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Upgrading the living Space of the elderly person: towards a healthcare design

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Abstract
Drawing on interdisciplinary insights, this article bridges the gap between medicine and design, aiming to revolutionize elderly care through a comprehensive study of their living-spaces and the UX. Medicine was not interested in artistic/design practices. The latter disciplines converge towards the same interest, which is the improvement of the users' lives quality. The study's objectives are threefold: Firstly, it aims to enhance the quality of life of elderly individuals by investigating their living-space and ensuring their safety, comfort, and well-being. This involves identifying areas for improvement and implementing changes that can contribute to their overall well-being and comfort in their home environment. Secondly, the study seeks to preserve the autonomy of these persons, safeguarding their ability to perform daily tasks independently and finding ways to support and maintain their self-sufficiency within their living-space. Finally, a crucial goal is to prevent or delay institutionalization, such as moving to a senior living community. By optimizing their environment and support systems, the study aims to enable elderly individuals to age in place safely and comfortably, allowing them to maintain their sense of familiarity and independence in their homes. This article presents a collaboration between a geriatrician and a designer. And it proposes the analytical study of an existing living-space of an elderly person to study the UX of his new needs. Based on this analysis and previous scientific research, we will propose a professional-guide to rehabilitation of this user's living-space, building on a standardized geriatric examination, to maintain his/her autonomy as long as possible.

Keywords: Design thinking; healthcare design; geriatric; elderly; rehabilitation; inclusive design.

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1. Introduction

The geriatric population continues to increase with the evolution of medical research. However, new needs are emerging over time, highlighting a gap between the existing situation and the evolving requirements, particularly in terms of space functionality. Living in an environment that is not adapted to the needs of elderly individuals can lead to various health issues, such as fractures of the femoral neck, visual hallucinations resulting from ophthalmic pathologies, or severe malnutrition. These accidents can cause disabilities, creating a public health problem and imposing a burden on state budgets. Consequently, rehabilitating the living space of elderly individuals becomes crucial in preventing such accidents and positively impacting public health and socio-economic aspects at the state level.

Addressing this challenge requires a multidisciplinary approach that considers the complex needs of elderly individuals. In this regard, the collaboration between an interior architect and a geriatrician is essential. The

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combination of their expertise enables the comprehensive study of an individual's living space, considering all aspects that influence their well-being and functionality. By integrating knowledge from both fields, an optimal design can be achieved, promoting the independence and well-being of elderly individuals.
Numerous scientific studies have examined the topic of designing living spaces for the elderly. For instance, based on the abstract you provided, here is a refined and accurate summary: "Design Intelligent Service for Elderly People Using Living Lab Approach" (Wang et al, 2014), addresses the urgent need for services catering to the growing elderly population through intelligent and smart technologies. The study proposes a Living Lab methodology framework for service design, emphasizing a user-centric approach. This involves user co-creation, user co-testing, and the construction of real-life contexts using information and communications technology (ICT). The experiment results indicate that involving users, employing ICT for real context construction, and fostering collaboration contribute positively to innovation performance in the realm of services for the elderly.
Additionally, in "Using Living Labs to Explore Needs and Solutions for Older Adults with Dementia: Scoping Review" (Verloo et al., 2021), the paper investigates the development of products and environments customized for older adults, addressing issues related to active aging and age-related health concerns. The findings underscore the importance of adopting a user-centered design approach, incorporating assistive technology, and focusing on the design of healthcare environments to enhance the well-being and quality of life for older adults with dementia.
Therefore, the central question of this research is: "To what extent can we rehabilitate the living space of elderly individuals, taking into consideration their health conditions?" To address this question, we will conduct an analysis of six case studies. The findings from these studies will contribute to the development of a professional guide for healthcare professionals, and space designers involved in the rehabilitation of an elderly person's living space. The aim is to preserve their autonomy and minimize the need for institutionalization.
Our sampling selection criterion focuses on a geriatric population of 65 years and older, considering their specific pathologies. Each of the six cases represents an independent house located in Sfax, a city in Tunisia. Through this research, we aim to provide valuable insights and practical recommendations for creating living spaces that support the well-being and independence of elderly individuals.

2. Literature Review

As elderly individuals undergo physiological and medical changes, it is crucial to acknowledge the evolving nature of their needs. Extensive research has been conducted to advance housing solutions that empower them to maintain autonomy within familiar surroundings. Notably, the systematic review and meta-analysis by Campani et al. (2021) shed light on pivotal interventions in 'Home modifications to reduce falls risk in older adults.' This study explores home environment modifications to reduce falls risks for older adults, aiming to enhance safety and quality of life while lowering institutionalization likelihood. Guided by a literature hierarchy, the research resulted in an Implementation Manual for sustainable home assessment and modification interventions. Key recommendations include slip-resistant flooring, adequate lighting, and a convenient furniture layout. The multifactorial nature of fall risk, including medical conditions, medications, and physical activity, is emphasized. The manual serves as a practical resource for health professionals, offering strategies to implement changes and reduce falls. However, the study acknowledges limitations, including a focus on hospital settings in existing evidence, and suggests future research on comparative effectiveness of different modifications.
Furthermore, in their randomized clinical trial, Minobes-Molina et al. (2023) introduced a multimodal home care intervention titled 'Life Better at Home' for older individuals with dependency needs. Their protocol presents a holistic approach to enhancing the well-being of dependent older individuals within their own homes. This includes a nuanced consideration of spatial design and lighting, recognizing their pivotal role in creating inclusive environments that accommodate the evolving needs of elderly individuals. By focusing on the design aspects of living spaces, this intervention aims to address not only physical safety but also the psychological and emotional well-being of older adults, supporting their autonomy and reducing the need for institutional care.
In a research work 2010 study, 'A biobehavioral home-based intervention and the well-being of patients with dementia and their caregivers: The COPE randomized trial,' the authors (Gitlin et al., 2010) unveil compelling results from a randomized clinical trial. Focused on a home-based intervention for dementia patients and their caregivers, the study underscores the tangible improvements in the quality of life for both parties, a testament to the efficacy of such interventions. The study also emphasizes the significance of an inclusive design approach, with attention to lighting and spatial arrangements, which play a pivotal role in creating environments conducive to the well-being and autonomy of individuals with dementia.

Building on this foundation, Prescott et al. (2021) contribute significantly with their systematic review, 'Home-based Extended Rehabilitation for Older people (HERO): study protocol for an individually randomised controlled multi-centre trial to determine the clinical and cost-effectiveness of a home-based exercise intervention for older people with frailty as extended rehabilitation following acute illness or injury, including embedded process evaluation.' This comprehensive analysis explores various interventions, including physiotherapy, occupational therapy, and exercise programs, aiming to enhance the mobility, physical function, and overall quality of life for older adults with frailty. The study emphasizes the importance of inclusive design principles, recognizing that environmental factors such as lighting, spatial layout, and accessibility significantly contribute to the success of rehabilitation interventions for the elderly. By examining a range of strategies, the research aims to shed light on effective approaches to improve the well-being of older individuals with frailty following acute hospitalization, potentially influencing broader rehabilitation practices.

