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Bridging the gap: a multidisciplinary approach to integrated care solutions for the aging population

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Abstract

This study addresses the challenges of the ageing population, focusing on enhancing the life of caregivers and the elderly. It proposes a multifaceted solution that allows dependents to live close to their carers, enabling oversight without a need for constant presence. The paper employs empirical studies to ensure a deep understanding of caregiving, capturing the breadth and depth of challenges. Presenting a novel design solution, Hygge, combines physical and system design with technology integration. This prioritises accessibility, cost, maintenance, and adaptability for diverse needs.

Keywords: inclusive design, healthcare design, elderly care system, user centred design, quality of life

1. Introduction

Currently the global population's increasing age represents the most pressing medical and societal demographic challenge globally (Rudnicka et al., 2020). This demographic shift is not unique to any specific countries but is particularly of concern in the developed world (Park and Shin, 2011). One prominent example is the UK, where the population of people over the age of 65 is expected to increase by 8.6 million over the next 50 years - equivalent to the size of London (Storey, 2018). One crucial issue arising from this demographic trend is the diminishing availability of formal social care (Dunatchik et al., 2019). This heightens the demand for informal caregiving, often undertaken by adult children for their elderly parents, resulting in a range of detrimental effects, such as a decline in mental health and wellbeing (Carers UK, 2022). This has led to a specific trend for adults who are caregivers, usually 50-60, often juggling employment and childcare duties, thus creating the phenomenon the "sandwich generation" (Storey, 2018).In response to the pressing challenges brought about by an ageing population, a range of innovative solutions have been explored and implemented across different sectors of society, as outlined in recent literature. On a social level, initiatives such as "Wohnen fuer Hilfe" present a symbiotic relationship between students and the elderly, where students provide companionship and carry out daily tasks, in return for accommodation (Huebner and Shipworth, 2015). The introduction of intergenerational nurseries further bridges the age gap, encouraging connections and mutual learning by placing children and the elderly in shared environments (Kernan and Cortellesi, 2019). From a legislative perspective, the adoption of various equality and anti-discrimination acts globally aim to provide a safeguard for the rights and well-being of the elderly (Kostova, 2019). In China, for instance, the ‘Elderly Rights Law’ mandates that children are responsible for the care of their ageing parents, ensuring familial support (Liu and Sun, 2015). On the educational front, principles like "Humanitude" underscore the importance of preserving the dignity and independence of every individual regardless of age (Hidenobu et al., 2021). Additionally, the De Hogeweyk gated village, tailored for dementia

patients, not only serves its inhabitants, but also acts as an enlightening case study for institutions, emphasizing the merits of biophilic design and holistic care approaches (Miller and Burton, 2019). In a world grappling with the complexities of an ageing population, caregivers find themselves navigating a labyrinth of challenges. Beyond the evident financial strains, there is also an absence of affordable resources for informal carers, such as guidance materials and documentation (Brimblecombe et al., 2018). Consequently, many informal caregivers perceive care homes as their sole alternative, despite their prohibitive costs (Swinkels et al., 2015). The exorbitant expense associated with placing a single individual in a care home, ranging from £41,600 – £56,056 (Age-UK, 2023), renders this option unfeasible for most. Furthermore, it's noteworthy to highlight that older individuals residing with their families generally report superior outcomes in perceived health status, self-esteem, depression levels, and overall life satisfaction compared to those living alone (Shin and Sok, 2012). Despite the evident benefits of this living arrangement, it remains an underutilized option; in 2021, 97.3% of individuals aged 65 and above in England and Wales resided in private homes, while only 2.7% stayed in shared facilities (ONS, 2023). Leveraging such affordable and supportive environments could serve as a beneficial intervention, not only economically, but also in improving the quality of life for the ageing populace i.e. psychosocially inclusive design solutions (Lim et al., 2021). Therefore, the absence of affordable care and easily accessible solutions emphasizes the urgent need for inventive and inclusive strategies aimed at assisting the ageing population and those who care for them. In the midst of rising challenges posed by an ageing global population, this paper aims to address the multifaceted needs of caregivers and their elderly dependents to enhance their quality of life. The primary goal is to find a solution that enables the dependent to live in close proximity to the carer while still allowing for remote monitoring of the dependent, ensuring continuous oversight without the necessity for constant physical presence. Recognizing the diverse caregiving landscape, the solution should permit access by multiple caregivers and also cater to those responsible for more than one dependent. This proposal pivots on creating a tool to enhance the caregiving experience, making it both effective and positive while reducing the effort and resources taken by the carer to full fill their role.

