Original Article

Enhancing Interior Environmental Quality in Bedrooms of Jordanian Elderly Housing

Husam Hussein Alhmoud[1], Mohd Rodzi Ismail[2]

[1,2]*School of Housing, Building and Planning, University Sains Malaysia, USM, Penang, Malaysia.*

[1]*Corresponding Author : husamalhmoud@student.usm.my*

Abstract - This paper aims to assess the interior environmental quality of elderly bedrooms in senior housing (houses for elderly aged 60 and older) in Irbid, Jordan. Interior Environmental Quality (IEQ) is a crucial factor in designing comfortable and healthy living spaces. In the context of bedrooms for the elderly in Jordan, IEQ encompasses various elements such as air quality, access to daylight, acoustic comfort, and the ability to control lighting and thermal conditions. A qualitative approach was adopted, examining three selected Jordanian houses to understand the evolution of elderly bedrooms, regional variations, and factors influencing the availability of social resources for elderly care and to understand the behavior of elderly individuals within their bedroom environments through focused interviews and surveys. Participants in the studies were of a similar age range. They were informed ahead of time that the interview would include a discussion of their perspectives on the environment and elderly people's houses. Participants' ages ranged from 60 to 70 years old, with a mean of 65 (SD = 13). The vast majority (57.5%) were men, and (SD =12) (42.5%) were women. The findings present valuable insights for designers, providing advice and solutions to enhance the design of elderly housing bedrooms.

Keywords - IEQ, Interior space, Design strategies, Elderly house, Air quality, Bedroom.

1. Introduction

The interest in interior design in housing bedrooms for the elderly is important because it affects the users directly or indirectly, as it affects them [1]. Among the most important elements of interior design that must be taken into account during the design process that will be used in the housing of the elderly are [2] the appropriate color, materials, appropriate materials, ventilation, and lighting of the place in which all of these elements have an actual effect on the behavior, comfort, well-being and productivity of each of the elderly in housing therefore, this housing is a residential environment that works to provide everything that the elderly need in terms of protection, safety, health care and comprehensive treatment to provide all aspects of relaxation that are important to the elderly in the house [3, 4].

Building managers and operators must consider all facets of Interior Environmental Quality (IEQ) rather than focusing solely on temperature or air quality to enhance the satisfaction of the building's occupants. Design, as both an art and a science, aims to improve the interior of a building to create a healthier and aesthetically pleasing environment for its inhabitants.

This involves meticulous attention to furniture arrangement, lighting, colors and materials to establish a comfortable and secure living space [5, 6].Given the global challenges posed by issues like global warming and poor air quality there is a growing imperative for enhanced, sustainable architectural designs, particularly in interior house design. The elderly, compounded by inadequate air quality, can lead to severe health complications. Hence, it is imperative to design elderly housing bedroom facilities with a focus on enhancing the quality of the interior environment [7, 8].

This research is focused on identifying trends related to elderly housing bedrooms to develop strategies that enhance the interior environmental quality of such facilities in Jordan. It seeks to optimize design elements such as movement and interior space. Additionally, the design of houses for the elderly will adhere to universal design principles emphasizing the organization of space, scale, and geometry to ensure accessibility and comfort for all residents [9, 10].

The interior environmental quality of bedrooms in housing for the elderly in Jordan is a significant but often overlooked aspect of architectural design. As Jordan's elderly population grows, there is a pressing need to design living spaces that meet their unique physical and psychological requirements. Current design practices frequently neglect key factors such as acoustic comfort,

thermal conditions, indoor air quality and ergonomic considerations, all of which are crucial for the well-being and comfort of elderly occupants.

The oversight of these factors can lead to discomfort, stress, and potential health issues among elderly residents. Furthermore, the cultural and social context of Jordanian society underscores the importance of a thorough study that takes into account local norms and preferences in the design of housing for the elderly.

Therefore, this study aims to evaluate and improve the interior environmental quality of bedrooms in housing for the elderly in Jordan, with the goal of enhancing the overall well-being and comfort of elderly residents. By identifying and addressing the deficiencies in current design practices, this research seeks to offer practical recommendations to architects and designers for creating more suitable living environments for the elderly in Jordan.

The research objectives focus on improving the interior environmental quality of elderly houses in bedrooms. The specific objectives of this paper are as follows:

- To examine the elements of interior environmental quality in elderly housing bedroom facilities.
- To enhance the interior air quality within in Bedrooms of Jordanian Elderly Housing.
- To examine interior strategies and assess environmental quality.
- To provide suggestions for creating an appropriate interior environment for elderly people.

2. Materials and Methods

2.1. Research Approach

The approach of this study is to delve into the behavior of elderly individuals within their bedroom environments, employing focused interviews and surveys to evaluate the interior environmental quality of their living spaces. To ensure a comprehensive understanding, qualitative data was collected and analyzed simultaneously, allowing for informed conclusions to be drawn.

Conducted as a case study, the research focused on residential apartments located in a suburban area of Jordan. Its primary objective was to gain insight into the health conditions, comfort levels, and impairments experienced by elderly volunteers within their living environments. Additionally, the study investigated the management approaches employed to address these conditions in relation to the interior environmental quality of Jordanian housing bedrooms. Through a comparative analysis, this study states to transcend simplistic explanations and provide insights. By examining houses within their social context, it sought to

develop strategies for enhancing environmental quality in elderly housing. Focused interviews and surveys were instrumental in evaluating environmental quality and interior space, offering valuable perspectives from elderly residents themselves, including general demographics of the elderly residents and their overall characteristics. Additionally, these interviews and surveys aim to provide insights into the specific area measurements of the house's interior, offering a detailed understanding of the living space. The study meticulously examines various design elements and furniture within the living environment, and the survey card consists of two parts:

In part one:
- Explanations, definitions, and dimensions of the area.
- House planning and the site of the observant area in that plan.
- Details plan of the observant area with site analysis and front building.

In part two:
- The observed area will be examined in the subjects of furniture, design elements, devices, and safety.
- There will be a space for the observer to provide extra information about the interior space.
- Photographs of that area will be attached.

This paper analyzes data related to the visualization of 3D image datasets in software with a specific focus on information extracted from architectural drawings. Through comparisons presented in tables and images, the paper presents a detailed perspective on the shape and structure of various house components. These visual representations are crucial for comprehending 3D building models and facilitating interior navigation. Additionally, the paper provides recommendations for guiding bedroom design for the elderly in Jordan, with the overarching goal of improving the quality of the interior environment. Figure 1 shows the design process for elderly houses.