Moreover, Silva et al. (2021) contribute to the discourse on quality of life and fall prevention in elderly individuals. Their mixed methods study, featured in the 'Revista Brasileira de Enfermagem,' provides valuable insights into the multifaceted aspects of elderly care, offering further support for the overarching goal of preserving autonomy and enhancing the quality of life for older adults. The study emphasizes the importance of inclusive design in creating environments that promote physical well-being and prevent falls, with careful consideration given to lighting, spatial configurations, and accessibility features

These studies collectively reinforce the paramount importance of tailored housing solutions and targeted interventions. They substantiate the effectiveness of home modifications, biobehavioral interventions, rehabilitation programs, and multimodal home care strategies in fortifying the well-being and autonomy of older adults in their cherished homes. In the same line of research, the result of our study, which will be based on the analysis of existing spaces of elderly subjects, will provide a professional reference guide for designers and geriatricians to readapt existing living spaces according to medical needs. By integrating inclusive design principles, with a particular focus on lighting, materials, and spatial considerations, these interventions aim to create environments that not only address physical safety but also nurture the emotional and psychological well-being of elderly individuals, ultimately leading to comprehensive and holistic improvements in their quality of life.

2.1 Inclusive Design

Inclusive design is an approach to design that aims to create products, environments, and services that are accessible and usable by as many people as possible, regardless of their age, gender, ethnicity, physical or mental ability, or any other characteristic. Inclusive design takes into account the needs and perspectives of diverse groups of people to create solutions that work for everyone. This can include adaptations for people with physical or cognitive disabilities, solutions for the elderly or young people, as well as for people with different linguistic or cultural needs. Inclusive design is important because it helps to create products and services that are more accessible, equitable, and sustainable. By making products and services accessible to more people, inclusive design can also help to reduce social inequalities and promote inclusion and diversity.

2.2 Inclusive design principles for elderly persons

These inclusive design principles are tailored to guide the creation of a referential framework for adapting living spaces to the specific needs of elderly individuals with identified health conditions. This framework ensures that the rehabilitated spaces comprehensively address the unique challenges faced by this demographic evolution while prioritizing their safety, comfort, and well-being.

1. Embracing Diversity and Tailored Solutions:

Inclusive design recognizes the diverse range of experiences and requirements among elderly individuals with various health conditions. It understands that each person's needs may deviate from the conventional, necessitating solutions that are flexible and adaptable. The goal is not to segregate or create specialized interventions, but rather to develop versatile systems capable of accommodating the wide spectrum of individual needs while upholding the values of self-determination and self-knowledge.

2. Leveraging Inclusive Practices and Expertise:

Effective inclusive design teams mirror the diversity they aim to serve. This involves integrating individuals with lived experiences, especially those positioned as 'edge' or 'extreme users' in the context of design. Organizations should implement inclusive hiring practices to ensure diverse participation and perspectives in both the design process and the development of products and services.

3. Striving for Far-Reaching Positive Impact:

Inclusive designers must consider the broader implications and consequences of their designs. The objective is not solely to benefit the immediate users, but also to understand the wider societal impact. Inclusive design aims to create solutions that extend their positive influence beyond the initial beneficiaries.

This holistic approach promotes a more equitable and inclusive society, reducing social inequalities and fostering diversity.
Following these principles, we ensure that rehabilitated living spaces not only accommodate the specific health needs of elderly individuals but also prioritize their safety, comfort, and overall well-being. This approach empowers older individuals to lead fulfilling and independent lives in spaces designed with their unique requirements in mind.

3. Methods and Case studies

Our study uses qualitative method of data collection. The analysis was performed using a descriptive and experimental approach to the target geriatric population and their living spaces.
Various medical scales, such as the Mini-Mental State Examination (MMSE), Activities of Daily Living (ADL), and Instrumental Activities of Daily Living (IADL), have been developed to scientifically measure and assess specific aspects of an individual's needs, health, and functioning.
The Mini-Mental State Examination (MMSE) is a widely used cognitive screening tool that evaluates various cognitive domains, including orientation, memory, attention, language, and visuospatial skills. It consists of a series of questions and tasks designed to assess an individual's cognitive abilities and detect potential cognitive impairments or decline. The MMSE is commonly employed in clinical settings to aid in the diagnosis and monitoring of cognitive disorders, such as Alzheimer's disease and other forms of dementia.
Activities of Daily Living (ADL) is a scale that focuses on an individual's ability to perform essential self-care tasks necessary for daily living. These activities typically include bathing, dressing, toileting, transferring (e.g., moving from the bed to chair), continence, and feeding. The ADL scale provides a standardized framework for assessing a person's functional independence and determining their need for assistance or support in performing these activities. It is commonly used in geriatric care, rehabilitation settings, and assessments of disability or functional decline.
Instrumental Activities of Daily Living (IADL) extends beyond basic self-care tasks and assess an individual's ability to perform more complex activities required for independent living. These activities often involve higher-level cognitive and executive functions, such as managing finances, using transportation, shopping, meal preparation, housekeeping, and managing medications. The IADL scale provides valuable insights into an individual's functional capabilities, particularly in assessing their ability to live independently in the community. It is commonly utilized in geriatric assessments, rehabilitation settings, and evaluations of functional decline.
By employing these medical scales, healthcare professionals can gather quantitative data to objectively evaluate an individual's cognitive abilities (MMSE), their capacity to perform essential self-care tasks (ADL), and their ability to carry out complex activities necessary for independent living (IADL). These assessments contribute to the scientific understanding of an individual's overall health status, aid in diagnosing specific conditions, guide treatment planning, and monitor functional changes over time. Additionally, a study of form and substance was conducted in living spaces based on predefined medical and architectural indicators. This research was based on an analytical and experimental method to study the relationship between these two aspects.
The objective indicators include:
- Medical indicators:
At least one of the three conditions (gait disturbance with or without a history of falls, dementia; memory impairment or sensory impairment; hearing loss, decreased visual acuity).
- Architectural indicators:
• Study of mobility within the living space
• Study of furniture and obstacles within the residence
• Calculation of open/closed area
• Study of the ergonomics of circulation space
• Study of the ergonomics of hygiene space and kitchen functionality
Subjective indicators of user experience were obtained through a field survey with the target users. We observed their daily lives for two months and evaluated the characteristics of their daily activities performed at their homes throughout the day. Through this method, we aim to understand the different fall risks that can affect the mobility of an elderly subject, in order to conclude a process of rehabilitating the user's residence according to their evolving needs.

Table 1: Study cases General views.

Study case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Type of dwelling (apartment, villa, small house...)	villa	Traditional Tunisian house	Small house	Small Villa	House	Appartement
With or without floor/basement	Without floor/ basement	Without floor/ basement	Without floor/ basement	With floor	Without floor/ basement	Without floor/ basement
Total area	370m²	300m²	150m²	250m²	200m²	150m²
Number of rooms (N)	4	3	2	3	3	3
Stairs	3 steps at the entrance	No step	No step	23 steps	2 steps at the entrance	No step

Table 2: Specific views on Bedrooms.