2. Research methodology

To obtain an in-depth understanding of the challenges and intricacies within the caregiving domain, a systematic and diversified research approach including mixed data collection methods was adopted (figure 1). Leveraging the methodology of Longitudinal Qualitative Research (LQR), which has gained traction in the healthcare sector, the approach underscored the significance of time and lived experiences (Calman et al., 2013). Particularly adept at capturing transitions in care, LQR illuminates the intricate processes affecting both the dependent and the carer over time (Cameron et al., 2019), making it particularly relevant to this study given the swift evolutions in caregiving scenarios. The overall project followed design process introduced by Design council that includes discover, define, develop, and deliver.

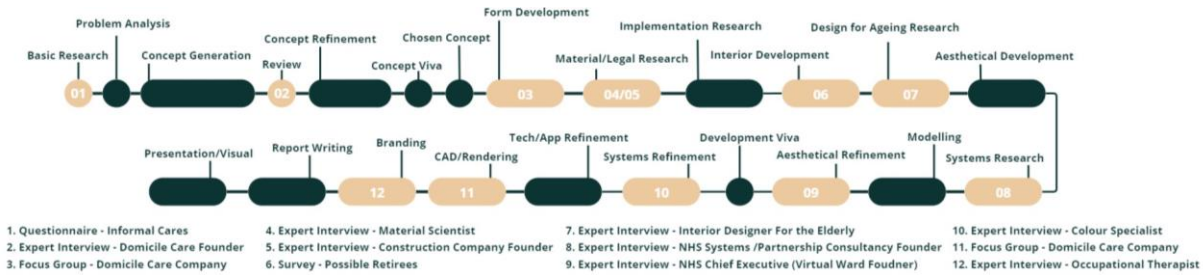

Figure 1. An illustration of the project methodology, i.e. desing process

2.1. Data collection method

The research commenced with questionnaires aimed at informal carers, 8 participants in total, with a majority in the age group of 61-70 years, to capture the realities of caregiving from a personal viewpoint. This data provides ground-level insights into the demands and challenges faced by individuals who care for the elderly informally, often without professional training or support. Building on this, a survey reaching out to a broader demographic of 28 future retirees was conducted to understand societal

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expectations and preparedness for entering the aging population. This survey aimed to extrapolate the needs and concerns of future care recipients, thus ensuring that the research addresses the full spectrum of the generational caregiving experience from both the provider and receiver perspectives. This led to an in depth focus groups with a Domicile Care Company, to add professional expertise. In two rounds, insights were sought from key figures including a founder with 12 years of experience, a care manager, and a quality and compliance officer, whose roles influence the operational standards and strategic direction of care services. These discussions are critical for identifying industry standards, gaps in service provision, and areas for improvement. Furthermore, based off the insights gained from the previous research methods, a series of specialized areas were identified for subsequent investigation as seen in table 1. Interviews were conducted with experts across various fields impacting elderly care services. These included a material scientist, a construction company founder, an interior designer specializing in environments for dementia and disability, a systems consultant for the NHS, an ex-chief executive of the NHS, a colour specialist, and an occupational therapist. The breadth of expertise ensures a comprehensive understanding of the physical, psychological, and systemic facets of elderly care. These interviews provided insights into how various elements of living environments and healthcare systems can be optimized for the well-being of the elderly. Together, these components synthesize into a holistic examination of the ecosystem surrounding elderly care. The questionnaire and survey offer a direct line to the experiences and anticipations of those giving and expecting to receive care. In contrast, the focus groups and expert interviews provide a top-down view of the industry's standards, challenges, and innovations. This comprehensive approach ensures the research is grounded in real-world experience while informed by professional standards and forward-looking practices, setting the stage for informed recommendations and strategies to enhance elderly care services.

