Developing Age-oriented Design Framework with Technology Acceptance Model for Smart Appliances to improve Technology Acceptance by Ageing Community in Guangzhou China

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Abstract

With the growing ageing community and the rapid development of smart appliances, the acceptance of smart appliances among the ageing community presents a critical challenge in the face of demographic shift and rapid technological improvement. This research seeks to address the pressing need for understanding and improving the acceptance of smart appliances among the ageing community, given the profound societal implications of facilitating their integration into daily life amidst demographic changes and technological advancements. As a result, improving the design of smart appliances is necessary to increase acceptance among the elderly population. This study adopted a literature review method to investigate the characteristics and design elements of smart appliances tailored to the needs of elderly users, providing insights into elderly smart appliance design. Results identified significant behavioural and psychological characteristics among the elderly. Through comprehensive analysis, it was revealed that variables such as familiarity with technology, perceived usefulness, ease of use, and trust in the reliability of smart appliances strongly influence technology acceptance among the ageing community. Moreover, the study elucidated specific preferences and concerns of elderly users, including the importance of clear interfaces, simplified controls, and compatibility with existing routines and habits. These findings underscore the importance of tailoring smart appliance designs to accommodate the unique needs of elderly users, ultimately enhancing their technology acceptance. By providing a framework for age-oriented appliance design, this research endeavours to facilitate the seamless integration of smart technologies into the lives of elderly individuals, enhancing their independence, safety, and overall well-being through the thoughtful design and implementation of smart appliances tailored to their specific needs and preferences.

Introduction

In recent years, technological advancements have significantly propelled the development of household appliances. Household appliances have evolved beyond a phase of broad development to one characterized by targeted and individualized services (Zhang, 2021). Concurrently, the global community is undergoing an ageing trend, as evidenced by the escalating proportions depicted in Figure 1. Notably, virtually all nations across the globe are witnessing an expansion in both the absolute numbers and relative proportions of elderly individuals within their communitys (United Nations, 2019). The surge in both absolute numbers and relative proportions of elderly individuals across nations underscores the pressing need to explore and address the specific challenges and opportunities arising from this demographic trend.
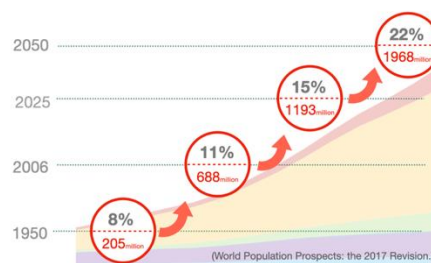

Figure 1. Growth rates and trends in global ageing

Smart appliances are rapidly evolving, offering a plethora of functions and features that enhance people's daily lives, as delineated in Figure 2. However, a notable deficiency lies in the realm of accessibility design, encompassing crucial design elements such as appearance, interface, and functionality. This deficiency impedes technology acceptance among users. The ageing community, characterized by cognitive decline, encounters difficulties in navigating inaccessible smart appliances. Moreover, this demographic necessitates both health and emotional care, further underscoring the importance of designing smart appliances tailored to their needs, particularly concerning dietary management at home.
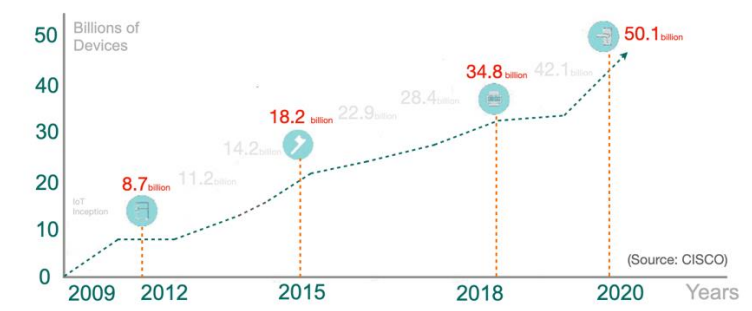