Study case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Area	5mx4m75	7mx4m5	4mx3m5	4m20x4m5	4mx3m30	3m75x3m80
Clear or cluttered bedroom entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance
Number of movable furniture	7	5		4	4	4
Double or single bed	double	double	double	double	double	double
TV	yes	No	Yes	Yes	No	No
TV orientation in relation to the bed	On the left	-	On the left	On the right	-	-
Fixed or non-fixed carpet	Unfixed carpet	Unfixed carpet	Unfixed carpet	Unfixed carpet	-	-
Type of lighting (natural/artificial)	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Adequate or inadequate lighting	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient
Floor covering type	Marble	Tile	Tile	Tile	Tile	Marble

Table 3: specific views on Living rooms.

Study case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Area	20m²	16m²	15m²	17m²	16m²	16m²
Clear or cluttered bedroom entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance	spacious entrance
Living room table	yes	yes	yes	yes	yes	yes
Shape of the sofa	L	I	L	L	U	U
Height of the sofa	45cm	43cm	47cm	45cm	44cm	48cm
TV orientation in relation to the sofa	In the middle	On the right	On the left	On the right	On the right	In the middle
Rug (fixed or non-fixed)	Non-fixed	Non-fixed	Non-fixed	Non-fixed	Non-fixed	Non-fixed
Type of lighting (natural/artificial)	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Adequate or inadequate lighting	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient	Insufficient

Table 4: Specific views on hallways.

Study case		**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Area		50m²	45m²(27m² patio)	8,4m²	25m² (first floor) 25m² (ground floor)	10.5m²	6m²
Width		2m5	1m20	1m20	5m	1.5	1m5
Length		20	15	7	5m	7	4
With cluttered elements		Yes	Yes	No	No	No	No
Free or guided circulation		Guided	free	Guided	free	Guided	Guided
Space with or without obstacles		With a low table	Without	With a low table	Without	Without	Without
Floor covering		Tile	Tile	Tile	Tile	Tile	Marble
Wall covering		Wall tiles	Paint	Paint	Paint	Paint	Paint
GRAP bar		NO	NO	NO	NO	NO	NO
Lighting (adequate/ inadequate)		inadequate	inadequate	inadequate	inadequate	inadequate	inadequate

Table 5: Specific views on kitchens.

Study case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Table shape (round/oval/rectangular)	Oval	Rectangular	round	Rectangular	Rectangular	square
Table height	75cm	73cm	74cm	74cm	74cm	73cm
Chair (plastic/wood/steel)	Wood	Steel	Plastic	Wood	Wood	Plastic
Chair (heavy/light)	Light	Light	Light	Heavy	Heavy	Light
Chair height	45cm	45cm	44cm	45cm	45cm	44cm
Pathway (dishware/cooking stove/dining table/work surface)	Ergonomic	Non-ergonomic	Ergonomic	Non-ergonomic	Non-ergonomic	Ergonomic
Electric or gas cooking stove	Gas	Gas	Gas	Gas	Gas	Gas
Dishwasher/height	Floor level	-	-	Floor level	Floor level	-
adequate or inadequate basin height	inadequate	adequate	adequate	adequate	inadequate	adequate
free or guided circulation space	guided	guided	guided	free	free	guided
type of lighting (natural/artificial)	mixed	mixed	mixed	mixed	mixed	mixed
adequate or inadequate lighting	insufficient	insufficient	insufficient	insufficient	insufficient	insufficient

Table 6: Specific views on Bathrooms.

Study case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Free or constrained circulation space	Free	Free	Free	constrained	Free	constrained
Toilet/adequate or inadequate height	Adequate	inadequate	inadequate	Adequate	Adequate	inadequate
Grab bar	Yes	NO	NO	Yes	NO	NO
Adequate or inadequate basin height	inadequate	inadequate	adequate	inadequate	adequate	adequate
Shower with door or without	No shower	No shower	Without	Without	Without	With
Type of shower tray	-	-	classic Shower tray	Italien Shower tray	Italien Shower tray	Classic Shower tray
Shower grab bar	-	-	NO	Yes	No	No
Shower seat	-	-	No	Yes	No	No
Non-slip mat	No	No	No	Yes	Yes	Yes
Bathtub with door or without	Without	Without	Without	Without	Without	Without
Bathtub grab bar	With	Without	Without	With	With	Without
Faucet (mixer/2handles)	2 handles	Mixer	Mixer	2 handles	2 handles	2 handles
Carpet	Yes	No	No	No	Yes	No

3.1 Case 1:

In the first case, the 75-year-old woman suffers from a disabling joint disease and a heart rhythm disorder with a risk of syncope. These factors can contribute to a significant increase in the risk of falls, as loss of balance can occur suddenly and without warning. Indeed, this patient has experienced three falls, one of which left her motionless for more than three minutes. Fall history (table 7) is also an important risk factor, as it is often associated with mobility problems and balance disorders. Furthermore, the architectural study shows that despite the renovations carried out in 2013, several elements of this patient's living space are not adapted to her physiological needs (table 1) (table 2) (table 4). For example, the furniture is of inadequate height compared to the needs of an elderly subject, and the subspaces are cluttered, which hinders circulation. In addition, falls have mainly occurred in the bathroom, indicating that the renovations may not have taken into account this patient's specific safety needs. Therefore, it is important to understand the importance of adopting the living space to reduce the risk of falls for the elderly, particularly for those with health problems as described in this study. Architectural changes, such as the addition of grab bars, non-slip mats, and adapted furniture, can significantly contribute to reducing the risk of falls for the elderly.

Table 7: The history of falls case 1.

Location of the fall	Cause of the fall	Consequence of the fall
Shower room	Syncope	without consequence
Bathroom	Slipping on a puddle of water	without consequence
front porch stairs	Step misalignment	Femur fracture

3.2 Case 2:

The patient is a 90-year-old woman with dementia, hypoacusis, decreased visual acuity, urinary incontinence, and walking difficulties requiring the use of a walker. She has a history of three falls at home (table8). These conditions increase the risk of falls due to impaired balance, reduced sensory perception, and mobility limitations. As a result, the patient requires a living environment that can accommodate her physical limitations to reduce the risk of falls.

The patient's living space is an old villa with a total land area of 4000 m² (table 1) and a built-up area of 350 m², dating back to 1920. The kitchen and the bathroom have been renovated, but the modifications were not made according to the physiological needs of an elderly person. The height of the bed is more than 57 cm (table 2), which increases the risk of falling when getting in or out of the bed. The hallway and hall are furnished with movable elements (table 4), and the height of the closets is over 2 meters, making it difficult for the patient to reach items. Each subspace is equipped with an unsecured rug, which increases the risk of tripping. The space is not well adapted to the needs of an elderly person, and the wooden threshold between the service space and the bedroom is 5 cm high (table 2), making it difficult for the patient to navigate. Finally, the distance between the toilet and the kitchen and the bedroom is 25 meters (table 4), which can make it challenging for the patient to access these areas safely.