Table 1. Summary of sampling for primary research

Chosen Study		Participants No.	Gender	Age band or Years of expertise
Questionnaire: informal carer		8	M: 3/F: 5	51-60: 1 / 61-70: 7
Survey: future retirees		28	N/A	N/A
Focus group workshop: Domicile care company R1		3	M: 1/F: 2	Founder: 12 years' Experience | Care Manager: Unknown | Quality & Compliance Officer: Unknown
Focus group workshop: Domicile care company R2		2	F: 2	Care Manager: Unknown | Quality & Compliance Officer: Unknown
Expert Interview:	Domicile care founder	1	M: 1	Founder: 12 years' experience
	Material scientist	1	F: 1	Over 3 years
	Construction company founder	1	M: 1	24 years' experience in industry
	Interior designer for dementia and disability	1	F: 1	8 years' experience in industry
	Organizations systems consultancy for the NHS	1	M: 1	30 years' experience in industry
	NHS Chief executive/Consultant	1	M: 1	25+ years' experience in industry
	Colour specialist	1	M: 1	36 years' experience in industry
	Occupational therapist	1	F: 1	20+ years' experience

2.2. Data analysis

In this multifaceted research, numerous key insights emerged. Interviews with the Domicile Care Founder highlighted a diminishing reliance on care homes due to several reasons including elevated costs and perceived low-quality care. Informal caregiving, despite its importance, is fraught with challenges including limited financial support and the isolating nature of elderly dependents relocating for retirement. However, technological advancements like fall monitors, GPS, and medicine management systems were identified as pivotal in current caregiving. Discussions with the Material Scientist underscored the importance of considering the lifespan of materials used in solutions. Insights included potential end-of-life options and recommendations like electrochromic windows and

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photovoltaic energy systems. The Construction Company Founder emphasized the cost implications and regulatory nuances of construction in the UK, with recommendations leaning towards non-permanent structures to circumvent excessive planning permissions. Expertise from the Interior Design for the Elderly professional highlighted critical design considerations such as retrofitting facilities, space management, and regulatory compliance for light and safety. The Organizations Systems Consultancy for the NHS shed light on new structures and virtual wards, underscoring the need for collaborative groups to expedite solution implementation. NHS Chief Executive focused on the infrastructure requirements for virtual wards, emphasizing the role of various potential users and the challenges of delayed discharge. Aesthetic considerations from the Colour Design Specialist emphasized the necessity for a homely feel, advocating for user personalization. The Focus Group with the domicile care company leadership accentuated vital design elements for elderly dependents such as ceiling hoists, voice activation, and space considerations which match similar responses from the occupational therapist. Findings from the Questionnaires and Surveys mirrored many sentiments from the expert interviews, highlighting the need for financial and physical support for carers, and emphasizing desires of the elderly such as independence, companionship, and connectivity. This holistic research approach underscores a growing need for innovative caregiving solutions that blend technological advancements with user-centric designs, addressing both functional and emotional needs of the elderly and their caregivers.

3. Results

3.1. Construction and design

Figure 2. An illustration of the final design (left) and possible construction options (right)

The final design of the "Hygge" Environment as seen in figure 2 emerged as a solution, intertwining physical design, system design, and technological integration. This approach was crafted to meet user accessibility, cost-effectiveness, ease of maintenance, and adaptability to diverse user needs. Intellectual Property (IP) protection emerged as a legal concern, particularly regarding trademark issues, prompting discussions about potential renaming or ownership transfer. In terms of costs, two pivotal aspects were evaluated: the expense of constructing the units and the costs associated with installation and removal. These considerations were informed by expert insights and extensive secondary research. A critical element of the project was interior design, which directly impacts user experience. Material choices, layout decisions, and other design elements were guided by expert advice and user feedback, ensuring both functionality and aesthetic appeal. The core structure utilizes timber for framing, chosen for its sustainability and long-life span, as highlighted in research by Chen et al. (2023) and Amoruso and Schuetze (2022). For the foundation, ground screws were selected due to their low cost, reusability, and quick setup capabilities, as recommended by a construction expert and validated by Koltm's (2022) research. The external membrane comprises an EPDM Membrane, chosen for its longevity, use of recycled materials, and ease of maintenance, as supported by Russell (2020) and Obex-UK (2018). Door selection was strategic: interior barn doors for their cost-effectiveness and space-saving quality, and exterior French doors for superior insulation and security, based on research by Vibrant-Doors (2023) and Cometa (2018). Flooring choices varied by room function: laminate for the living room, favoured for durability and ease of maintenance; carpet or vinyl in bedrooms, depending on wheelchair accessibility; and vinyl or rubber in bathrooms for slip resistance and shock absorption, as outlined in