Figure 2. Annual growth of smart appliances

Consequently, the burgeoning ageing community, juxtaposed with the swift evolution of smart appliances, exacerbates challenges related to their acceptance and utilization among the elderly. There exists an imperative to enhance the design elements of smart appliances to ameliorate technological acceptance and subsequently elevate the living standards of the ageing community. Thus, it becomes paramount to explore the integration of the Technology

Acceptance Model (TAM) within the development of an age-oriented smart appliance design framework aimed at enhancing technological acceptance among the ageing populace in Guangzhou, China. Recognizing the critical intersection between technological innovation and demographic change, this study endeavors to investigate the acceptance of smart appliances among the ageing community, aiming to shed light on essential factors influencing adoption and to propose strategies for enhancing usability and accessibility in this rapidly evolving landscape. This research endeavors to provide insights and guidance not only to appliance manufacturers and designers but also to policymakers, caregivers, and elderly individuals themselves, aiming to foster the creation of age-friendly smart appliances that improve quality of life and promote independence among older adults.

Literature Review

The ageing community often experiences cognitive decline, posing challenges in utilizing smart appliances effectively (Debajyoti, 2018). Moreover, this demographic segment necessitates heightened health and emotional care (Abdi & Hindawi, 2018), accentuating the importance of designing smart appliances that cater to their unique needs, particularly in addressing dietary concerns at home. Despite the rapid development of smart appliances, there exists a notable deficiency in accessibility design and essential design elements such as appearance, interface, and functionality, hindering their acceptance among users (Lin et al., 2021). This oversight overlooks the special emotional and social requirements of the ageing community, highlighting the necessity for a shift in the development direction within the home appliance industry (Zhang, 2022). Investigating key appliance design elements, notably appearance, interface, and function, that influence the ageing community's attitude toward using smart appliances is paramount for supporting an ageing-oriented design framework based on the Technology Acceptance Model (TAM). By improving the ageing community's perception variables, including perspective, emotion, usability, and user experience, toward smart appliances, the effectiveness of technology acceptance among the ageing community in Guangzhou, China, can be enhanced. The literature review will be structured into four main parts, aligning with the constructs of the E.A.G.L.E Navigator 4 RQ framework (Rahinah, 2008).

Current Developments of Smart Appliances

The discourse on smart appliances encompasses an analysis of their characteristics, design elements, and current status. Within this realm, considerable attention has been directed towards understanding the intricacies of smart appliance design and usage dynamics, particularly concerning various demographic groups such as the elderly and individuals with disabilities.

Foreign research has notably advanced in the domain of smart appliance development, particularly focusing on energy consumption and management aspects. For instance, Kobus (2013) conducted extensive research on the consumption factors influencing user attitudes towards electricity usage, highlighting the influences of user motivation, situational factors, and energy management systems. Meanwhile, Jo et al (2021) emphasized the need to identify design variables affecting the elderly's utilization of smart appliances. Conversely, Zhang et al (2021) criticized current appliance designs for their low quality and complexity, advocating for improvements across structural, circuitry, software, and user experience domains. Notably, there is a paucity of research focusing on specific user groups, such as the elderly, to

deliver tailored appliances meeting their unique requirements (Zhang et al., 2021; Bai et al., 2020; Liegeard & Manning, 2020).

Moreover, research has explored the integration of advanced technologies, such as AI and IoT, in kitchen appliances to enhance functionality and user experience (Trieu Minh & Khanna, 2018; Chatterjee et al., 2018). However, concerns persist regarding technical complexities and the lack of standardized protocols for seamless integration across diverse appliance ecosystems (Moy Chatterjee et al., 2018; Kaner & Bostan, 2018). Similarly, studies have underscored the significance of accessible design principles in facilitating the usage of smart appliances, particularly for elderly and disabled users (Lee, 2021; H et al., 2021).