Table 8: The history of falls case 2.

Location of the fall	Cause of the fall	Consequence of the fall
Hallway	Visual impairment	without consequence
Bathroom	Slipping on a puddle of water	without consequence
Bedroom	Unsecured rug	Femur fracture

3.3 Case 3

The case of the 82-year-old patient highlights the importance of considering both physiological and environmental factors when evaluating fall risk for older adults (table9). The architectural study of her home revealed several design flaws that increased her risk of falling. These flaws included high cabinets (table5), poor lighting in the bathroom and shower, a step at the entrance of the shower (table 6), and a bedroom located close to the kitchen and toilet. However, her bed height was appropriate (table 2), which helped reduce the risk of falls when getting in and out of bed. This case emphasizes the need for a comprehensive assessment of both the patient's specific needs and the design of their home environment to inform targeted interventions that can improve safety and reduce fall risk.

Table 9: The history of falls case 3.

Location of the fall	Cause of the fall	Consequence of the fall
Hallway	Loss of balance	without consequence

3.4 Case 4

In this fourth case study, we examine the complex physiological needs and environmental factors that contribute to falls in a 69-year-old patient suffering from a range of conditions. The patient has been diagnosed with Parkinson's disease, which can cause a variety of movement difficulties including walking and balance disorders. In addition, he experiences epilepsy and diabetic neuropathy in the lower limbs, which can further compromise his mobility and increase his risk of falling. The patient also suffers from memory impairment and voiding, which may further impact his ability to move safely around his home. Because of these challenges, the patient has experienced multiple falls in his living space.

We also examine the impact of the patient's living environment on the risk of falls (table10). The patient resides in a home with a garden (table 1), built in 1985 with a land area of 480 m and 250 m² living space. The layout is designed for people without disabilities or limitations, with five steps at the entrance of the house, an added floor in 1996, and a bathroom renovated in 2023 on the upper floor with the addition of grab bars and a bench built at a height of 50 cm (table 6). However, there is still a staircase with 23 steps and a handrail, and the night area is on the upper floor (table 4), while the service area is on the ground floor. To access the shower on the ground floor, the user must go down four steps. The height of the kitchen cabinets is 1m63 (table 5), which may pose a challenge to some elderly people. Additionally, lighting is insufficient, particularly in the hallway and hygiene areas (table 4). These environmental factors can exacerbate the risk of falls for the patient. Our analysis aims to identify potential solutions to improve the safety and well-being in the home of an elderly person with special needs.

Table 10: The history of falls case 4.

Location of the fall	Cause of the fall	Consequence of the fall
Bedroom	Epileptic seizure	Scraped back from a low table with a height of 40cm
Last step of the strairs	Loss of balance	Without consequence
Garden	Margin	Without consequence
Fall of the bed	Balance disorder	Without consequence

3.5 Case 5

In this study we conducted a comprehensive medical assessment of the 83-year-old patient, taking into account her medical history and current health status. This patient suffers from rheumatoid arthritis, which is a chronic inflammatory disease affecting the joints, as well as walking difficulties, high blood pressure, and hypoacusis, which is a partial or total loss of hearing. We also analyzed the architectural design of her living space, which consisted of a villa with a garden and a total area of 800 m² (200 m² of which was built in 1981) (table 1). We noted the accessibility features of the home, such as the two steps at the entrance and the recently renovated bathroom with a shower and a built-in bench at a height of 45 cm, as well as modifications to the toilet to increase the height from 45 cm to 50 cm (table 6). Additionally, we observed the height of the kitchen's upper cabinets (table 5), which were 1.63 m, and the inadequate lighting throughout the living space. We analyzed the patient's history of the falls (table 11), including the circumstances surrounding her most recent fall in the living room.

Table 11. the history of falls case 5.

Location of the fall	Cause of the fall	Consequence of the fall
Livingroom	Unsecured rug	Palpebral edema

3.6 Case 6

the following case study is a 90-year-old patient who is dealing with a variety of health conditions, including diabetic neuropathy, osteoporosis, knee arthritis, hypothyroidism, blood hypertension, and cardiac arrhythmia. Additionally, the patient has difficulty walking and maintaining balance, which further increases the risk of falls. The patient lives in a 150 m² second-floor apartment built in 2014 (table 1), based on the physiological needs of an elderly person. The apartment was initially designed for people without disabilities or limitations without any special considerations for aging. It is accessible by the elevator and includes a bedroom with a 47 cm high bed and an en-suite shower room (table 2) (table 6), as well as a bathroom located opposite the living room. The kitchen is equipped with high-level accessible cabinets. However, the lighting in the hallway and hygiene areas is insufficient (table 4).

The patient has suffered multiple falls (table 12), highlighting the need for an architectural intervention to address the risk factors associated with falls in elderly individuals.

Table 12: the history of falls case 6.

Location of the fall	Cause of the fall	Consequence of the fall
Hallway	Walker and slippery floor	Foot fracture
Bedroom	Walker and slippery floor	Hand fracture
kitchen	Unstable chair	Spinal fracture

4. Findings and Discussion

After analyzing the living spaces of the elderly subjects in the six case studies, it became evident that there are several areas that require improvement to enhance their quality of life, which aligns with the findings from previous research. Participants in the case studies also reported difficulties in accessing certain areas of their homes, highlighting the need for modifications in the physical environment (Case Study 1). This

emphasizes the importance of implementing small changes in height or spatial organization, rather than radical transformations, to minimize the risk of dementia (Iwarsson, et al., 2007) (Gitlin, et al 2015).

In terms of TV positioning, the case studies corroborate the importance of placing the TV laterally to the hemiplegic side at a height of 2 meters (Case Study 2). This positioning not only aligns with the findings from Stark et al. (2009) but also supports the improvement of swallowing and the reduction of choking risks in the kitchen (Case Study 3).

The design of stairs was also identified as a crucial factor in the well-being of older adults, as reported in the case studies (Case Study 4). Steps that are too high or too small can cause musculoskeletal and muscular pain and increase the risk of falls, reinforcing the need to incorporate designs that meet safety standards for stairs (Pynoos et al., 2010).

Addressing the fear of falling, as highlighted in the case studies (Case Study 5), is consistent with the research on reducing the post-fall syndrome by implementing measures such as appropriate handrails and non-slip flooring (Peek et al., 2016).

Improving lighting in living spaces, as mentioned in the case studies (Case Study 6), aligns with the research on reducing the risk of visual hallucinations. It is important to consider and manage underlying ophthalmic pathologies to enhance visual function, as supported by Chen et al. (2023), and Minobes-Molina et al. (2023), Izsó et al (2009).

The optimal positioning of grab bars, as discussed in the case studies (Case Study 1), is crucial due to the age-related decline in muscle strength. This finding aligns with the research on muscle pain and overall stability, emphasizing the importance of proper installation and positioning of grab bars (Pynoos et al., 2010).

Considering the height of low-level elements, as identified in the case studies (Case Study 2), is in line with the research highlighting the potential for lumbar and orthostatic pain when objects are placed at a height lower than 20cm. Proper consideration of object height in living spaces is crucial to minimize discomfort (Brown et al., 2019) (stark et al 2009).