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Checkatrade reports (Checkatrade-(A), 2023; Checkatrade-(B), 2023; Checkatrade-(C), 2023;) and Householdquotes (2023). Insulation was a key focus, with Structural Insulated Panels (SIPs) and cork chosen for their airtightness, durability, and non-toxic properties, as recommended by Eco-Passive-House (2019). Window design incorporated Fineo Glass for its insulation and soundproofing capabilities, complemented with options for electrochromic and photovoltaic additions for privacy and sustainable energy, as noted by AGC (2021), Martin (2005), and Ding and Yu (2022). The colour scheme allows user personalization, guided by Dulux dementia palette recommendations and LRV acceptance tests, informed by interviews with interior designers and colour specialists (Building-Better-Healthcare, 2017). Lastly, lighting considerations focused on high angular coverage and a high colour rendering index (CRI) of 90+, ensuring no shadows are cast on key activities and enhancing readability and accessibility, as suggested by Park and Farr (2009).

3.2. System and business model

The product life cycle was envisioned on two levels. The primary level was based on a potential lifespan of 50 years, understanding that future advancements might render the product obsolete. The secondary level detailed the user's journey from assessment to installation, usage, and eventual removal. Financially, a rental model was proposed, supported by detailed projections of potential profits over the product's lifespan. Governmental partnerships were deemed essential for the success and integration of the solution. Collaborating with entities like the NHS could help address significant gaps in the current care system, in figure 3 you can see a comparison highlighting the pitfalls of the current system and the possible remedies that Hygge can provide to improve the process and experience for all stakeholders.
The business model proposes a rental scheme with pricing options depending on selected unit combinations. Over a 50-year period, profit per unit is projected to range from £124,800-£164,640 as seen in table 2. Given the model's five-year breakeven point and the estimated 5 years no-operation time (time in storage or repairs), supplemental income streams, such as a subscription-based app model - which has demonstrated profitability (Randhawa and Kumar, 2008) - and affiliation or partnership programs with other companies offering requisite furniture or technology (Haq, 2012), could sustain cash flow if the five-year breakeven is not viable.

Figure 3. A comparison between the current (left: source tricordant) and hygge care scenario (right)

igure 4 illustrates the practical and financial aspects of the Hygge housing units. It provides a breakdown of the unit combinations available with Hygge, showcasing the flexibility and adaptability of these living spaces to meet varying user requirements. The unit configurations range from combinations of living rooms and bedrooms to the inclusion of bathrooms, with detailed monthly costs and spatial dimensions. The practicality of these units is underscored by the statistic that 87% of UK homes have a garden, with an average size of 188 square meters (ONS, 2020), suggesting that the proposed units would fit comfortably within the average garden space, making them a viable option for many consumers.

Table 2. An illustration of unit cost breakdown

	Living room	Living/ bedroom	Bedroom (Large)	Bedroom (Small)	Bathroom (Large)	Bathroom (Small)
Building cost	£20,550	£20,550	£16,700	£15,800	£17,800	£15,600
Monthly cost for 5yr. break even	£343	£343	£278	£263	£297	£260
40 yr. profit	£164,640	£164,640	£133,440	£126,240	£142,560	£124,800

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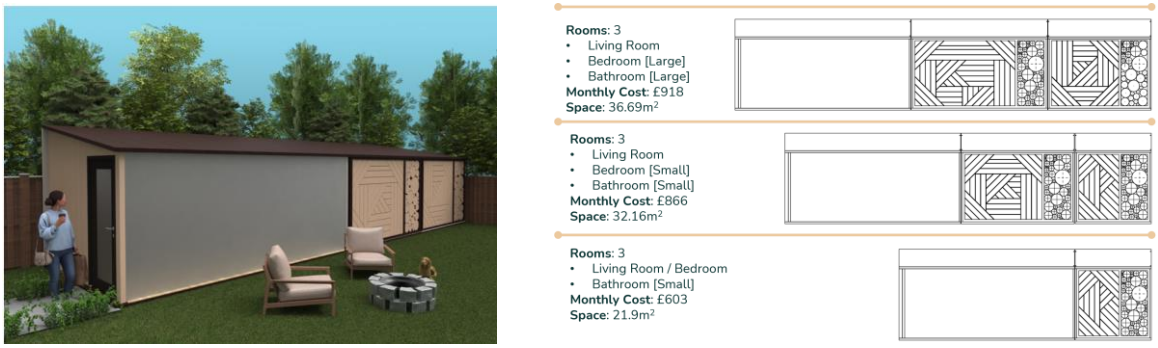

Figure 4. An illustration of monthly cost breakdown based on different construction options

3.3. Technology integration

On the technology front, the selection was informed by extensive consultations with experts from diverse domains. Tools like voice-activated assistants were integrated to aid those with impairments, while medication management devices aimed to ensure health safety. The incorporated technologies were designed to work in tandem, creating a cohesive environment for users. An application was also developed to complement the hardware components, ensuring seamless integration, and providing a comprehensive solution to address caregiving needs as seen in figure 5.