Despite these advancements, several gaps remain in existing research. Many studies focus solely on technical aspects, overlooking crucial design methodologies necessary for achieving desired outcomes (Mtshali, 2019; Kosch et al., 2018). Additionally, the absence of clear target user groups and insufficient consideration of usability factors hinder the effectiveness of proposed design solutions (Kaner & Bostan, 2018; Jeong & Kim, 2018). Furthermore, limited attention has been paid to comprehensive validation methodologies, with studies often lacking robust prototyping and user testing processes (Wu et al., 2018).

In short, while the evolution of smart appliances promises to enrich users' lives, addressing accessibility concerns and tailoring designs to specific user demographics remain imperative. Future research should emphasize interdisciplinary collaboration, integrating insights from design theory, user experience research, and technological innovation to develop inclusive and user-centric smart appliance solutions.

Current Challenges of Aging Community
The world is witnessing a demographic shift towards an aging community, presenting unique challenges and opportunities. In this literature review, various studies are examined to understand the characteristics, issues, and activities associated with aging communitys.

Jo et al (2021) explored the perceptions of the elderly towards smart home systems, highlighting the need for user-friendly designs catering to cognitive decline. Ziqi (2020) analyzed the trends and consequences of China's aging community, emphasizing the urgency for effective solutions. Tyrovolas et al (2014) proposed a multidimensional approach to successful aging, emphasizing gender-specific considerations. Khan (2018) outlined the global risks and dilemmas associated with community aging, underscoring the need for comprehensive strategies. Troutman-J et al (2020) investigated brain health knowledge among the aging community, emphasizing the importance of interventions like dietary improvements and increased physical activity. Karczewska & Bogusława (2019) highlighted the growing challenge of dementia in Poland's aging community, advocating for targeted healthcare and support services.

Bruins et al (2019) studied the role of nutrients in mitigating noncommunicable diseases among the elderly, suggesting dietary interventions. Moguel et al (2018) conducted a systematic review of food-intake monitoring technologies, offering insights into potential solutions. Kosch et al (2018) proposed design requirements for smart kitchens catering to cognitively impaired individuals, aiming to enhance independence and safety. Hiremath et al.

(2022) identified high blood pressure as a prevalent issue among the aging community, emphasizing the importance of dietary interventions. Lee & Chaiwoo (2014) explored the adoption of smart technologies among older adults, highlighting factors influencing acceptance. Herne (1995) reviewed factors influencing food choices in the elderly, suggesting tailored interventions.

Based on the literature, there is a clear need for targeted strategies to address the diverse needs of aging communitys. Designing user-friendly technologies, implementing dietary interventions, and enhancing healthcare services are crucial steps. Future research should focus on developing comprehensive solutions integrating technological, social, and healthcare aspects to promote healthy aging and quality of life.

As the global community ages, understanding and addressing the challenges faced by older adults are paramount. By integrating insights from diverse studies, policymakers, healthcare professionals, and designers can collaborate to develop holistic solutions that empower aging communitys and enhance their well-being in an ever-changing world.

Develop an Age-oriented Appliance Design Framework with TAM
This section delves into various iterations of the Technology Acceptance Model (TAM), factors influencing its application, and the integration of User-Centered Design (UCD) principles. The aim is to develop an age-oriented appliance design framework leveraging TAM. Figure 4 listed a flow of the development of technology acceptance model.

