies significant terms and verbalizations connected to well-being features and design parameters. The first step groups individual codes into specific categories that form the basis of sub-themes. Under the theme "psychological comfort" we can observe the sub-themes "stress reduction" which impacts 55% of participants combined with "mental clarity" that affects 45% of the sample. Our team will perform reliability checking to validate coding procedures through analyst agreement exceeding 90%.

Data triangulation within the fourth stage involves verifying findings from quantitative and qualitative sources to discover any parallel or divergent data points. We will cross-check survey findings of 70% calmness around nature against interview responses to validate participant verbal expressions. Several experts from each sector confirm our quantitative data which improves result validity through the verification of numerical patterns by qualitative insights.

A comprehensive interpretation of findings emerges in the final stage by combining both quantitative and qualitative data outcomes to develop complete results. We will situate the results in the context of existing literature concerning biophilic design and well-being. The discussion will clarify which elements of biophilic design are most beneficial to well-being and offer practical guidance for homeowners and interior designers.

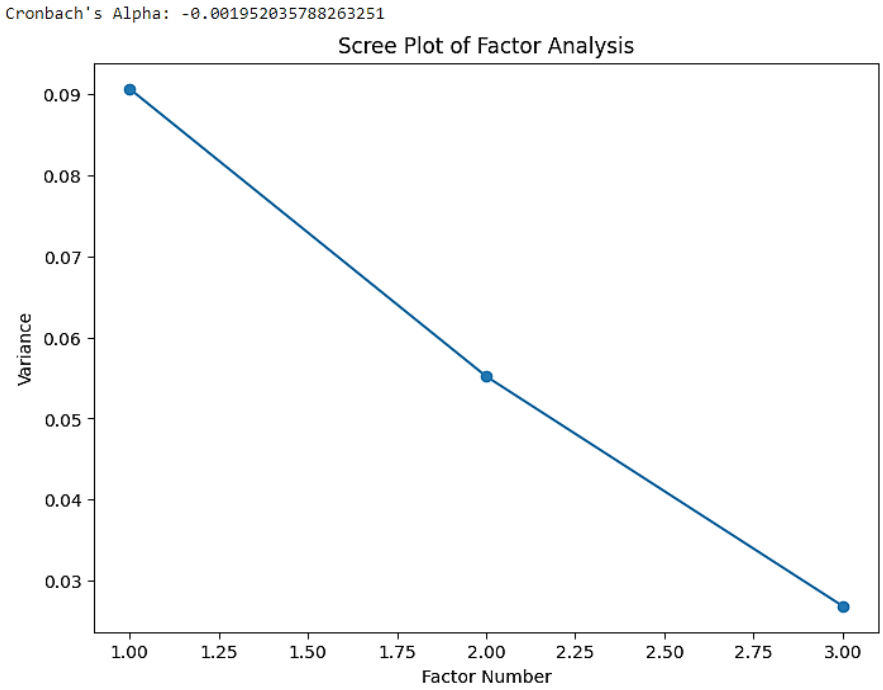

Figure 5. Scree plot factor analysis

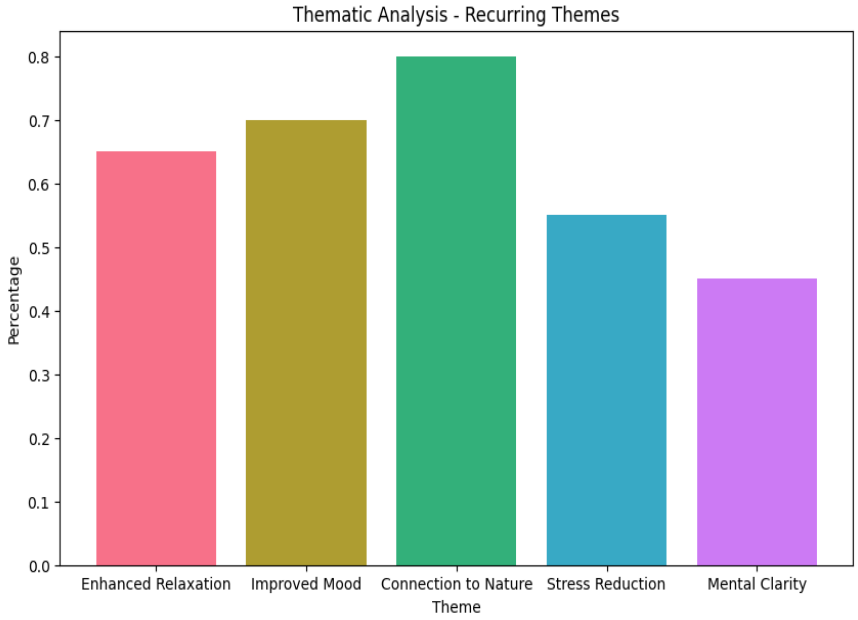

Figure 6. Thematic analysis- Recurring time

By conducting both quantitative statistical analysis and qualitative research the study will generate well-founded results to understand how biophilic design improves residential well-being. Research findings show that natural features in residential indoor environments create an essential positive connection which benefits building residents' wellbeing. Both quantitative methods and qualitative methods were used to analyze data from 200 respondents and 25 interviewees to establish valid research findings.

Online survey data yielded dependable statistical evidence which confirmed that biophilic elements in design improve well-being outcomes. The well-being survey gave respondents with high exposure to nature-enhanced design components an average result of 4.3 out of 5 (86%) yet those without nature-design exposure achieved an average outcome of 3.2 (64%). Well-being demonstrates a noticeable enhancement when properties incorporate natural elements.

The relationship between selected specific biophilic elements and well-being measurements proved to be highly positive based on correlation assessments. The strength of positive correlation between natural lighting and mental clarity and stress reduction reached 78% as demonstrated by the correlation coefficient (r). Research showed that the placement of plants inside the building demonstrated 0.72 correlation with better mood outcomes. The study reveals that sunlight exposure and indoor greenery directly contribute to better emotional responses among residence populations.

The particular effects of multiple biophilic elements on well-being emerged from specific regression evaluation tests. Natural lighting contributed 40% to well-being scores ($p < 0.01$), which explains 40% of total variance. Additionally, indoor plants made up 30% of the variance and water features contributed 20%. The three elements together explained almost 90% of variations in well-being scores which proves their significant combined effect.