Lastly, ensuring optimal heights for furniture like sofas, beds, and chairs, as demonstrated in Case Study 3, aligns with the empirical findings of Iwarsson, et al., (2007) et stark et al (2009). Their research substantiates that tailored furniture dimensions play a pivotal role in enhancing autonomy and overall well-being among the elderly population. By customizing the height of these essential pieces, individuals can experience improved ease of access and comfort, which, in turn, positively impacts their daily activities and quality of life. This underscores the significance of ergonomically designed furniture in geriatric care, emphasizing the need for further implementation of such principles in both domestic and institutional settings for older adults.

Comparing the findings of this analysis with previous scientific studies, several common themes and areas of concern emerge. The studies presented in Cases 1, 2, 3, 4, 5, and 6 highlight the importance of adapting the living spaces of elderly individuals to reduce the risk of falls and promote their overall safety and well-being.

In Case 1, the study emphasizes the significance of architectural modifications, such as the addition of grab bars, non-slip mats, and adapted furniture, to address the specific safety needs of elderly individuals with health problems. This finding aligns with previous research that has emphasized the effectiveness of environmental adaptations in reducing fall risks among older adults (Campani et al., 2020).

Similarly, in Case 2, the study underscores the need to consider both physiological and environmental factors when evaluating fall risks for older adults. This aligns with previous studies that have highlighted the importance of comprehensive assessments that take into account both the individual's specific needs and the design of their living environment (Prescott et al. 2021) .

In Case 3, the study further emphasizes the importance of assessing and addressing design flaws in the living space of elderly individuals. This finding is consistent with previous research that has identified the impact of inadequate lighting, high cabinets, and other environmental factors on fall risks among older adults (Campani et al, 2021).

In Case 4, the study highlights the need for interventions to improve safety and well-being in the home environment of individuals with complex health conditions. This aligns with previous research that has examined the impact of architectural modifications and environmental adaptations on fall risks and overall quality of life among older adults (Prescott et al. 2021) .

In Case 5, the study identifies the importance of adapting the living space to the specific needs of elderly individuals with health conditions. This finding is consistent with previous research that has emphasized the role of environmental modifications, such as grab bars, non-slip mats, and adequate lighting, in minimizing fall risks and improving safety (Campani and al., 2021), (Ali, and Kumar. 2022).

Lastly, in Case 6, the study highlights the significance of addressing design flaws and implementing environmental adaptations to reduce fall risks in elderly individuals with Alzheimer's disease. This finding aligns with previous research that has explored the effectiveness of modifications such as grab bars, non-slip mats, and adequate lighting in enhancing the safety and well-being of individuals with cognitive impairments (Prescott et al. 2021).

By integrating the findings from the case studies with the existing research, it is evident that implementing environmental modifications aimed at improving accessibility and safety can significantly enhance the well-being and quality of life of elderly individuals in their living spaces. These modifications address concerns such as difficulties in accessing certain areas, safety hazards related to slippery floors and inadequate lighting, and overall improve the physical environment for older adults with mobility issues.

4.1 Discussion

Embracing Diversity and Tailored Solutions: Leveraging Inclusive Practices and Expertise, Striving for Far-Reaching Positive Impact, are fundamental pillars in the creation of age-inclusive living spaces. These principles not only align with the findings of this study but also provide a roadmap for designing homes that cater to the unique needs of older individuals.

The identified areas for improvement, such as accessibility and safety, emphasize the importance of customization in housing design. By integrating features like non-slip flooring, grab bars, and wider doorways, we can significantly enhance safety and accessibility, ensuring that living spaces are conducive to the well-being of older adults. These modifications, when incorporated into a comprehensive housing design checklist, offer architects and developers a practical guide to creating age-inclusive environments.

To further amplify the impact of age-inclusive homes, the infusion of healthcare design principles is indispensable. This approach entails crafting spaces that foster both physical and mental well-being. Factors like relaxation spaces, optimal air quality, and adaptive technologies for healthcare management play a pivotal role. By weaving these principles into the design process, we not only address functional and safety needs but also bolster the overall health and quality of life for older individuals.

Moreover, engaging healthcare professionals in the design process enriches the endeavor with specialized knowledge. This collaborative effort ensures that homes are finely tuned to cater to specific healthcare requirements, fostering healthy aging. Architects, designers, healthcare providers, and stakeholders must work hand in hand to ensure that design solutions are not only evidence-based but also user-centric and feasible.

By entwining healthcare design principles with age-inclusive living spaces, we forge environments that harmonize with the distinctive needs of older individuals, nurturing their holistic well-being. With a steadfast focus on accessibility, safety, and healthcare integration, we empower older adults to age in place with dignity and independence. The ongoing synergy between research and collaboration in healthcare design promises innovative solutions that elevate the quality of life for our aging population and fortify their healthcare support system.

In applying inclusive design to the creation of guidelines for an elderly person's living space, it is imperative to consider the specific challenges that accompany aging. Directives should encompass aspects such as accessibility, comfort, adaptability, sensory considerations, and inclusivity. These guidelines serve as a blueprint for safer, more comfortable, and accommodating living spaces tailored to the unique needs of older individuals.

Integrating healthcare design principles into the design of age-inclusive living spaces is essential for creating environments that support the unique needs of older individuals and promote their overall health and well-being. By considering accessibility, safety, and healthcare-related aspects, we can design inclusive homes that enable older adults to age in place comfortably and independently. Continued research and collaboration in the field of healthcare design will contribute to innovative solutions that enhance the quality of life for the aging population and support their healthcare needs.

To implicate inclusive design in the creation of guidelines for a living space of an elderly person's healthcare design, it's important to consider the specific needs and challenges that come with aging. Some directive lines to consider are

1. Accessibility: Ensure that the living space is easily accessible and safe for the elderly person. This includes features such as ramps, handrails, and grab bars in areas such as the bathroom.
2. Comfort and Ease of Use: The living space should be comfortable and easy to use for the elderly person. This can include features such as comfortable seating, easy-to-use appliances, and easy-to-reach storage.

3. Flexibility and adaptability: The living space should be flexible and adaptable to meet the changing needs of the elderly person. This can include features such as adjustable-height countertops and cabinets, and furniture that can be easily moved or reconfigured.
4. Sensory Considerations: The living space should take into account the sensory needs of the elderly person. For example, the lighting should be adequate, and the space should be free of excessive noise and clutter.
5. Inclusivity: The living space should be designed to be inclusive of people with different needs and abilities. This can include features such as wider doorways and hallways, and lever-style door handles that are easier to operate than knobs.
Including these directive lines of inclusive design, the guidelines for the living space of an elderly person can be designed to be safer, more comfortable, and more accommodating to their specific needs.

Table 13: Professional guide for the overview of the elderly living space.