Hong et al (2011) examined the factors affecting usage of digital archives, emphasizing the impact of Human-Computer Interaction (HCI) on perceived ease of use and usage intentions. Yuen et al (2021) applied an integrated model combining Innovation Diffusion Theory (IDT) and TAM to study factors influencing the adoption of autonomous vehicles (AVs). Salloum et al (2019) explored students' acceptance of E-learning using a comprehensive TAM. Shore et al (2018) discussed the design of assistive exoskeletons for the elderly, incorporating TAM and UCD principles.
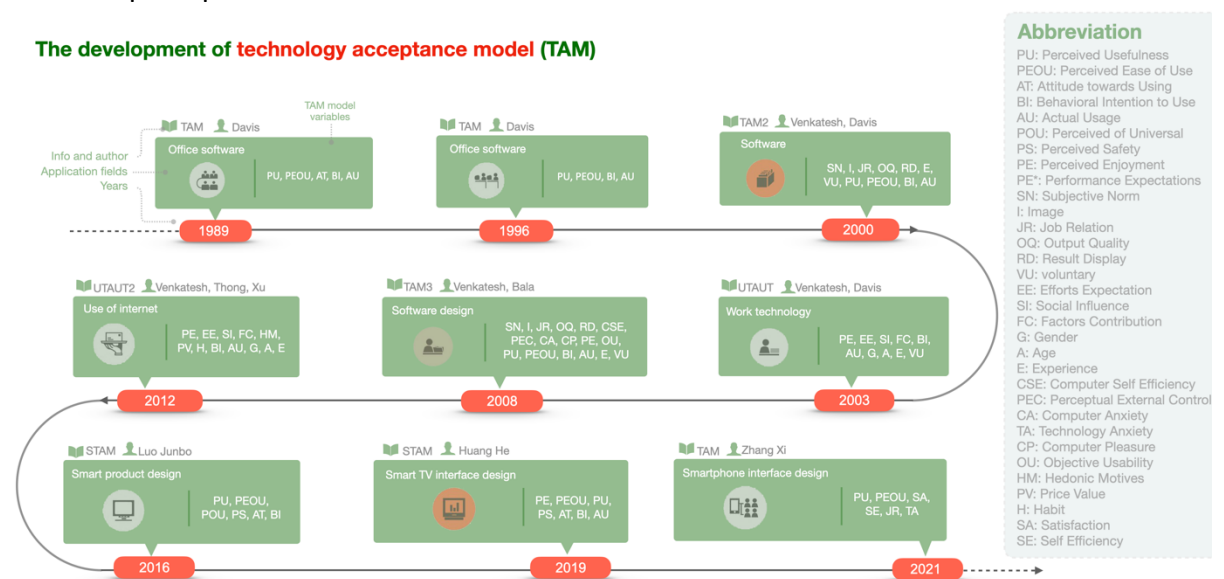

Figure 3. The development of technology acceptance model (TAM)

Hong et al (2011) identified significant impacts of interface design on perceived ease of use, emphasizing the importance of quality interface design for promoting usage. Yuen et al (2021) found that perceived usefulness and ease of use positively influence users' behavioral intention to use AVs. S et al (2020) investigated factors influencing the acceptance of telemedicine services, focusing on rural communitys. Salloum et al (2019) highlighted external factors influencing e-learning acceptance, suggesting the need for new TAM versions. Shore et al (2018) discussed TAM variations like Almere and Senior TAM, relevant for understanding acceptance of assistive robots by older adults.

While existing studies contribute valuable insights, there are gaps to address. Hong et al (2011) focused solely on interface design, necessitating research on other design factors. Yuen et al (2021) restricted their study to AVs, overlooking specific user groups. S et al (2020) concentrated on telemedicine acceptance, warranting investigation into broader smart appliance acceptance among the elderly. Salloum et al (2019) confined their study to e-learning, suggesting the incorporation of new TAM versions. Shore et al (2018) proposed theoretical frameworks but lacked practical validation.

Building upon existing research, this study aims to develop a comprehensive framework integrating TAM with other relevant theories to facilitate smart appliance acceptance among the elderly. By investigating key design elements influencing attitudes toward smart appliances, this research will contribute to an aging-oriented design framework grounded in TAM principles.