2.2. IEQ Parameters Significance for the Elderly

The elderly process brings about significant physical changes that influence how elderly individuals perceive and interact with their environment. Challenges such as reduced visual field area, color discrimination issues and difficulty adapting to darkness are common among the elderly. Age-related hearing loss can affect their social interactions and self-confidence, highlighting the importance of creating quieter environments with minimal reverberation to aid in speech comprehension [11, 12], especially considering the significant amount of time elderly individuals spend indoors. Interior contaminants, which often exceed outdoor levels, underscore the need to address IAQ to reduce potential health risks and maintain overall wellness [13]. Thermal comfort is a critical consideration as it directly impacts the physical and mental well-being of the elderly.
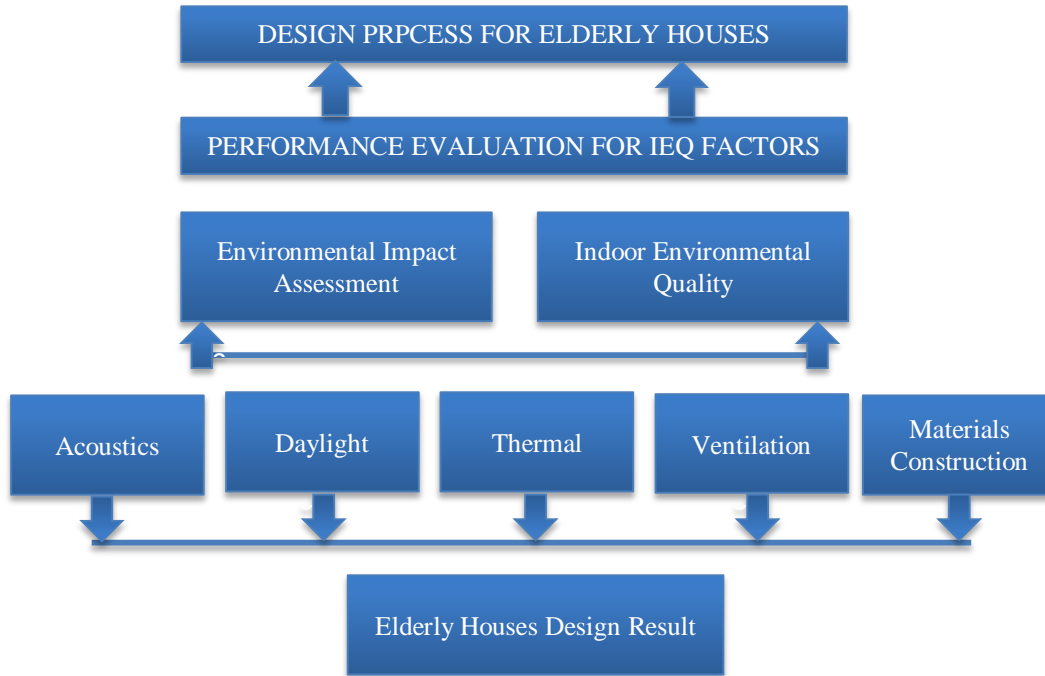
Fig. 1 Design process for elderly houses

Adhering to standards like ISO 7730 and ANSI/ASHRAE 55 is essential to ensure that the thermal conditions are optimal for their comfort and health [14-16]. Understanding and addressing the specific needs of elderly individuals in spatial environments is vital. By doing so, it creates environments that enhance comfort, well-being, and quality of life for people of all ages [17].

2.2.1. IEQ-Affecting Factors

The interior environment of buildings is influenced by a variety of factors that collectively determine its quality. Airborne contaminants, originating from sources such as emissions from office equipment, cleaning products, construction activities, furnishings, carpets, and deteriorating building materials, as well as microbial growth, have a significant impact on interior air quality. Additionally, outdoor pollutants can infiltrate interior spaces, further complicating efforts to maintain optimal air quality [18].

Ventilation strategies play a crucial role in mitigating the accumulation of airborne contaminants and ensuring sufficient air exchange within interior environments. Proper ventilation systems help remove pollutants and replace interior air with fresh outdoor air, thus promoting a healthier interior environment [19].

As well as humidity levels are another important factor affecting interior environmental quality. Excessive moisture can create conditions favorable for mold growth and can compromise occupant comfort, while inadequate humidity levels can lead to discomfort and respiratory issues.

Maintaining optimal humidity levels is essential for a healthy interior environment [20].

Access to natural daylight, effective lighting solutions, and unobstructed views are crucial for the overall satisfaction of elderly individuals living in bedrooms. These factors, though sometimes overlooked, can significantly impact the health and well-being of the elderly. Therefore, implementing prudent management and mitigation strategies is important to address these considerations.

Acoustic conditions also play a significant role in shaping the interior environment. Excessive noise levels can cause discomfort, stress, and reduced productivity among occupants. Using sound-absorbing materials and strategic design interventions can help mitigate noise disturbances and create more acoustically comfortable interior environments.

2.2.2. Elderly Houses and its Universal Design

Universal Design (UD) in elderly houses focuses on accessibility, safety, and comfort, including features such as ramps, wider doorways, and grab bars in bathrooms to accommodate individuals with mobility challenges. The layout is also should strategically be planned to minimize the need for navigating stairs, making movement easier for elderly people.

As well as safety is another critical consideration, with features like non-slip flooring, well-lit hallways, and emergency call systems to quickly assist residents in emergencies [22].The importance of Universal Design

principles in the context of elderly house bedrooms. It effectively explains how features such as accessibility, safety, and comfort are prioritized to meet the specific needs of elderly houses. These rooms often incorporate universal design principles to ensure they are accessible and comfortable for residents [21].

2.2.3. Elderly Houses in Jordan

The design of housing for the elderly in Jordan demands a nuanced approach that considers various factors to ensure the comfort and well-being of this demographic. Several key dimensions of interior environmental quality are particularly salient in this context.

Acoustic Comfort: Noise pollution can profoundly affect the quality of sleep and overall health of elderly individuals. Therefore, it is imperative to incorporate effective sound insulation measures in bedroom design, especially in Jordan, where extended family living arrangements are prevalent.

Thermal Comfort: Elderly individuals are known to be more susceptible to thermal discomfort. Given Jordan's climatic extremes, it is crucial to design bedrooms with robust insulation and efficient heating and cooling systems to maintain optimal thermal conditions for elderly residents.

Indoor Air Quality: Poor indoor air quality can exacerbate respiratory issues and other health problems among the elderly. Implementing adequate ventilation systems and utilizing low-emission building materials are essential strategies to enhance indoor air quality within bedrooms.

Material Considerations: Designing bedrooms with features such as adjustable beds and grab bars can significantly improve safety and usability for elderly individuals, particularly those with mobility challenges.