Figure 5. A view of the technical capabilities integrated with a mobile application

4. Discussion

4.1. Originality: Unique selling proposition (USP)

The unique selling proposition (USP) of the final design lies in its innovative, user-focused approach, distinguishing it from existing solutions within construction and design academia. This model uniquely intertwines physical design, system operations, and technology, creating a holistic "Hygge" atmosphere prioritizing user well-being over time, a concept often overlooked in traditional designs which tend to focus on a single issue such as fall monitors or mobility aids or outdated holistic approaches that are expensive and inaccessible like care homes. With the system design and business modelling, the innovation is twofold: the product life cycle anticipates long-term relevance while acknowledging the inevitability of technological evolution. Partnered with a Huf Haus design approach for ease of implementation in a user's home, the design can be installed and removed within a few days, which in contrast to the months it can take to construct a granny annex can make all the difference. The financial construct, pivoting around a rental system, exhibits a flexible, user-friendly approach, while the pursuit of governmental alliances showcases a commitment to systemic integration and social health welfare augmentation. Furthermore, the technology employed, specifically chosen through expert consultation, caters to underserved niches like assistance for individuals with impairments, ensuring safety and convenience. This integration, particularly evident in the custom application, promises an intuitive and cohesive user experience, positioning the design as not just a physical construct but an immersive, user-enhancing environment that can use its knowledge of the user to detect when they are changing in behaviour to spot issues in health that might be otherwise missed. Figure 6 presents a cost comparison

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over time, contrasting Hygge with traditional residential care homes, nursing care homes, and NHS bed costs. Hygge's financial model includes an installation charge, monthly fees, and a removal charge, with the cumulative expense over 5, 10, and 15 years depicted in a bar graph. This comparison highlights a substantial cost advantage when choosing Hygge, whether for short-term or long-term accommodation needs. The analysis suggests that Hygge not only offers a cost-effective solution but also provides a private, customizable living space that can evolve with the consumer's changing needs.

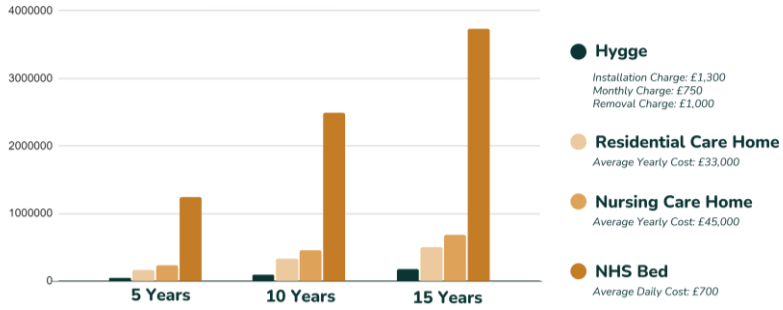

Figure 6. Cost comparison of hygge to residential / nursing care homes (Age-UK, 2023), and NHS beds (NHS, 2021)

4.2. Significance: Enhance quality of life

The innovative three-part design solution holds transformative potential for all stakeholders identified in table 3, dramatically enhancing the quality of care across the board. Care-recipients benefit from an environment crafted with their unique needs in mind, underscored by the emphasis on adaptability, accessibility, and a "Hygge" ambiance. Such an environment not only eases their daily routines but also bolsters emotional well-being. Primary and secondary carers, ranging from family members to nursing professionals, gain from the integration of advanced technological aids, simplifying caregiving processes and ensuring safety. This alleviates stress and allows for more quality interactions. Organizations and services, particularly charities, non-profits, and community centres, find value in the cost-effective, rentable design, making it a feasible solution to endorse or adopt. The involvement of governmental entities and services like the NHS signals an alignment with broader public health objectives, addressing gaps in the current system and promoting general societal welfare. In essence, this ground-breaking approach ensures a more interconnected, supported, and enriched life for every involved party.