Understanding the nuances of technology acceptance among the aging community is essential for designing user-friendly smart appliances. By leveraging TAM and UCD principles, this study seeks to bridge existing gaps and develop a tailored framework conducive to enhancing technology acceptance among the elderly.
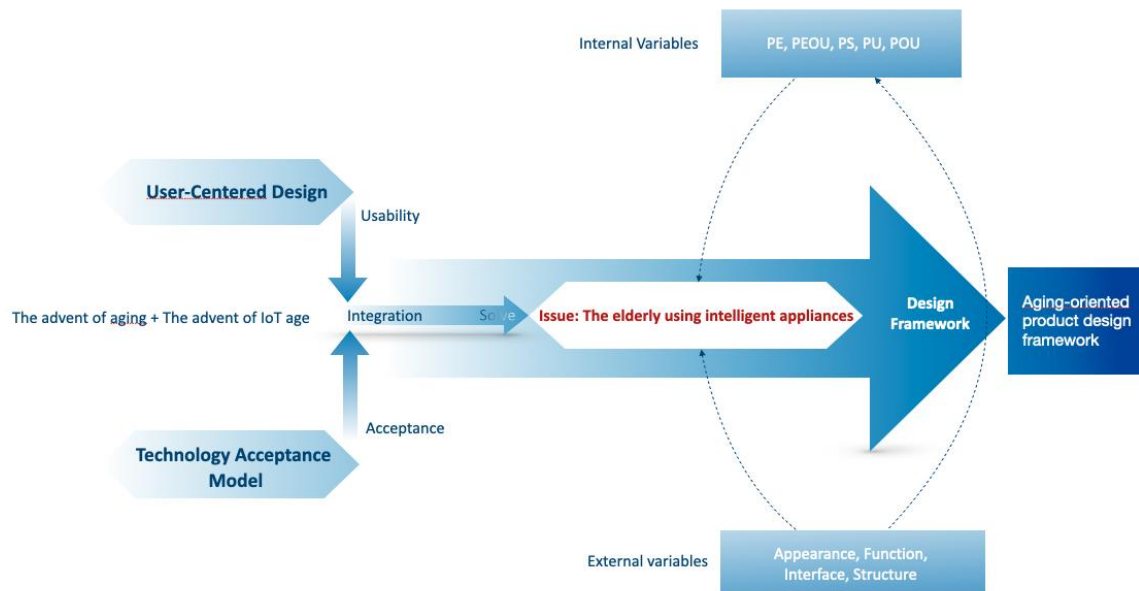

Figure 4. Ageing-oriented product design framework

Enhancing Technology Acceptance among the Aging Community

This section synthesizes various studies focusing on improving technology acceptance, perception variables of the aging community, and framework validation.

Kim et al (2009) emphasized the importance of nutritional management and education for elderly adults. Park et al (2009) investigated factors influencing the adoption of digital library systems, highlighting the need for considering external variables in system design. E (2020) identified influential factors in users' intentions to use smart wearable devices. S et al (2019) discussed barriers and facilitators of technology use among the elderly.

While these studies offer valuable insights, there are limitations to address. Several studies focused solely on theoretical aspects, neglecting practical application. For instance, Park et al. (2009); E (2020) concentrated on original TAM concepts, overlooking the integration of new theories. Others, like et al (2019), focused narrowly on specific areas, such as elderly acceptance attitudes.

Building upon existing research, this study aims to develop an integrated TAM framework tailored to the aging community. By incorporating emotional feedback, semantic attributes, and user acceptance tests, the framework will address key perception variables influencing technology acceptance among the elderly in Guangzhou, China.

An integrated TAM design framework is essential for improving technology acceptance among the elderly. Future research should explore emotional feedback, semantic attributes, and user experience to validate technology acceptance effectively. Enhancing perception variables can significantly impact the effectiveness of technology adoption among aging communitys.