Cultural and Social Factors: Considering Jordanian cultural norms, it is essential to design bedrooms that facilitate social interactions and accommodate family gatherings. Given the importance of familial support networks in Jordanian society, such designs can enhance the quality of life for elderly residents.

In summary, optimizing the interior environmental quality of bedrooms in Jordanian elderly housing requires a comprehensive approach that integrates these factors. By doing so, architects and designers can create living spaces that promote the well-being and comfort of elderly residents in Jordan.

2.3. Interview Procedure

Structured interviews primarily consisted of open-ended questions. Maximum information was collected and noted during the interviews, including explanations, definitions,

and dimensions of the area. The questions aimed to understand how design can improve and maintain the quality of life for the elderly bedrooms, as well as how they manage daily activities to improve their health; the three (3) houses elderly in downtown Irbid allowed me to observe houses, take a photo, and draw plans. Each resident was interviewed individually with the caretaker present.

Out of 25 eligible residents, a total of 11 residents from three houses were interviewed. The duration of each interview ranged from 60 to 120 minutes, depending on the individual's capacity to respond. Interviews in Irbid City were conducted in the morning, from 10:00 to 12:00, to accommodate the residents' convenience and avoid meal times. In addition, questions explored the type of environment the elderly bedroom is in and whether it influences them in any way. They were also asked about their ability to adapt to new lifestyles and interact with their environment. Table 1 below provides the characteristics of the elderly people sample of the study, including information such as age, gender, income level, education level, and other relevant demographic factors, which can help researchers understand the context and potential influences on the study outcomes.

2.4. Description of Case Studies

Three houses in Irbid were chosen in this study. These case studies provide a snapshot of the different approaches to designing elderly bedrooms in senior housing in Irbid, Jordan. Each case study offers unique insights into how design can impact the quality of life for elderly residents, highlighting the importance of accessibility, comfort, and environmental quality in senior housing design [23, 24].

2.4.1. Case Study (A)

This elderly house, located in Irbid, Jordan, is a three-story structure covering a total area of 280m² (see Table 2). The floor plan includes walls, partitions, doors, windows, stairs, furniture, and other elements. The exterior is adorned with white stone, and the building is oriented towards the west to suit the local climate. Its design allows for openness to the west, ensuring optimal natural light, with three windows on the east side for additional light. The internal layout is designed to maximize natural light, enhancing the overall ambience. The building features a simple yet solid design with a central heating system.

The second floor, designated for the elderly, offers four bedrooms, two bathrooms, a living room, a guest room, a kitchen, and a balcony with an elevator entrance. These spaces are not shared and strategically arranged among the units, and they do not provide ample room for residents. One notable downside of the building is its frontal orientation towards the street, limiting space and movement and reducing direct sunlight into the balcony or interior space.

Table 1. Socioeconomic and demographic data

	Nationality	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Jordanian	9	81.8	81.8	81.8
	Non-Jordanian	2	18.2	18.2	18.2
	Total	11	100.0	100.0	
	Age	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Under 65 years	6	57.5	57.5	57.5
	66 – 75 years	5	42.5	42.5	42.5
	76 – 85 years	0	0	0	0
	85 years and above	0	0	0	0
	Total	11	100.0	100.0	100.0
	Gender	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	4	36.3	36.3	36.3
	Female	7	63.7	63.7	63.7
	Total	11	100.0	100.0	100.0
	Ability	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Ability to walk	8	72.7	72.7	72.7
	Non Ability to walk	1	9.1	9.1	9.1
	Use wheelchair	2	18.2	18.2	18.2
	Total	11	100.0	100.0	100.0
	Occupational	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Artisan	1	9.1	9.1	9.1
	Civil servant	2	18.2	18.2	18.2
	Doctor	2	18.2	18.2	18.2
	Nurse	1	9.1	9.1	9.1
	Teacher	3	27.2	27.2	27.2
	Freelancer	2	18.2	18.2	18.2
	Total	11	100.0	100.0	100.0
	Education Level	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Not graduated from primary school	4	36.4	36.4	36.4
	Primary School	1	9.1	9.1	9.1
	High School& Higher Education	5	54.5	54.5	54.5
	Total	11	100.0	100.0	100.0

Table 2. Illustration of elderly house (case A)

Elderly House	Explanation
 Site Plan (Google map, 2023)	The design of the house includes a single main entrance at the front and an entrance at the back, which enhances convenience. Moreover, a strategically placed large olive tree in front of the building serves aesthetic. Apart from enhancing the visual appeal of the surroundings, the tree provides shade, which aids in replenishing stale air.

Plan

The building boasts a balcony that enhances natural light penetration, leading to a significant 30% decrease in electricity usage. The presence of a glazed roof and wall further enhances natural lighting. Thoughtful choices in color and materials contribute to creating a sense of spaciousness within the building.

The layout is not designed also with wheelchair users in mind and does not ensure comfortable accessibility with appropriately spaced furniture.

Front Elevation

The design of the building prioritizes the use of natural light, establishing a close relationship with nature and minimizing the reliance on artificial lighting during daylight hours.

The living quarters for the elderly are situated on the second floor. This differs from the recommended approach, which typically suggests two accessible entrances on the first floor for the elderly. In this design, however, their accommodations are located on the second.

Bedroom Elderly People

This is a good example of a simple bedroom design. However, the furniture of the bedroom layout area hinders the movement of the wheelchair and uncomfortable distances for the users.

The acoustic comfort in the bedroom is insufficient, as the audio system reflects little sound, which causes discomfort.
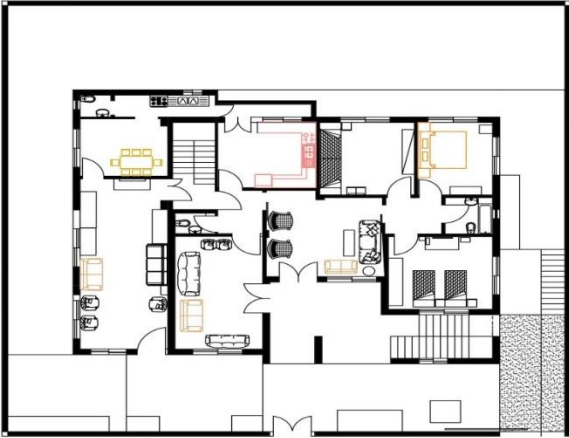
The bedroom also responds effectively to environmental conditions, using a ventilation system and a hygrometer.