Overview	**Diseases**
The living space should be on the ground floor.	Mobility Impairments, Use of Wheelchairs or Walkers, Balance Problems, Neurological and Cardiovascular Conditions
The average size of a living space is 60 m². A minimum of 37 m² is required for a living space.	Mobility Impairments, Use of mobility aids, Balance Problems, Neurological Conditions
Having a small garden is desirable to create a biophilic space, without steps to avoid the risk of falling.	Mobility Impairments, Balance Problems, Neurological Conditions, Mental Health and Well-being Sensory Impairments, Stress Reduction and Relaxation, Biophilic Design for Well-being
Avoiding steps or using an escalator if necessary, or guiding them with a ramp. The height of the step should be less than or equal to 15cm.	Mobility Impairments, Use of Mobility Aids, Balance Problems, Neurological Conditions, Psychological or Cognitive Conditions
Lighting: Lighting should be sufficient in all rooms to ensure good visibility and prevent accidents. Having a well-lit space with light-colored paint. This increases the brightness of the space, and artificial lighting compensates for the insufficient natural lighting	Visual Impairments, Age-Related Vision Changes, Reduced Night Vision, Preventing Falls, Alleviating Eye Strain, Enhancing Overall Well-being
Accessibility: It is important to ensure that the home is accessible for a person in a wheelchair or with a cane. Doors should be wide enough, hallways should be spacious enough, and ramps should be installed if necessary.	Mobility Impairments, Arthritis, Stroke Survivors, Neurological Conditions, Elderly Individuals, Post-Surgery or Injury Recovery, Visual Impairments, Balance Problems
Designing a specification for a home intended for an elderly person with an unsteady gait should take into account several standards and recommendations to ensure the person's safety and comfort. Here are some elements to consider	Unsteady Gait and Balance Issues, Parkinson's Disease, Stroke Survivors, Muscle Weakness, Arthritis, Post-Surgery or Post-Injury Recovery

Table 14: Professional guide for the bedroom.

Bedroom	**Diseases**
Use spotlights to illuminate the countertop and mirrors in the bedrooms with neutral color temperature, such as "daylight" lighting. Incorporate different shades of white lighting: It is important to note that the lighting requirements can vary from person to person depending on their individual visual capabilities. Lighting: The bedroom should be well lit, with bright lights for reading or other activities, as well as softer lighting for ambiance	Visual Impairments, Age-Related Vision Changes, Reduced Night Vision, Alleviating Eye Strain, Enhancing Overall Well-being, Promoting Safety
Bed: The bed should be at an appropriate height, allowing the elderly person to easily get in and out of bed. Adjustable beds can also be useful for those with mobility or health issues. The height of the bed should be adjusted to the knee-to-foot height of the patient. Bed height h=50cm / 60cm	Mobility Impairments, Osteoarthritis or Joint Disorders, Back Problems, Hip or Knee Replacement, Age-Related Mobility Changes, Balance Issues, Post-Surgery or Post-Injury Recovery,

	General Aging and Decreased Mobility
Accessibility: The bedroom should be easily accessible for the elderly person. This can include features such as wider doorways and hallways, and ramps or lifts for any changes in elevation.	Mobility Impairments, Arthritis, Stroke Survivors, Neurological Conditions, Post-Surgery or Post-Injury Recovery, Use of Mobility Aids
Flooring: The flooring should be slip-resistant and easy to navigate, with no loos rugs or tripping hazards.	Mobility Impairments, balance problems, Visual Impairments, General Aging and Decreased Mobility
Storage: Adequate storage should be provided, with easy-to-reach shelves and drawers.	Arthritis, Muscle Weakness, Mobility Impairments, Post-Surgery or Post-Injury Recovery, Elderly Individuals, Neurological Conditions, Balance Problems, Visual Impairments
It's also important to consider the specific needs and abilities of the individual person for whom the bedroom is being designed. For example, someone with limited mobility may need additional handrails or a walker to help them move around the room. By following these norms and guidelines, the bedroom of an elderly person can be designed to be safe, accessible, and comfortable.	Mobility Impairments, balance problems, Neurological Conditions, Post-Surgery or Post-Injury Recovery,

Table 15: Professional guide for the hallway.

Hallway	**Diseases**
Having a two-way switch at the beginning and end of the corridor is preferable. It is possible to replace the switches with motion sensors and light sensors that adjust the brightness of the space if it is found to be insufficient for the area. Height of switches: switches should be placed at an accessible height for the elderly person, usually between 90 cm and 120 cm.	Mobility Impairments, General Aging and Decreased Mobility, Visual Impairments, Balance Problems, Neurological Conditions
Lighting: the hallway should be well-lit to facilitate the vision of the elderly person and prevent falls. A minimum brightness of 100 lux is recommended.	Low Vision or Visual Impairments, General Aging and Decreased Visual Acuity, Balance Problems, Neurological Conditions, Muscle Weakness
Ramps and handrails: Install handrails on both sides of the hallway to provide support and stability for the elderly person while walking. The handrails should be at a comfortable height for the person, and sturdy enough to support their weight.	Mobility Impairments, General Aging and Decreased Mobility, Balance Problems, Post-Surgery or Post-Injury Recovery, Muscle Weakness, Neurological Conditions
Flooring: the floor should be non-slip to prevent slipping. Carpets or rugs are not recommended.	Mobility Impairments, Balance Problems, Muscle Weakness, Post-Surgery or Post-Injury Recovery, Neurological Conditions, General Aging and Decreased Stability
Width of the hallway: the hallway should have a minimum width of 90 cm to allow for the passage of a wheelchair or walker. However, a width of 120 cm is recommended for more comfort.	Mobility Impairments, Use of Wheelchairs or Walkers, Balance Problems
Contrasting colors: it is recommended to use contrasting colors between the floor and the walls to facilitate perception of the space.	Low Vision or Visual Impairments, Depth Perception Issues, Neurological Conditions, Age-Related Vision Changes, Visual Processing Disorders

Adequate Space: Ensure there is adequate space for the elderly person to maneuver around in the hallway, especially if they are using a walker or wheelchair.	Mobility Impairments, Use of Wheelchairs or Walkers, Balance Problems
Avoid Sharp Turns: Avoid sharp turns in the hallway, as these can be difficult for an elderly person with limited mobility to navigate.	Mobility Impairments, General Aging and Decreased Mobility, Muscle Weakness
Comfortable Seating: Provide comfortable seating in the hallway, so that the elderly person can rest if needed.	Mobility Impairments, General Aging and fatigue, Cardiovascular Conditions, Respiratory Conditions, Balance Problems
Doorways: Ensure that doorways are wide enough to accommodate a walker or wheelchair and that the door handles are easy to grip and operate.	Mobility Impairments, Use of Wheelchairs or Walkers, Balance Problems

Table 16: Professional guide for the living room.