Summary and Synthesis of Literature Review

This section cross-analyses, integrates possibilities, and prioritizes the synthesized literature review summaries under the thematic theme smart appliances towards high probable solutions to improve appliance elements design of smart appliances. The Point of Department (POD) can be synthesis from each theme from literature review. Therefore, after the detailed literature review and combining each POD, there is a final POD to conclude the aim of this research is to Investigate aging community's perception and appliance key design elements for developing aging-oriented design framework based on TAM to improve technology acceptance on smart appliances to reduce aging's using difficulties in Guangzhou China.
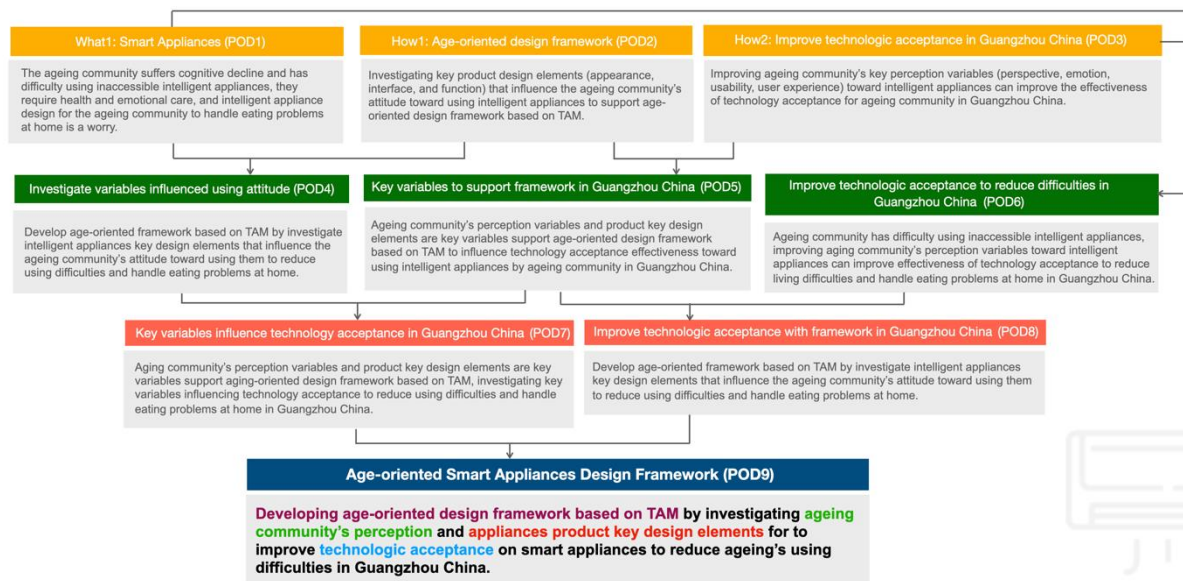
Figure 5. Final POD of this research goal

Discussion and Conclusion

This study addresses the prevalent challenges faced by the aging community in utilizing smart appliances, highlighting the imperative to enhance the design elements of such appliances to foster technology acceptance among this demographic. The primary objective is to utilize a framework for developing smart kitchen appliances as a case study, integrating the Technology Acceptance Model (TAM) into appliance design. This research contributes to the formulation of proposed appliance design guidelines, informed by TAM principles, tailored to smart appliances for the elderly populace in Guangzhou City, Southern China.

The paper endeavors to develop appliance design guidelines incorporating TAM principles to enhance technology acceptance among the aging community. It documents the outcomes of a systematic literature review synthesis conducted under the thematic theme of "Improving technology acceptance." The review identifies the necessity for an integrated TAM design framework to facilitate the elderly's acceptance of new technology. Additionally, it emphasizes the importance of investigating users' emotional feedback, appliance semantic attributes, and conducting user acceptance tests to validate technology acceptance.

In terms of perception variables specific to the aging community, the study underscores the significance of enhancing key perception variables such as perspective, emotion, usability, and user experience concerning smart appliances. This approach is envisaged to enhance the effectiveness of technology acceptance initiatives among the aging population in Guangzhou, China.