2.4.2. Case Study (B)

The elderly house is located in Aydoun, Irbid, Jordan, with a total area of 275m² across two floors (see Table 3). The floor plan includes walls, stairs, furniture, and other elements. The main door of the house provides quick and easy access for car drivers with ample parking available in both the front of the building. The curtains, made of PVC, are heavy and act as windows without compromising privacy; some issues with the windows in each room need to be addressed. In addition, the surrounding area features abundant vegetation, which provides shade and acts as a windbreak.

Table 3. Illustration of elderly house (case B)

Elderly House	Explanation
  Site Plan (Google map, 2023)	The site of the house includes small windows that do not offer uninterrupted views of the outdoors. Walls and sections of the residential area are equipped with small windows on the south side of the lower courtyard construction. The design element is also intended to ensure that the elderly have nonstop views, maximizing their ability to enjoy the natural scenery outside from within the room.
  Plan	The design of the corridors and rooms do not take into account factors such as adequate door and corridor widths, the strategic use of color to enhance perception, and appropriate lighting, all in accordance with established design principles. The interior spaces are arranged parallel to each other, lacking clear distinctions between them.
  Front Elevation	The design of this house was primarily influenced by considerations related to materials and structural design, without sufficient regard for the specific needs of elderly individuals. As a result of their physical limitations, the elderly often face challenges in venturing outdoors, which can adversely affect their health.

The bedroom poses safety risks for wheelchair users, who find the spacing between furniture uncomfortable, exacerbated by the use of carpeting. The lighting design is inadequate, leading to headaches and poor vision among the elderly. Furthermore, the bedroom lacks the flexibility and convenience principles necessary for elderly occupants.

Bedroom Elderly People

2.4.3. Case Study (C)

The elderly house is situated in Irbid, Jordan, covering a total area of 475m² across three floors (see Table 4), and the building exterior is clad in white stone. The building is oriented east-west and features a monolithic design with a small footprint.
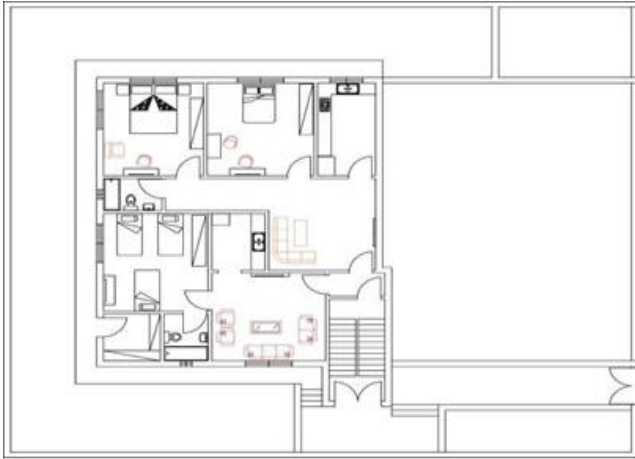
The building's service areas serve as an acoustic barrier, minimizing noise from the roadway. The windows designed with low thresholds allow ample natural light and views of the surrounding nature while providing effective shading from the sun.

However, a notable design flaw is the east-facing orientation of the building's four-story front which limits direct sunlight penetration into the rooms, resulting in a lower ambient temperature. Additionally, some windows do not provide adequate natural light.

Natural ventilation, essential for effective airflow between rooms, is not optimally utilized in elderly houses impacting interior air quality. Trees and shrubs surrounding the building provide privacy and reduce ground reflectivity, which helps in moderating the amount of sunlight reaching the building.

Table 4. Illustration of Elderly House (case B)

Elderly House	Explanation
 Site Plan (Google map, 2023)	This house was not designed to address the elderly housing crisis, as it features construction and the use of unsuitable materials for elderly people. Additionally, there are few trees and shades in this area, not allowing winds to pass through the structure easily.

Plan

The design includes west-facing views through doors and walkways, although there is only a garden and a few trees and shrubs. The garden primarily consists of grasslands and trees.

The design was intended to tightly link the buildings together, which unfortunately leads to a lack of air circulation and natural light for the elderly.

Front Elevation

The building features doorways on the east and south sides for flexible access.

Although there are clusters of dwellings, their design does not facilitate proper air exchange and ensures that the prevailing breeze remains undisturbed.

Bedroom Elderly People

The design of the bedroom is not safe and wheelchair users are uncomfortable with the distances between the furniture.

- The design does not provide good ventilation, as a result, it causes an Abnormal hygrometer and low natural light for the elderly.

-This is a poor example of a simple bedroom design. It does not respond well to the environment and does not make effective use of sustainable design, acoustics system, ventilation system, and hygrometer.

Table 5. Evaluation of case studies according to sustainable criteria

S/N	Criteria	Elderly People House -A	Elderly People House -B	Elderly People House -C
1.	Environmental quality	Very Good	Very Good	Very Good
2.	Sustainable use of resources	Good	Good	Good
3.	Elderly behavior	Good	Good	Good
4.	Total energy demand and renewable primary energy	Poor	Poor	Poor
5.	Drinking water demand and the volume of wastewater	Very Good	Good	Very Good
6.	Land use	Good	Good	Good
7.	Residential environment	Good	Good	Good
8.	Interior air quality	Good	Good	Very Good
9.	acoustic comfort	Poor	Poor	Poor
10.	Interior Environmental Quality (IEQ)	Good	Good	Good
11.	Quality of outdoor space	Poor	Good	Poor
12.	Safety and security	Poor	Poor	Poor
13.	Accessibility	Good	Good	Good
14.	Visual comfort	Good	Good	Good
15.	Suitability for conversion	Poor	Poor	Poor
16.	Integration of public art	Good	Good	Good
17.	Thermal comfort	Good	Good	Good
18.	Ventilation effectiveness and interior air quality	Poor	Poor	Poor
19.	Ease of cleaning and maintenance	Very Good	Very Good	Very Good
20.	Quality lighting and views	Poor	Poor	Poor
21.	Integrated and comprehensive planning	Poor	Good	Poor
22.	Space necessity for the elderly	Poor	Poor	Poor
23	Solutions for a better IEQ	Good	Good	Good
24	Design and construction materials	Good	Good	Good
25	Operations and maintenance	Good	Good	Good
26	Societal perception of the aged	Good	Good	Good

Evaluation of Case Studies According to Sustainable Criteria involves assessing selected case studies based on specific sustainability criteria. These criteria typically relate to environmental quality and other aspects of sustainability. The evaluation process includes analyzing how well each case study aligns with these criteria using qualitative measures. The aim is to determine the extent to which the case studies demonstrate sustainable practices and outcomes, offering valuable insights for future sustainable design endeavors. During each interview, additional questions were asked to gather more detailed information, following the initial general questions. The scores presented in Table 4 indicate the extent to which each criterion has integrated sustainable planning principles into their practices.

