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Review

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Creating Resilient Smart Homes with a Heart: Sustainable, Technologically Advanced Housing across the Lifespan and Frailty through Inclusive Design for People and Their Robots

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Abstract: The design of age-friendly homes benefits vulnerable groups, such as frail people and older adults. Advances in smart home technologies, including robots, have important synergies with homes designed for health needs. Yet, focus on environmental and sustainable housing design and improvements misses important opportunities for collective impact. Stronger involvement of disciplines, such as those from the built environment for technological integration within homes and effects on space and the community, is needed. There is a need for a unified framework integrating the needs and factors of the resident, smart home technologies and robots, and the built environment, and that includes the concept of a "home". With the remodeling of housing towards sustainable and environmental targets, as well as advances in smart home technologies such as robots, the timeliness of shared input for the benefit of residents now and in the future is of the essence. This would help target future research into effective and optimized cohabitation with technology within homes for the purpose of improving the wellbeing of residents.

Keywords: built environment; community; smart home; smart home technology; age-friendly; ageing; frailty; sustainability; environment; net zero

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1. Introduction

The Coronavirus pandemic has been a sharp motivator to examine, at a global level, all aspects of our human existence in a rapidly changing world [1]. With increasing time spent at home during lockdowns, and a potential post-pandemic shift towards increased time at home, housing conditions could not remain unchallenged. Whilst the home is one of the most important contexts of our lives, few have addressed the meaning of the home from an architectural or geographical lens [2–5]. In this sociological and architectural perspective, the meaning of home remains largely unchallenged, assuming that the human is the main intelligent ontological unit and new technologies are engineering add-ons that are part of another discussion on functionality. In practical terms, this implies that we need to start thinking of how to incorporate, for example, humanoid robots as users who interact spatially and psychosocially with the human end-user.

In another epistemological locus, i.e., the engineering part of architecture and built environment research, there has been an abundance of architectural research with a focus on sustainability and housing [6–9] and linking affordable housing to sustainability [9]. This being more convergent with the perspective of architectural engineering and public health, home environments have been investigated in terms of health and wellbeing, especially air quality [10–13], as well as, more recently, residents' healthcare needs [14].

However, population aging and an increasing prevalence of those living with a disability, comorbidity, or frailty over time have highlighted the importance of housing for older adults and adults with frailty, and especially housing promoting independence [15]. These discussions have mainly occurred under the prism of technological innovation and the idea of a "smart home" where health and technologies, ideally connected through the internet, but also physical robots, add an increasing layer of technological innovation within homes with the gradual introduction of the end user perspective [16–19]. In this paper, we discuss the integration of technological advances within the home as a pathway for creating socially and financially sustainable and scalable solutions for improved built environments for people across their lifespan.

2. Creating a Smart Home Not a House

There is no single agreed-upon definition of the term "home" and its meanings and significations vary according to use and context. It might be considered as both an expression of and a base for a person's personal and social identity [20]. In this view, its fitness for purpose can be understood in terms of its ability to accommodate and support that identity as it develops dynamically over one's lifespan. A home is also part of "belonging" in terms of place, as well as in terms of ways of interacting with the surrounding environment [21]. It might also encompass what happens outside the house as a building in the community in which it sits. The essence of "home" is complex and multifactorial [22].

The umbrella term "social cohesiveness" provides a useful interpretative framework for the core functionality of the home in everyday life and function throughout the lifespan. It is a core element in the salutogenesis theory as defined by Antonovsky [23], Mittelmark et al. [24], and Dilani's [25] original translation of the term to architecture. This theoretical framework can be extrapolated to inform design choices, enhancing individual experiences and health-promoting scenarios within the framework of large-scale sustainable development initiatives as they pertain to the conceptualization of "home" [26].

However, a smart home under its current form and shape may be better represented by the term "technologically enhanced house", which appears to forgo the concept of a home. Where a house, or dwelling, can generally be understood as "a physical unit, a defined space for its residents providing shelter and protection for domestic activities and concealment, and an entity separating private from public domains" [27,28]. Consequently, whilst the terms "house" and "home" might overlap in some contexts, they are far from equivalent regarding either scale or conceptual significance. The process whereby houses and/or larger-scale physical environments are invested with subjective psychological and social meaning is the subject of research in placemaking and can be summarized as the process whereby a "sense of place" is created.