Table 3. A breakdown of stakeholder involvement

Category	Subcategory	Entities/Individuals
Government / Officials	-	Leading Party, The Opposition, Local Councils, Local MPs, NHS, Public Transport
Organisations	-	Charities, Non-Profits, Places of Worship, Community Centres, Local Shops, Delivery Services
Individuals	Care-recipient	Parents (Elderly), Aunts (Elderly), Uncle (Elderly), Grandparents
	Primary/ Secondary Carers	Children, Husband, Wife, Brother, Sister, Niece, Nephew, Grandchild, Neighbours, Nurse, Care homes

4.3. Rigour: Potential challenge

The design solution, while offering significant advancements, also brings forth potential challenges. The integration of various technologies requires seamless interoperability, and any shortfalls can lead to system glitches or malfunctions, potentially compromising user safety. Financially, while the rental model has its merits, its execution needs to be meticulous to ensure it doesn't become cost-prohibitive or misaligned with market demands. Collaborating with entities like the NHS offers immense potential benefits, but it also means delving into intricate negotiations and aligning with bureaucratic processes that could cause delays in implementation. Moreover, understanding the intricate needs of care-

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recipients and their primary and secondary carers presents its own set of challenges. Balancing user feedback with expert advice, especially in a constantly evolving care environment, is pivotal. Thus, for the solution to truly thrive, these multifaceted challenges must be adeptly navigated.

4.4. Design limitation

The design, despite its pioneering approach to caregiving, presents certain limitations. The system shines in delivering high-quality care affordably, but it meets challenges when a situation calls for a second professional carer. In such cases, facilities like nursing homes, equipped with more specialized amenities, might be more appropriate. However, the design remains optimal for cases needing only one professional carer, especially when supplemented by an informal carer. The applicability of the solution is also restricted, as it necessitates a garden with adequate space. With 87% of UK homes boasting gardens averaging 188m^2 (ONS, 2020), a significant portion of the population can theoretically accommodate the units. This doesn't account for existing structures, irregularly shaped gardens, or unsuitable terrains. On the installation front, while the process is conceptualized to be expedient, it's not without potential hurdles. As the construction expert pointed out, quality control could be inconsistent due to varying contractors based on location. Lastly, the integration of tracking technology raises potential privacy concerns, especially when interfaced with external systems like the NHS, potentially causing apprehension among users who prioritize their privacy.

5. Conclusion and future work

The double diamond design process was instrumental in steering the project through a structured and thorough design process. During the Discover phase, rigorous research highlighted critical aspects of the ageing population, leading to goal setting specifically tailored to caregivers and elderly dependents. The Define phase honed the project's direction, identifying stakeholders, crafting user journeys, and pinpointing the concept for development through thorough analysis and exploration. The Develop phase was characterized by iterative design and substantiated decision-making, ensuring each design choice was justified. The Deliver phase solidified the project, addressing its applicability and relevance to future scenarios through careful evaluation and preparation.

The culmination of this rigorous process was a solution adept at meeting its core objective: making life simpler for informal caregivers and enhancing the lived experiences of the older individuals. Success was multi-faceted; it began with the creation of a physical structure that was not only affordable but also adaptable, allowing for quick installation with minimal disruption. The project went a step further by integrating with established institutions and organizations. This symbiosis equipped users with a holistic support system, marrying practical caregiving tools with an invaluable knowledge base, thereby boosting confidence among caregivers. Technological integration was the capstone, offering real-time, remote health and safety monitoring capabilities, and predictive functions for age-related health concerns, dramatically reducing the need for constant physical supervision. Evaluations from key stakeholders, incorporating perspectives from a diverse focus group and healthcare professionals, revealed admiration for the solution's thoughtful design, adaptability, and cost-conscious approach. However, concerns were raised, particularly regarding the brand name's distinctiveness and potential escalations in cost in cases of intensive care. A comprehensive SWOT analysis affirmed the solution's strengths and its readiness for future challenges, highlighting environmental sustainability, future-oriented design, and compliance with legal standards. The analysis was candid in recognizing potential hurdles, including installation complexities, privacy issues, and market acceptance challenges. Nonetheless, it also illuminated promising opportunities for community integration and global market expansion, emphasizing the need to address younger demographics with similar care requirements. Moving forward, recommendations emphasize diversifying the solution's target demographic, leveraging its adaptable architecture to cater to a broader spectrum of dependents with varying needs. Furthermore, a re-evaluation of the brand name is suggested to bolster market presence and consumer recall. Given the pressing market need, swift action is recommended to make any necessary refinements for immediate market integration, ensuring the solution's relevance and efficacy in delivering transformative care experiences.

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