3. Results and Discussion
3.1. Interior Environment Quality
The wave of the elderly population is already sweeping through many advanced and emerging sectors through important buildings.

The use of sustainable materials in elderly people's houses in the bedroom is crucial because it enhances various aspects of the living environment [25, 26]:

- Health and Safety: Sustainable materials are often non-toxic and emit fewer harmful chemicals, which improves interior air quality and reduces health risks. This is particularly beneficial for elderly individuals who may be more susceptible to respiratory issues.
- Durability: Sustainable materials are typically more durable and long-lasting. They reduce the need for frequent replacements and maintenance, which can be challenging for elderly residents to manage.
- Energy Efficiency: Sustainable materials, such as energy-efficient windows and insulation, help reduce energy consumption for heating and cooling. This leads to lower energy bills and a more comfortable interior environment.

- Environmental Impact: Sustainable materials are sourced and manufactured in environmentally friendly ways. They reduce carbon footprint and promote environmental conservation, which is important for creating a sustainable future.
- Comfort and Well-being: Sustainable materials contribute to a more comfortable and aesthetically pleasing living environment quality. This promotes a sense of well-being and enhances the overall quality of life for elderly people.

3.1.1. Environmental Impact Assessment of Elderly People House

The construction sector often emphasizes the importance of construction settings in addressing issues such as leakage in old distribution systems. However, there is a growing emphasis on providing long-term solutions to improve the standard of housing for the elderly [27].

Improving the standard of elderly housing in Jordan and other countries offers numerous benefits for various stakeholders, including builders, designers, architects, and residents. These benefits include enhanced interior environmental quality, incorporation of sustainable design elements, creation of a more comfortable residential environment, reduction of airborne diseases, use of appropriate materials, and increased satisfaction among elderly residents [28].

Each case study demonstrated that the design of the building was influenced by its context, including the physical surroundings. The orientation of the building played a significant role in determining the layout of the interior spaces, with most dwelling units facing south or north and circulation spaces located on the west side of the building [29].

The quality of natural light and air entering the spaces was directly affected by the building's orientation and layout. The case studies underscored the importance of maximizing natural light and air circulation to enhance the interior environmental quality of elderly care facilities. For example, the design of the elderly house ensured that no artificial lighting was needed during the day.

These findings have significant implications for the design of houses and environments for elderly people, particularly in light of the global demographic shift towards an elderly population.

3.1.2. Sustainable Design

The findings of this study suggest several key factors to consider when designing sustainable bedrooms for the elderly:

- Flexible Modular Design: This allows for spatial adaptability, which is crucial for accommodating elderly individuals with limited mobility or respiratory limitations.
- Open-Plan Design: Promotes mobility and enables the incorporation of health-monitoring technologies, enhancing overall accessibility and functionality.
- Controlled Environmental Parameters: Sustainable houses can offer environmental parameters that can be controlled for both artificial conditioning and natural ventilation, ensuring optimal interior conditions.
- Well-Designed Windows: Windows should be easy for the elderly to reach and operate, enhancing natural light and ventilation while ensuring user comfort.
- Energy-Efficient Envelope: An energy-efficient building envelope improves and maintains comfortable conditions, contributing to overall energy savings and sustainability.
- Non-Intrusive Healthcare Monitoring Technologies: Incorporating such technologies can provide valuable health monitoring and assistance to elderly residents, enhancing their safety and well-being.
- Outdoor Spaces for Activities and Social Interaction: Including areas for outdoor activities and social interaction is crucial for improving the physical and psychological health of elderly residents.

Elderly bedrooms can serve as platforms for tracking health conditions and providing healthcare to the elderly in their own houses [30, 32]. Interior designers are increasingly focused on implementing innovative, sustainable, and eco-friendly strategies to maximize house efficiency while minimizing environmental quality. The use of 'green' interior design is a rapidly growing trend, offering a wide range of creative solutions, such as gardening and recycling, to promote sustainability [33, 34].

3.1.3. Disability People / Wheelchair and Elderly Movement

Incorporating sustainable technology applications and designing wide corridors in senior housing to accommodate wheelchairs and two people walking side by side are crucial considerations for ensuring accessibility and comfort for elderly individuals and people with disabilities.

This approach aligns with the principles of Universal Design (UD), which aims to create environments that are usable by all people regardless of age or ability. By prioritizing these aspects in architectural design, it can create more inclusive and accommodating living spaces for everyone.

Moreover, areas such as bedrooms and corridors are resting areas when walking long distances, as well as up and down the stairs and the electric chair mounted on the wall. Keep passageways clear of obstructions such as loose wires

[35, 36]. Otherwise, furniture should be arranged appropriately with comfort due to the elderly using wheelchairs on the floor.

However, there are many issues in elderly houses, such as inappropriate site planning, single function, under developed facilities, and a lack of multi-level communication space. These buildings face challenges in meeting the standards for high-quality bedrooms while also catering to their diverse needs. In Interior design, prioritizing movement and accessibility is crucial for individuals with disabilities, including wheelchair users and the elderly.

Creating spaces that cater to these needs not only fosters independence but also enhances overall quality of life. Several key aspects should be considered:

- Accessibility: Ensure entrances, doors, and hallways are wide enough to accommodate wheelchairs and walkers. Use Crane for the elderly instead of stairs, and install grab bars and handrails for added support.
- Maneuverability: Design bedrooms with ample space for wheelchair maneuvering, avoiding clutter and arranging furniture to allow easy movement.
- Flooring: Choose smooth, slip-resistant flooring materials to facilitate wheelchair movement and secure low-pile carpets to prevent tripping hazards.
- Reachability: Install commonly used items like light switches and outlets at easily reachable heights from a seated position.
- Bathrooms: Design bathrooms with features such as roll-in showers, grab bars, a crane for the elderly in the ceiling, and adjustable height sinks to accommodate various mobility needs.
- Lighting: Ensure spaces are well-lit to aid visibility and reduce the risk of falls, utilizing natural light where possible and supplementing with artificial lighting as needed.
- Technology: Incorporate smart bedroom technology, such as voice-activated controls, to enhance accessibility and convenience for those with mobility limitations.

Addressing these considerations in architectural design can lead to the creation of more inclusive and accessible spaces, promoting independence and enhancing the quality of life for individuals with disabilities and the elderly.

3.1.4. Acoustics

This study focuses on evaluating the acoustic comfort experienced by elderly residents through an on-site survey, sound measurements, and a question interview administered in a public space within an elderly house bedroom in Irbid, Jordan. Building on prior research, this investigation has been extended to compare the acoustic perceptions of elderly individuals in private bedrooms.