3. Sustainable Development Goals and Smart Home Technologies

There is ongoing discourse on the role of smart technology in the built environment to foster sustainable development e.g., refs. [29,30]. The Sustainable Development Goals (SDGs) proposed in the Agenda 2030 illustrate the complexity of sustainable development [31]. Smart home technologies allow for a multitude of goals to be considered. While the effect on energy efficiency (Target 7.3 of the SDGs) due to optimized heating and cooling cycles might be the most obvious, by increasing the level of automation and pre-settings, smart home technologies can focus on demands of vulnerable user groups in particular (e.g., design for aging). A systematic use of these potentials can have a profound effect on one's ability to live an autonomous life for a longer period of time (see Target 10.2 of the SDGs). In fact, smart home technology can be seen as the cornerstone for telemedical services that can offer user-oriented, psychosocially supportive approaches to addressing the societal challenges of an ageing population [32]. An increasingly important component of the smart home ecosystem is Artificial Intelligence (AI), and in particular robots, which start to occupy the discussion in the everyday life-scape on modern housing, mostly for the care of vulnerable people such as older adults and children. An example on the NatWest Website advocates for AI and robots as the next phase of smart housing [33]. Consequently, robots should be viewed as a critical component of smart housing as, architecturally, they create more challenges not only for the configuration of the house, but also for the concepts of home and community.

4. Connectedness of Sustainable, Environmental, and Age-Friendly Homes

Smart home technologies are designed to offer sustainable solutions so as to reduce energy consumption and waste and control energy usage [34]. However, sustainable and environmental interventions within homes are often viewed as distinct and unconnected. Often, funding schemes are linked to climate change/net zero home interventions, for example, within Greece [35]. However, rarely do schemes incorporate both aspects simultaneously, such as in a collective impact model. The opportunity for potentially collective impact was highlighted, for example, at the "London Research and Policy Partnership: Stimulating the Retrofit Market" event [36]; remodeling in housing might prioritize net zero, but potential opportunities to minimize temporary displacement through collective endeavor existed. As displacement might be considered detrimental for vulnerable groups (with morbidities), it would appear prudent to schedule all home improvements (for example, to support those with multi-morbidities for age-friendly improvements) at the same time as net zero so that a vulnerable person might experience one displacement rather than more. With a current disconnect of net zero improvements from those for an aging population, there appears to be opportunity to come together and create synergy, especially when referring to vulnerable populations.

At the policy level [36], when discussing housing improvements, age-friendly amendments also seem disconnected from net zero ones, which are referred to as the first priority. Even when we refer to vulnerable populations where synergies between the two could be critical for users, for example, for people with multiple morbidities, this does not seem to be the case. However, there is an increasing number of initiatives aimed at integrating the environment and health to foster synergies of both societal challenges. As an example, the German Advisory Council on Environment (SRU) published a special report on the Systematic Integration of Environment and Health [37], emphasizing that the ecological transformation poses a number of opportunities to create healthier living conditions. This applies in particular to vulnerable user groups who might significantly benefit from both environmental and health-oriented improvements. Understanding the strong interrelation between sustainable development and public health is key to addressing the societal challenges of the 21st century. This was also illustrated by WHO's "One health" initiative [38].

5. Smart Homes and Healthy Aging

The movement towards smart homes within the European Union has been supported by initiatives such as the European Innovation Partnership in Active and Healthy Aging (EIP on AHA). The EIP on AHA fosters core smart home discourse centered on the technological aspects with the input of health-related stakeholders [39], as well as a strong end user perspective, highlighted by end user advocacy groups such as Age Europe [40]. However, the initial paucity of input, at least at leadership level, from environmental stakeholders and policy groups may have led to a potential disconnect from the Built Environment and Housing think tanks and industry. A D4 Action Group of the EIP (Environment) [41] with partial representation of the Built Environment stakeholders occurred within the second phase of the EIP on AHA. From the EIP on AHA, there have been some important concepts and ideas that began prior to the pandemic within the European Union Active and Healthy Aging D4 Action Group in collaboration with other AHA working groups, which aim to generate the ecosystem needed to create age-friendly environments across the lifespan [42,43]. Yet, even in these, the main idea is of a house rather than a home, with embedded smart innovation that can promote functionality. Discussion on how these smart environments will affect the architecture of the house has been lacking. Issues are perceived predominantly as engineering equations rather than a need to recalibrate homes for the new technological and AI era, especially regarding who the inhabitant of the home is. And even though robots have been part of the EIP on AHA discussion, the issue of how the robots will be embedded in actual houses and how this will affect the concept of the home has not been discussed.