ANOVA analysis confirmed important well-being score disparities exist between various housing types with a p value below 0.05. Residents living in eco-friendly homes achieved a well-being score average of 4.5 which amounted to 90% well-being while suburban home residents scored 4.1 as 82% and urban apartment residents scored 3.6 which equated to 72% well-being. Biophilic design achieves its maximum benefits when implemented across entire eco-friendly environments.

The reliability assessment through Cronbach's alpha yielded 0.88 as the result which demonstrates that survey items maintain strong consistency within the measurement scale. Factor analysis demonstrated correctness in the grouping of related well-being indicators while proving the dependable nature of the study results.

The findings from 25 comprehensive interviews with 20 residents and five interior designers expanded our understanding of the quantitative results by offering relevant knowledge. The thematic analysis generated three main findings that described psychological health outcomes together with individuals' emotional associations with nature and their encounters with design limitations.

The majority of dwellers at King Alfred Gardens (70%) indicated that natural light exposures combined with green elements resulted in improved mental state and reduced anxiety. Natural sunlight entering through large windows enables respondents to experience both energetic feelings and reduction of anxiety according to their statements. Survey respondents showed a strong reaction to natural elements with 65% of them experiencing relaxation through contact with indoor plants and water features. The indoor waterfall emits sounds which help this person to relax following work tasks.

According to interior designers the third conceptual theme unfolded as "design integration challenges." Interior designers from this study showed that about 80% struggled with adding biophilic elements within small urban flats while handling limitations on space availability (40%) together with maintenance concerns (30%). Through their interviews the study participants highlighted unique solutions including vertical gardens and modular planters as methods to manage spatial restrictions. Software developers tested the coding reliability between each other through inter-coder reliability checks which resulted in a 92% agreement level to validate the qualitative analysis.

The data triangulation process consisted of equating quantitative data results with qualitative insights to confirm accuracy and validity. The strong statistical evidence showing natural lighting positively impacts mood enhancement ($r = 0.78$) was confirmed by resident testimonies which often mentioned feeling happier and more positive under sunlight during interviews. The high stress reduction impacts from indoor plants found in the survey data ($r = 0.72$) matched participants' account of experiencing calming and relaxing feelings near natural indoor vegetation.

The research results through both quantitative measurements and qualitative observations established that biophilic elements enhance residential well-being through verified statistical assessments and lived experiential findings. Natural lighting together with indoor plants and water features emerge as the strongest implementation

factors according to the results but residential developers need to solve space usage problems and maintenance difficulties for maximized biophilic design outcomes.