When designing the acoustic environment of the elderly bedroom, consider the following strategies. In the studied cases, excessive reverberation time in private spaces negatively impacted the semantic intelligibility of the elderly.

To address this issue, it is recommended to control the reverberation time in private areas and incorporate sound-absorbing materials. Additionally, placing humidifiers in public areas can contribute to improving the acoustic comfort of the elderly. Installing perforated sound-absorbing panels in bedrooms can help mitigate high-frequency noise.

- The acoustic perception of the elderly is significantly influenced by the loneliness index and Activities of Daily Living (ADL). Therefore, elderly houses should organize more group activities in public spaces and enhance geriatric care for individuals facing behavioral challenges [37].
- To improve the acoustic comfort in the bedrooms of Jordanian elderly housing, consider the following strategies:
- Control Reverberation: Excessive reverberation can negatively affect the acoustics of a room. Use sound-absorbing materials such as curtains and acoustic panels to reduce reverberation and improve speech intelligibility.
- Minimize External Noise: Ensure that windows and doors are well-sealed to reduce external noise from entering the bedroom. Use double-glazed windows and solid-core doors for better sound insulation.
- Use Soft Furnishings: Incorporate soft furnishings like upholstered furniture and rugs to absorb sound and reduce noise levels in the bedroom.
- Strategic Furniture Placement: Arrange furniture in the bedroom to minimize sound reflections and create a more acoustically comfortable environment.
- Consider Sound Masking: In some cases, sound masking systems can be used to add a low-level, non-distracting background sound that can help mask other noises and improve overall comfort.
- Optimize Room Layout: Consider the layout of the room and the placement of the bed and other furniture to minimize noise disturbances and enhance privacy.
- Consult with Acoustic Experts: For more complex acoustic issues, it may be beneficial to consult with acoustic experts who can provide tailored solutions for improving acoustic comfort in the bedroom.
- By implementing these strategies, you can enhance the acoustic comfort in the bedrooms of Jordanian elderly housing, providing a more pleasant and relaxing environment for residents.

3.1.5. Material of Quality and Construction Materials

Using high-quality materials that are environmentally friendly and easily recyclable benefits both people and the

planet. Taking a life cycle approach to construction is crucial for reducing a care house's environmental impact while also promoting the well-being of its occupants.

Designing sustainable houses can create healthy, safe, and more comfortable interior spaces.

Materials that are visually and tactilely appealing contribute to the creation of healthy interior environments positively affecting the elderly psychologically. When people are surrounded by materials they enjoy, their emotional and physiological health improves. This is particularly important for elderly people who spend a lot of time interior and may have limited opportunities for health-promoting activities [38].

3.1.6. Ventilation Effectiveness and Thermal Discomfort

Heating is one of the simplest ways to make houses as environmentally friendly as possible. Because most establishment heat escapes through windows, the windows must be of the highest quality while also providing adequate insulation. Heat and energy escape through poorly insulated windows. It should use thick curtains to block out light in the summer and to add insulation in the winter [39, 40].

This study gathered empirical data on thermal comfort and air quality in existing bedrooms of the elderly as part of a larger study that aims to understand the health risks for the elderly population in Irbid as a result of extreme heat events.

Furthermore, the findings point to a potential trade-off between thermal comfort and air quality in these buildings. Purification of the buildings' "air tightness" will result in better thermal comfort at the expense of higher CO_2 levels, particularly in buildings with a higher number of populations [41, 42].

3.2. Analyze Interview Questions

A comparative study was undertaken to pinpoint dimensions with a lower satisfaction percentage among the sampled individuals regarding the design of in-between spaces and the quality of the interior environment within their houses. The pre-test results revealed that, upon survey, the researcher identified a lack of consistent design features and sustainable design in the in-between spaces of the case studies, leading to the lowest satisfaction rates among participants (see Figure 2) show the results of participants.
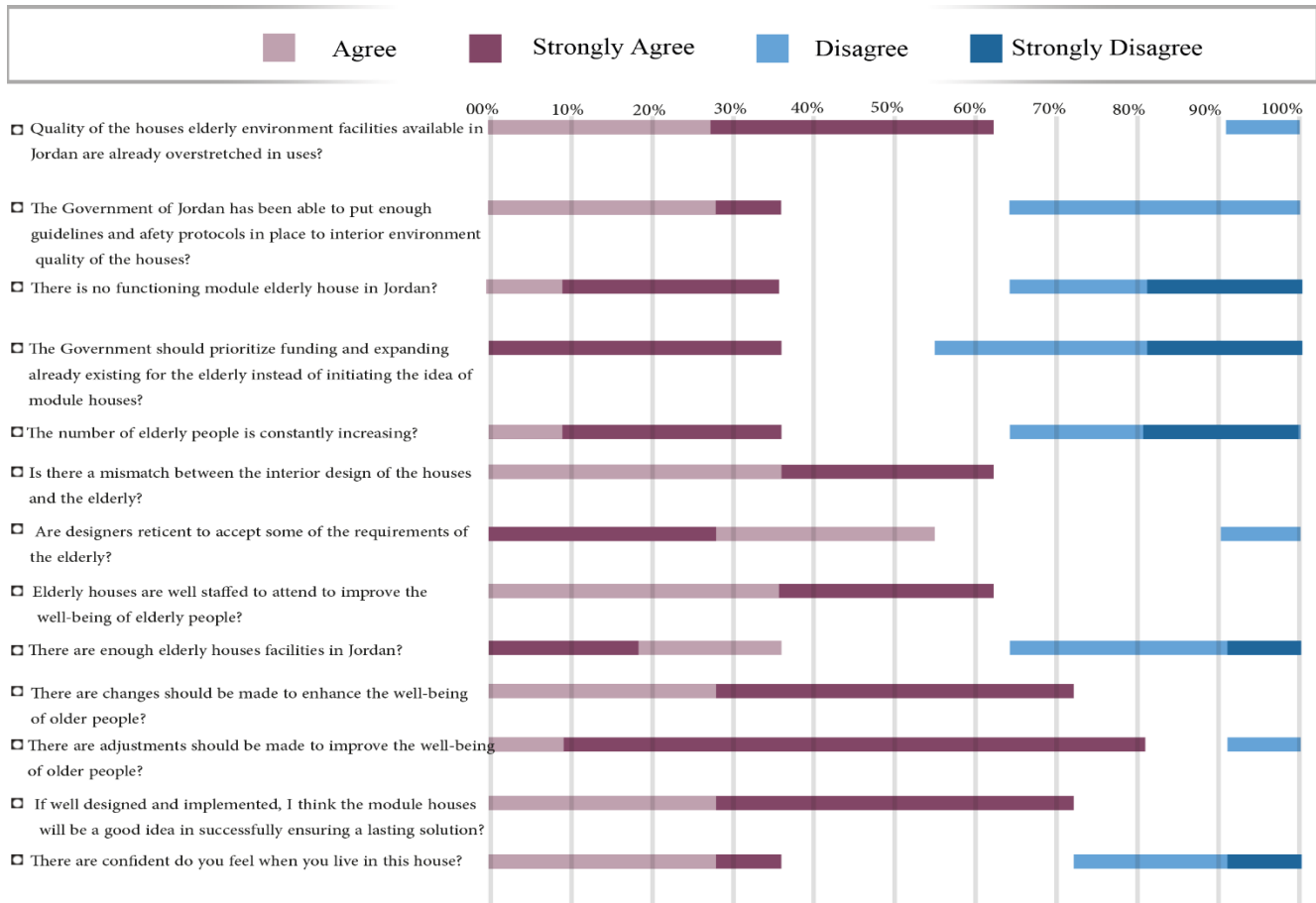