Regarding the validation of the framework, the study underscores the importance of scrutinizing the aging community's perception and essential appliance design elements to develop an aging-oriented design framework rooted in TAM principles. This framework aims to ameliorate technology acceptance concerning smart appliances, thereby alleviating the challenges faced by the aging population in Guangzhou, China.

The findings of this research are noteworthy as they contribute to the advancement of proposed theories regarding appliance design guidelines incorporating TAM principles to enhance technology acceptance among the aging community. They hold significance for the broader field of study, underscoring the imperative to address technology acceptance challenges among the aging populace.

Recommendations for future research include conducting meta-analytical exercises on literature supporting the proposed theoretical propositions. This research aims to offer valuable insights and recommendations not just to appliance manufacturers and designers, but also to policymakers, caregivers, and elderly individuals, with the goal of fostering the development of smart appliances tailored to the needs of older adults, thus enhancing their quality of life and autonomy. Moreover, it is suggested that subsequent studies integrate these findings into the development of aging-oriented smart appliance designs, furthering the efficacy of technology acceptance initiatives among the aging population.

References

Bloch, H. P. (2005) Seeking the Ideal Form: Appliance Design and Consumer Response. /, /(/): //.
    liang, Z. & Zhiyi, C. (2022) Analysis on the current situation and development prospect of smart household appliances. China Academic Journal Electronic Publishing House, /(/): 135-137DOI:10.16520/j.cnki.1000-8519.2022.03.031.

Bloch, H. P. (2005) Seeking the Ideal Form: Appliance Design and Consumer Response. /, /(/): //.
    D, T.,T, W.,T, W.,T, Z.,X, Z. & X, Q. (2020) A systematic review and meta-analysis of user acceptance of consumer-oriented health information technologies. Computers in Human Behavior, 104(/): /10.1016/j.chb.2019.09.023.

Dun-rui, C., Qian, W., & Sha-sha, S. (2020) Research on CMF Design of Aging-friendly Furniture. /, 57(5): 61-64DOI:10.19531/j.issn1001-5299.202005014.

Gardener, L., Gardener, S. L. S. (2018) The Role of Nutrition in Cognitive Function and Brain Ageing in the Elderly. Current Nutrition Reports, 7(3): 139-14910.1007/s13668-018-0229-y.

Hanson, & L., V. (2010) Influencing technology adoption by older adults. Interacting with Computers, 22(6): /10.1016/j.intcom.2010.09.001.

Herne, S. (1995) Research on food choice and nutritional status in elderly people: A review. British Food Journal, 97(9): 12-2910.1108/00070709510100136.

Ibrahim, R., & Kamal, M. R. (2018). Templates for Thinking. (Unpublished Literary. Copyright MYIPO LY2018002437).

Ibrahim, R. (2008). Setting up a research question for determining the research methodology. ALAM CIPTA International Journal on Sustainable Tropical Design Research & Practice, 3(1), 99-102.

Ibrahim, R. (2011). Demystifying the arduous doctoral journey: The eagle vision of a research proposal. Electronic Journal of Business Research Methods, 9(2), pp130-140.

Karczewska & Bogusława. (2019) Dementia in the aging community of Poland: challenges for medical and social care. Health Problems of Civilization, 13(null): 161-16910.5114/hpc.2019.81339.

KARJALAINEN, T., & HUT. (2005) STRATEGIC DESIGN LANGUAGE – TRANSFORMING BRAND IDENTITY INTO APPLIANCE DESIGN ELEMENTS. /, /(/): //.

KARJALAINEN, T., & HUT. (2005) STRATEGIC DESIGN LANGUAGE – TRANSFORMING BRAND IDENTITY INTO APPLIANCE DESIGN ELEMENTS. /, /(/): //.

Karoline, F. L.,Filgueiras, M. J. F. & Ferreira, & Caputo, M. E. (2018) Evaluation of lifestyle and quality of life in the elderly: a literature review. Revista Brasileira de Geriatria e Gerontologia, 21(5): 616-62710.1590/1981-22562018021.180028.