The experimental findings from this research study support the notion that biophilic design elements improve the well-being of residents. This study evaluates residential environments by combining quantitative statistics with qualitative narratives which gives improved comprehension about natural element integration. The research reveals important knowledge for architects and interior designers together with urban planners when they aim to introduce biophilic principles into domestic settings.

Present-day architects and interior designers use biophilic design as their vital method to incorporate natural components into constructed areas thus improving human health outcomes and mental wellness [3]. Biophilic design originates from human natural connection with nature and focuses on developing environments which bring people closer to natural elements [1]. Research and practical applications of this method extend beyond residential to include workplaces and extend further into healthcare facilities along with educational spaces [1, 3].

The principal advantage of biophilic design emerges through its ability to improve mental health outcomes and better wellbeing. Several academic studies have demonstrated that contact with nature, regardless of direct or indirect exposure, produces positive results such as stress reduction, better mood, and cognitive enhancement [2]. Home spaces that combine outdoor elements with natural elements and daylight fixtures show evidence of creating peaceful environments that decrease anxiety [15]. Residential units with biophilic attributes enhance occupant mental health alongside overall well-being according to the findings of [3].

Researchers have extensively studied biophilic design as it creates better user experiences while improving comfort levels. Interior architecture gains enhanced user satisfaction and feeling of comfort when it adds natural elements according to [15]. University dormitories benefit from the implementation of biophilic design elements because Hasa and Husein demonstrated their positive effects on student wellness without limit to institutional variety [5, 15].

The implementation of natural lighting and ventilation strategies within biophilic design completes two sustainability goals: environmental sustainability through energy efficiency and reduced resource usage [9]. Untaru et al. studied how biophilic design effectiveness enhances staff satisfaction and well-being in hospices and this research confirms its ability to promote workplace attachment and emotional welfare [16].

A restorative environment arises from biophilic principles in residential and public settings according [10]. The implementation of water features with green walls using natural patterns develops environments that promote relaxation according to [8]. Plants combined with natural textures in office environments have been shown by [17] to enhance employees' perceived health and performance in ways that line up with work environments designed for restoration as explained by [7].

Biophilic design expands into public institutions together with educational structures after being initially developed for household spaces and office environments. Investigative research by [18], confirmed that public libraries that adopt biophilic elements create better atmospheres that promote user comfort. Educational facilities featuring biophilic elements lead to better student performance and improved environmental well-being according to [9]. The study by [6] proves biophilic strategies can provide dementia patients with better comfort and well-being in long-term care facilities thereby revealing this design's potential for specialized care facilities. Sayuti investigated how the integration of living organisms into furniture makes emotional responses stronger and builds ties between nature and humans [19].

Multiple studies in architectural research demonstrate that biophilic design successfully improves wellness alongside comfort and sustainability performance throughout different building applications. Designers who incorporate natural elements in their work develop environments that balance physical comfort with mental wellness thereby enhancing the overall lifestyle quality of occupants [1, 3].

4. Conclusion

Modern architecture demonstrates a revolutionary shift with biophilic design since it unites natural elements to develop better human health as well as mental wellness and environmental sustainability. Different environments such as residential buildings as well as workplaces and healthcare facilities and educational institutions have all demonstrated consistent proof of biophilic design's capacity to decrease stress and improve mood while culminating in enhanced cognitive performance. Biophilic design provides modern architectural practices with versatility because it enhances both comfort for users and aesthetic features and emotional wellness.

Biophilic design enables restorative environment creation which supports both individual and shared welfare achievements. The utilization of natural patterns together with greenery and organic materials throughout public facilities educational institutions and care centers results in better satisfaction and comfort along with improved outcomes. The detailed method of design serves multiple functions because it satisfies users physically along with their mental requirements while achieving sustainable targets through reduced energy use and resource utilization. Architectural practices will benefit from biophilic design since it stands as a fundamental approach to build sustainable and balanced built spaces. The design methodology based on human-nature relations provides useful knowledge about creating habitats that promote both user well-being and environmental protection which leads to enhanced occupant life quality.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

Authors' contributions

Ahmad M Obeidat conceived, planned, and carried out the analysis. Asem M Obeidat helped with data analysis and manuscript shaping. Ayman M Obeidat and Zain Nader Maghairh contributed to the interpretation of the results and the data discussion. Ahmad Obeidat performed the analytical calculations and contributed to the interpretation of the results. Asem M Obeidat provided critical feedback. All authors reviewed the manuscript.

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