Fig. 2 Likert-scale results of participants

3.3. 3D Model Bedroom Designs for Interior Environment Quality as a Sustainable Requirement for Elderly House

In recent years, there has been a notable shift in the approach to enhancing the interior environmental quality of residential spaces.

Modern systems can now regulate various aspects such as lighting, ventilation, air quality, acoustics, sustainable design, and accessibility for people with disabilities throughout an entire household.

In the past, the practice that was accepted all over was the use of writing in books for documentation. However, with the extent of incorporation of technology into daily lives electronic registers have emerged as a faster, more reliable, and efficient alternative.

This transition enables information about elderly individuals to be accessed globally when stored online while also facilitating seamless communication and cooperation among multiple systems in elderly care facilities.

The future is expected to witness a rise in the use of handheld or control systems online, offering increased flexibility and efficiency in managing residential environments. Technological advancements also play a crucial role in tracking supplies and inventory in elderly care facilities, ensuring efficient management and allocation of resources.

This study aims to evaluate the impact of bedroom privacy on residents in care facilities for elderly people, recognizing the inherent decrease in privacy that comes with communal living arrangements.

While the universal bedroom setting is efficient, it may compromise the acoustic and visual privacy of elderly individuals. Thus, promoting the use of inboard toilets over outboard toilets can help mitigate these privacy concerns.

Accidents in elderly bedrooms often occur in areas such as the space between the bed and the toilet or during stair navigation. To prevent such incidents, it is recommended to install grab bars near wet and slippery surfaces like the bathtub, shower floor, slick tile walls, and toilet areas.

Additionally, reducing the distance between these points, for example, by installing a chair and a bridge affixed to the wall, can enhance safety and mobility for elderly individuals.

The research focused on evaluating the indoor environmental quality of bedrooms for elderly residents in senior housing in Irbid, Jordan. This involved studying how the design of these spaces can be tailored to meet the specific needs of elderly individuals.

The study included three houses in Jordan, and participants were between 60 and 70 years old, with an average age of 65.

Environmental Quality: Participants were concerned about air quality, especially ventilation and air circulation. They preferred natural lighting for its positive effects on mood and health and adjustable artificial lighting. Noise, both internal and external, was a concern, leading to a desire for soundproofing. Individual temperature control was favored for personal comfort.

Spatial Design: Participants preferred furniture layouts that allowed for easy movement and access. They liked adjustable and multi-functional furniture for its adaptability. Adequate and accessible storage was deemed important. Light colors for walls and furniture, as well as natural materials, were preferred for comfort and aesthetics.

Comfort and Safety: Non-slip flooring was preferred for safety, especially for wheelchair and walking aid users. Comfortable and easily accessible beds were emphasized, with suggestions for features like adjustable height. Accessibility, including clear pathways and reachable amenities, was highlighted.
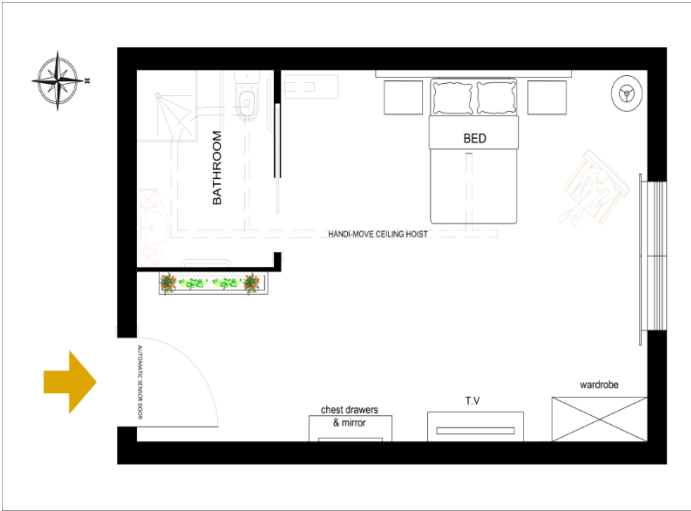
The study suggests that there is room for improvement in the indoor environmental quality of elderly bedrooms in Jordanian senior housing. Enhancing ventilation, maximizing natural lighting, reducing noise levels, and providing individual temperature control are key areas for improvement.

Flexible furniture layouts and storage solutions, as well as safety considerations like non-slip flooring and accessible beds, can significantly enhance comfort and safety for elderly residents. Integrating these findings into the design of elderly bedrooms can improve residents' quality of life and well-being (see Table 6).

Today's interior environmental quality can instruct the entire system to perform a wide range of tasks, including turning on and off lights, ventilation effectiveness and interior air quality, acoustics, and sustainable design, disability people/wheelchairs, materials.

Each of these facets assumes profound significance in shaping the overall experiential quality and well-being of aging individuals within built environments.