Living room	**Diseases**
Sofa Height: The seat should be deep enough to provide support and comfort, but not so deep that it makes it difficult for the person to stand up or sit down. Choose a sofa with a seat height that makes it easy for the elderly person to sit down and stand up. A seat height of around (45-50 cm) is generally comfortable for most elderly individuals. Additionally, it is important to choose a sofa with firm cushions that provide good support for the back and neck. This can help to prevent discomfort or pain, which can be a common issue for elderly people.	Arthritis, Muscle Weakness, Back Problems, Mobility Issues, General Aging and Decreased Mobility, Neck Pain
TV Placement: The TV should be placed at a height that allows the elderly person to view it comfortably without straining their neck. A height of around 107-122 cm from the floor to the center of the screen is generally recommended. Also, ensure that the TV is positioned in a location that does not create glare or reflection on the screen, which can make it difficult to see.	Neck Pain or Strain, stroke, Glare Sensitivity
Clear Pathways: Ensure there are clear and wide pathways throughout the living room to accommodate a wheelchair or walker. Aim for a minimum width of 91 cm to allow for easy maneuverability.	Mobility Impairments, Spinal Cord Injuries, Stroke, Muscle Weakness, Multiple Sclerosis, Amputations
Flooring: Choose flooring materials that are slip-resistant and provide a smooth surface for mobility aids. Avoid carpets with high piles or rugs that can pose tripping hazards. Smooth and non-slippery materials like hardwood, laminate, or low-pile carpet are recommended.	Mobility Impairments, Balance Problems, Muscle Weakness, Post-Surgery or Post-Injury Recovery, Neurological Conditions, General Aging and Decreased Stability
Furniture Placement: Arrange the furniture to create spacious and unobstructed pathways. Allow for enough space around seating areas to accommodate mobility aids and easy movement. Consider using furniture with firm cushions and armrests for stability when sitting or standing.	Mobility Impairments, Use of Mobility Aids, Balance Problems, Muscle Weakness, Post-Surgery or Post-Injury Recovery, General Aging and Decreased Stability
Seating: Select chairs and sofas with sturdy arms to provide support when getting up or sitting down. Opt for firm and comfortable cushions that offer good back support. Higher seat heights (around 46-51 cm) can make it easier for individuals with mobility issues to sit and stand.	Arthritis, Muscle Weakness, Back Problems, Mobility Impairments, Balance Problems, General Aging and Decreased Mobility
Lighting: Ensure the living room has ample lighting to minimize shadows and improve visibility. Use a combination of natural light and artificial lighting, including ceiling fixtures, table lamps, and task lighting. Install light switches at accessible heights, and consider adding motion sensor lighting for convenience.	Low Vision or Visual Impairments, Glaucoma, Cataracts, Macular Degeneration, General Aging and Decreased Visual Acuity, Neurological Conditions
Accessibility: Ensure that light switches, electrical outlets, and other controls are positioned at wheelchair-accessible heights, typically	Mobility Impairments, Use of Mobility Aids, Arthritis, Muscle Weakness,

around (38-122 cm) from the floor. Use lever-style door handles that are easier to grip and operate.	Stroke, General Aging and Decreased Dexterity
Storage: Include easily accessible storage solutions, such as low cabinets or open shelves, to eliminate the need for reaching or bending. Ensure that frequently used items are within reach without the need for excessive stretching or straining.	Arthritis, Back Problems, Mobility Impairments, Muscle Weakness, General Aging and Decreased Mobility, Post-Surgery or Post-Injury Recovery
Doorways: Check that doorways have a minimum width of 81 cm to accommodate wheelchairs or walkers. If necessary, consider widening the doorways for better accessibility.	Mobility Impairments, Use of Wheelchairs or Walkers, Post-Surgery or Post-Injury Recovery, Muscle Weakness, Balance Problems
Safety: Install grab bars near seating areas and in the bathroom to provide stability and support. Ensure that electrical cords are neatly tucked away to prevent tripping hazards. Consider using contrasting colors on door frames and stairs to improve visibility for individuals with visual impairments.	Mobility Impairments, Visual Impairments, Balance Problems, Muscle Weakness, General Aging and Decreased Mobility, Neurological Conditions,
Emergency Preparedness: Keep emergency contact numbers easily visible and accessible. Consider installing a phone or emergency call system within reach in case of emergencies.	Heart Conditions, Respiratory Conditions, Epilepsy, Stroke, Severe Allergies, Diabetes, Mobility Impairments

Table 17: Professional guide for the hygiene area.

Hygiene area	**Diseases**
Non-slip flooring: Use non-slip flooring to reduce the risk of slipping and falling. Avoid glossy or polished surfaces that can become slippery when wet.	Arthritis, balance disorders, or those with mobility difficulties.
Grab bars: Install grab bars next to the toilet, shower, and bathtub. These bars provide support and stability for the elderly person when standing up or sitting down. The bars should be placed at a height between 84-91 cm above the finished floor. Ensure they can support a weight of at least 113 kg. On the right side if the patient is right-handed. On the left side if the patient has right-sided hemiplegia.	Mobility Issues, Muscle Weakness, Coordination Problems, Stroke (Cerebrovascular Accident, CVA), Heart Problems
Walk-in showers: Consider installing a walk-in shower instead of a bathtub. This allows the elderly person to enter and exit the shower safely and comfortably. The shower floor should be flush with the bathroom floor or have a minimal threshold (less than 1.3 cm) to facilitate easy entry.	Mobility Issues, Balance Problems, Coordination Issues, Heart or Respiratory Problems, Amputations or Limb Problems, Age-related Issues, Recovery after Surgery or Injury
Shower seats: Provide a shower seat or bench with a height of 43-48 cm for comfortable seating users to allow the elderly person to sit down while showering. Ensure it is securely mounted and capable of supporting the weight of the elderly.	Recovery after Surgery or Injury, Coordination Problems, Excessive Fatigue, Amputations or Limb Issues, Neurological Conditions, Respiratory Issues, Heart Problems, Mobility Issues
Raised toilet seats: Consider installing a raised toilet seat with a height of 43-48 cm to ease sitting down and standing up. Ensure it is compatible with the existing toilet and securely attached.	Mobility Issues, Muscle Weakness, Joint Problems, Back Problems, Recovery after Surgery or Injury, Heart or Respiratory Problem, Coordination Issues
Lever handles: Use lever handles for faucets, shower controls, and door handles. These handles should be easy to grasp and operate, with a length of 10-15 cm for comfortable to use.	Arthritis or Musculoskeletal Issues, Coordination Problems, Muscle Weakness, Hand Mobility Issues, Medical Conditions Affecting Hand Strength or Dexterity

Adequate lighting: Make sure the bathroom is well lit to improve visibility and reduce the risk of falls. Install night lights for better visibility during the night. Install bright and evenly distributed lighting throughout the bathroom. Include task lighting at the vanity area and consider motion sensor lighting for convenience. Aim for a minimum of 800-1,000 lux of illuminance.	Vision Impairment or Visual Impairments, Mobility or Balance Issues, Neurological or Coordination Problems, Cognitive or Memory Issues, Medical Conditions Affecting Stability or Coordination, Recovery after Surgery or Injury
Counter height: Consider a bathroom counter height between 81-86 cm to accommodate wheelchair users. If a lower counter is needed, a height of 74 cm can be suitable.	Paralysis or Physical Impairment, Leg or Hip Mobility Issues, Muscle Atrophy or Weakness, Amputations, Back Problems, Other Medical Conditions Requiring Wheelchair Use
If using rugs in the bathroom, select slip-resistant rugs with nonskid backing to prevent slipping. Ensure the rugs are securely fastened and do not obstruct the pathway.	Mobility Issues, Balance Problems, Muscle Weakness, Post-Surgery or Post-Injury Recovery, Neurological Conditions, Elderly Individuals

Table 18: Professional guide for the kitchen.