Khan, H. T. (2018) Community ageing in a globalized world: Risks and dilemmas?. Journal of Evaluation in Clinical Practice, 25(5): 754-76010.1111/jep.13071.

Lee, C., & Coughlin, J. F. (2015) PERSPECTIVE: Older Adults' Adoption of Technology: An Integrated Approach to Identifying Determinants and Barriers. Journal of Appliance Innovation Management, 32(5): 747-75910.1111/jpim.12176.

Lee, J. H. (2021) Accessible home appliance design methods for disabled and elderly users: from issue investigation to design solutions. /, /(/): //.

Lee & Chaiwoo. (2014) Adoption of Smart Technology Among Older Adults: Challenges and Issues. Public Policy & Aging Report, 24(1): 14-1710.1093/ppar/prt005.

Mary, Y., Eirini, M. A, A. C., Niki, M., Irene, L., & Irene, L. (2018) Eating habits and behaviors of older people: Where are we now and where should we go?. Maturitas, 11414-2110.1016/j.maturitas.2018.05.001.

Masiran, R., Ibrahim, N., Awang, H., & Lim, P. Y. (2020). Improving multicultural parenting program for children with emotional and behavioral problems: an integrated review. Asian Journal of Psychiatry, 51, 101851.

Mtshali. (2019). A Smart Home Appliance Control System for Physically Disabled People. Conference on Information Communications Technology and Society, null(null): 1-5null. &

Ning, Y. W. (2020) Design Application of Smart Kitchen for Aging Based on Interactive Behavior Analysis. /, /(/): /.

Rousseau, D. M., Manning, J., & Denyer, D. (2008). 11 Evidence in management and organizational science: assembling the field's full weight of scientific knowledge through syntheses. Academy of Management Annals, 2(1), 475-515.

Salloum, S. A., AlHamad, A., Q. M., Al-Emran, M., Monem, A. A., & Shaal, A. K. (2019) Exploring Students' Acceptance of E-learning through the Development of a Comprehensive Technology Acceptance Model. IEEE Access, 7(null): 128445-12846210.1109/ACCESS.2019.2939467.

Sivathanu, & Brijesh. (2018) Adoption of internet of things (IOT) based wearables for healthcare of older adults – a behavioural reasoning theory (BRT) approach. Journal of Enabling Technologies, 12(4): 10.1108/JET-12-2017-0048.

Templier, M., & Paré, G. (2015). A framework for guiding and evaluating literature reviews. Communications of the Association for Information Systems, 37(1), 6.

Troutman-Jordan., Meredith., O'Brien., Tara., Coggin., Jordan., Page., & Kandace. (2020) Brain Health Knowledge in the Aging Community: Eat Better, Move More. ACTIVITIES, ADAPTATION & AGING, null(null): 1.10.1080/01924788.2019.1676627.

Xianhui, X., & Suping, M. (2018) Research on the design of smart home appliances under the trend of the Internet of Things. China Academic Journal Electronic Publishing House, 1(1): 7-8DOI:10.13612/j.cnki.cntp.2018.02.005.

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. Journal of Planning Education and Research, 39(1), 93-112.

Xing, L., & Hengfeng, Z. (2017) Cognitive Research of CMF on Household Appliances for Elderly Users. /, 7(5): 113-120/.

Yang, Z. (2020) The characteristics, the trend and the possible solutions to China's aging Community. International Conference on Social Sciences and Social Phenomena, 1(null): 49210.38007/proceedings.0001122.

Zongfeng, Q. (2022) Standards promote green development of smart household appliances. /, /(/): //. & al., S. A. M. B. e. (2021) An Overview of Architecture and Security Issues of a Smart TV. IEEE Xplore, null(null): 1835-1843Santani AGangaramani MChopra B et al.