Table 6. Bed wards type

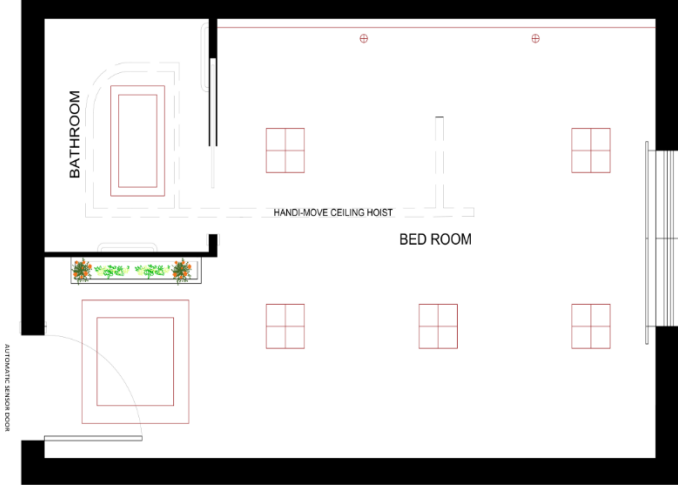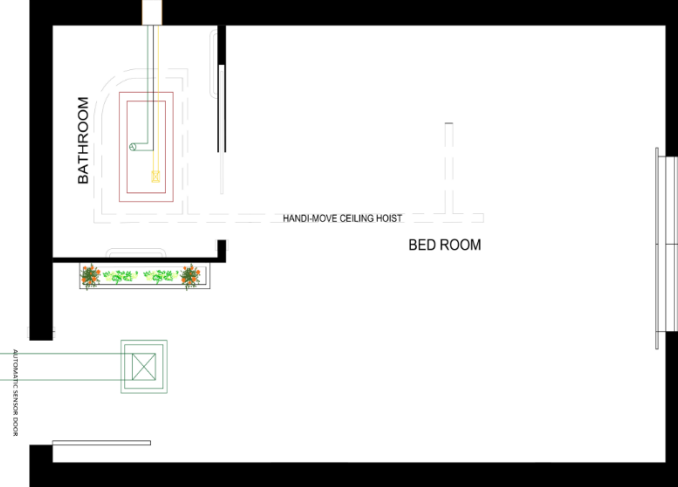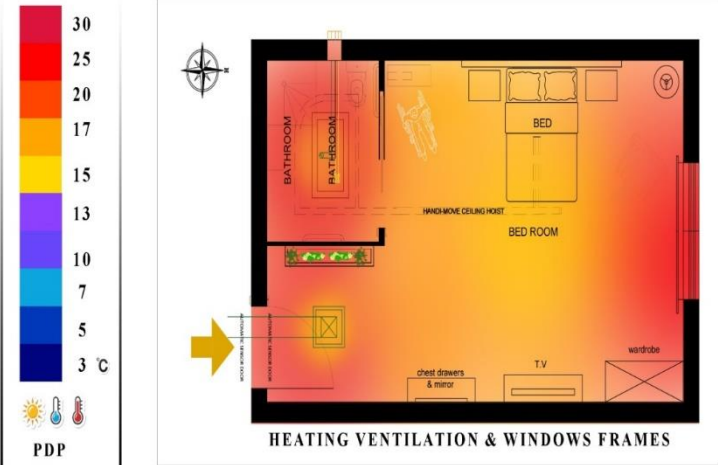| Elderly House (3D design 1 - bed)	Remarks
 Top view	1. Green spaces provide physical comfort and can improve mood. 2. Interior plants can instil a sense of responsibility in the elderly, encouraging them to spend time pleasantly and feel more comfortable in their houses. 3. Green spaces also improve the oxygen level in a room. 4. Alarms and monitoring devices inside the room track the movement of the elderly in case of emergencies. 5. A tablet allows the elderly to have full control over the room, including controlling lighting, curtains, television, and other features.
  3D- View	6. The room features a floor made of natural marble, which is both durable and aesthetically pleasing. Additionally, the paint used in the room emits no harmful substances and is resistant to disease and moisture. 7. A ceiling hoist is installed to assist elderly individuals who have difficulty moving. This feature greatly improves mobility, boosting the confidence of the elderly and reducing their reliance on others.

ELC- Top view

8. Ensure even and appropriate distribution of lighting to avoid shadows inside the room.

9. LED (Light-Emitting Diode) lighting is currently the most sustainable option available.

10. Consider adding wall lighting to minimize light reflection.

Air Control Top -View

11. The ventilation system prevents the accumulation of odors and fumes.

12. It helps to remove germs and bring in fresh air.

13. The system controls the room temperature in both summer and winter according to the preferences of the elderly.

14. Fresh air from a window can naturally improve one's mood and respiratory system.

HEATING VENTILATION & WINDOWS FRAMES

In this section, it explores how various building characteristics can influence the interior environment, focusing specifically on heating, ventilation, and overall interior air quality. The model bedroom demonstrates significant differences in interior air-suspended particles based on window characteristics. Additionally, ventilation features, roof lining and insulation types, and interior architectural modifications play a role in shaping interior air quality and meeting the building's needs. These building characteristics also impact several environmental parameters, including 'Bacteria,' 'Fungi,' 'Temperature,' 'Relative Humidity,' and the Predicted Percentage Dissatisfied (PDP) Index.

Fig. 3 New design stair lifts for elderly houses

Stair lifts are installed in residential houses to provide wheelchair users with a comfortable and user-friendly means of accessing different floors within a house. These devices offer a practical solution, enabling users to move effortlessly between levels (see Figure 3).

4. Conclusion and Recommendations

The finding of this paper addressed the integration of sustainability management or interior environmental quality with evidence-based design, emphasizing the significant impact of the built environment on the health of elderly people. By providing detailed insights into the shape and structure of bedroom components, these visualizations can greatly enhance the design process and improve the quality of the interior environment.It highlights a growing concern about unsustainable materials in health and elderly houses leading to a call for a new sustainability approach.

This paper contributes to exploring how sustainability and technology can enhance the living environments and daily activities of elderly people with a focus on designing suitable environments and incorporating new technological installations.Despite increasing interest, the progress in this area has been impeded by a lack of interior design and architects. The paper suggested various research avenues for interior design in elderly housing bedrooms, advocating for the integration of existing and new evidence into designs to promote healing and well-being. It emphasizes that designers with a deep understanding of spatial functionality and human perception are well-suited to design strategies that cater to the specific needs of the elderly. Recommendations for elderly housing include ensuring optimal artificial lighting for daylight utilization, installing a noise control system, enhancing safety by reducing slipperiness of flooring, using curtains that are easy to maintain and fireproof, providing sufficient natural and artificial lighting sources, and designing spaces that are scalable, flexible, and adaptable to meet changing needs.

In addition, further studies could focus on exploration, including comparative analysis of housing facilities, technology integration, understanding user experiences, exploring sustainability practices, investigating health impacts, examining policy and planning, considering cross-cultural perspectives, and studying interior design. Seeking guidance from acoustic experts can be advantageous for addressing intricate acoustic challenges. These experts can offer tailored solutions to enhance acoustic comfort, specifically in bedroom settings. Additionally, the model employs the principle of universal design to ensure that living spaces are easily navigable, usable, and accessible as a foundational principle. This approach is strategically planned to minimize the need for navigating stairs, making movement easier for elderly people.

Acknowledgement

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