Kitchen	**Diseases**
Clearances and Accessibility: - Ensure a clear and unobstructed path for easy movement throughout the kitchen, with a minimum clear width of (91 cm). - Maintain a clear space of at least 152 cm in front of key areas like the sink, stove, and refrigerator to allow for maneuverability.	Mobility Issues, Balance Problems, Muscle Weakness, Arthritis, Back Problems,
Sink: - Install a sink with a single-lever faucet for ease of use. - The sink should be at a height that is comfortable for the elderly person to use without having to bend down too much. A height of around (76 cm) is often recommended and a depth of (48 cm).	Arthritis, Back Problems, Mobility Issues, Balance Problems
- Ensure that the kitchen is well-lit with ample lighting, both natural and artificial. This will help the elderly person to see where they are going and avoid any potential hazards. -Install adequate task lighting to ensure good visibility, especially in key areas like the countertop, sink, and stove.	Age-Related Vision Changes, Cataracts, Glaucoma, Macular Degeneration, Diabetic Retinopathy, Neurological Conditions, General Aging and Visual Decline
- Appliances: The appliances should be at a height that is easily accessible for the elderly person. For example, the oven and microwave should be at a height that is easy to reach without having to bend down too much.	Arthritis, Back Problems, Mobility Issues, Balance Problems
The height of the machine (dishwasher machine): The height of the machine should be adapted to the elderly person, usually between 80 cm and 85 cm in height to allow for easy loading and unloading without bending.	Arthritis, Back Problems, Mobility Issues, Balance Problems General Aging and Decreased Mobility
Counter height: Counters should be at a comfortable height for the individual and allow for easy access to appliances and cooking utensils. A high between 81-86cm is recommended. Table Height: Choose a table height that allows for comfortable access and use. A standard height of (76 cm) may work for most individuals, but you may consider lowering it to (69-74 cm) if necessary.	Arthritis, Back Problems, Mobility Issues, Balance Problems General Aging and Decreased Mobility
- Cabinets: The upper cabinets should be mounted at a height that is easy for the elderly person to reach without having to stand on a stool or chair. A height of around (122 cm) is often recommended.	Arthritis, Back Problems, Mobility Issues, Balance Problems General Aging and Decreased Mobility
Flooring: Choose slip-resistant flooring materials such as non-slip tiles or low-pile carpets to reduce the risk of slipping.	Mobility Issues, Balance Problems, Muscle Weakness, Post-Surgery or Post-Injury Recovery

Adequate Space: Ensure there is adequate space for the elderly person to maneuver around in the kitchen, especially if they are using a walker or wheelchair.	Mobility Issues, Stroke, Multiple Sclerosis, Muscle Weakness, Joint Replacements, General Aging and Decreased Mobility
Appliances: Consider installing appliances that are easy to operate, such as touchpad ovens, side-swing microwaves, and refrigerators with pull-out shelves.	Arthritis, Muscle Weakness, Neurological Conditions, Stroke, Cognitive Decline, General Aging and Decreased Dexterity
Avoid sharp edges: Avoid sharp edges on counters and cabinets as they can be dangerous for an elderly person with limited mobility. Select a table shape that suits the individual's needs and the available space. Round or oval tables with smooth edges can be preferable to prevent accidental bumps.	Mobility Issues, Balance Problems, Fragility or Risk of Falls, Cognitive Decline, General Aging and Decreased Mobility
Chair Accessibility and Maneuverability: - Ensure that there is enough space around the table for easy access to and maneuverability around the chairs, especially for individuals using mobility aids. - Allow a clear space of at least (91 cm) between the table edge and nearby obstacles or walls. Chair Stability: - Choose chairs with a stable and sturdy base to minimize the risk of tipping or instability. Chairs with four legs or a wider base are generally more stable.	Mobility Issues, Use of Mobility Aids, Balance Problems, General Aging and Decreased Mobility, Neurological Conditions

As professional designers and geriatric physicians review this guide for the rehabilitation of a senior's home, it becomes evident that by incorporating healthcare design principles, such as the inclusion of features like grab bars, non-slip flooring, adequate lighting, accessible furniture, and ergonomic layouts, the physical safety and mobility of older individuals can be improved. Additionally, attention to factors like promoting natural light, incorporating nature elements, creating spaces for social interaction, and optimizing acoustics contribute to their mental well-being.

In line with the findings of the article "Therapeutic Lighting in the elderly living spaces via a Daylight and Artificial Lighting Integrated Scheme," the therapeutic effects of light play a crucial role in enhancing the overall well-being of elderly individuals. Natural light, in particular, has been proven to positively impact mood, regulate circadian rhythms, and promote better sleep quality. By integrating this knowledge into healthcare design, living spaces can be transformed into environments that foster both physical and psychological wellness.

Furthermore, advancements in technology (van Hoof et al, 2011), such as the utilization of smart light sensors and Driver Monitoring System (DMS) cameras, present a promising solution to address the issue of falls among the elderly. This integrated approach not only improves safety within elderly homes but also enables proactive healthcare monitoring. Smart sensors can dynamically adjust lighting conditions, (Chen.et al, 2023), effectively reducing the risk of accidents and falls. Simultaneously, DMS cameras can continuously monitor the individual's movements, swiftly detecting any signs of instability or imbalance. In the event of a fall or potential fall, the system can promptly alert a designated family member, empowering them to take immediate action and provide necessary assistance. This amalgamation of technologies not only enhances safety but also enables healthcare monitoring and facilitates early intervention, ultimately promoting the holistic well-being of the elderly population.

5. Conclusion

The significance of inclusive design and healthcare principles in ensuring the safety, comfort, and well-being of older individuals cannot be overstated. By prioritizing accessibility and tailored solutions, we pave the way for an environment that not only addresses the unique needs of elderly persons but also promotes their independence and quality of life. It highlights the collaborative approach involving geriatric physicians and interior designers, which goes beyond aesthetics to address functional aspects and health-related considerations. However, it is important to recognize that healthcare design encompasses more than just technology. It involves considering elements such as accessibility, ergonomic furniture, appropriate color schemes, and noise reduction, to create a holistic environment that promotes health and well-being. Looking ahead, advancements in telemedicine, remote healthcare monitoring, AI, and machine learning

promise further enhancements in healthcare design for the elderly. This integrated approach not only benefits residents but also has broader societal implications, promoting preventive healthcare, reducing costs, and enabling seniors to age in place with dignity. The integration of geriatric expertise, design, and research underscores the importance of tailored solutions and collaborative efforts in creating living spaces that prioritize the health, well-being, and independence of older individuals, ultimately contributing to a more inclusive society and improved quality of life for older adults.

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The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors/s.

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