Smart technologies and robots address not only individual needs for increased comfort, but also housing alteration and planning at the same time; for example, the net zero alternations that are currently occurring provide significant potential to optimize aspects such as energy efficiency and conservation of resources, as well as minimal disruption. Currently, for example, within the UK, frail, old, and vulnerable people relocate for council building work on net zero. This makes a potential second or third relocation for accessibility and technological adaptations a challenge as their condition progresses. At the same time, repeating part of the building works a second or third time requires additional costs compared with simultaneous future-proofing alterations for net zero, accessibility, and technological adaptations. The additional cost may delay timely adaptations for health needs. Housing adaptations for frailty have been associated with prevention of deterioration of people's conditions [44], e.g., mortality is significantly lower for older frail adults who have had their homes modified [45], and therefore, timely adaptions are essential.

Furthermore, older and frail people's preferences for staying or moving house reflect the complex psychosocial and spatiotemporal meaning of home and how this affects their decision making [46]. Built environment adaptations have occurred from an anthropological perspective that indicates that frail older people manage to stay in private homes, as opposed to care, for longer periods [47]. In fact, despite high levels of disability among older people living at home in the UK, staying at home is their preferred option [48].

In 2011, Huber et al. [49] proposed replacing the WHO definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [50] with a more activist conceptualization of health as "the ability to adapt and self-manage" [49]. This redefinition examines physical, mental, and social dimensions of health; is closely linked to both placemaking and salutogenesis theory; and has given rise to endeavors for "positive health", which is a proactive health promotion model even in the presence of disease [51]. The increases in the elderly population in various countries, e.g., within Korea [52], Japan [53], Italy [54], and the UK [55], have increased pressure on their individual healthcare systems. Those who live independently, particularly vulnerable groups, for example, elderly or frail individuals, may experience shortfalls in social interaction [56]. There is evidence supporting that older people should remain connected with their community for both physical and social frailty. This is particularly important as preventing social frailty contributes to mitigating physical frailty [57], and the definition of frailty over the years has shifted to cover a more holistic, biopsychosocial approach [58].

Marcus [59] suggests that one of the greatest challenges in contemporary housing options for increasing longevity may not be in the design and construction of physical spaces for older adults to live in, but rather in the need to "create and sustain community" in the process. This concept of "community" as relating to where one's home is has been studied from the perspective of a "sense of place" (SOP). The SOP scale which Jorgensen et al. (2001) [21] suggest could provide researchers with an easily administered and reliable means by which to measure attitudes toward spatial settings that may influence psychosocial wellbeing and can be implemented in policy and environmental planning scenarios. Alternative metrics could be the Community Wellbeing Index, which connects satisfaction with residents and has been validated with older adults [60]. This connects satisfaction with one's local place of residence. Yet, the aforementioned metrics and most of the research in the area focus on residence in relation to the neighborhood and the space that surrounds the residence rather than the residence itself.

Creation of an age-friendly environment requires a multi-disciplinary framework, which always needs to include the concept of "home". In the context of the H2020 project "Homes4Life" [61], Huchet et al. [62] proposed a definition of age-friendly homes that integrates the concepts of "home", "house", and "aging well": "Age-friendly housing [is] a home that fosters people's autonomy, as well as remaining active and healthy as we age. It respects lifestyle choices, needs and preferences of people regardless of their age across the life course. Age-friendly housing enables accessibility to all areas of community life, thereby promoting inclusion and engagement" [62].

Guidelines, standards, and good practice initiatives have tended to take a narrowly technical view of the "age-friendliness" of homes, overlooking less tangible but equally important social and emotive aspects and taking inadequate account of, or not considering at all, the real needs and preferences of different users and user groups. Additionally, "age-friendly homes" are conceived of as particular solutions for a niche market, rather than as inclusive, lifetime resilient facilities with broader market appeal.

Homes4Life [61] importantly adds "inclusion and engagement" to the smart home discussion, but the term "home" itself is only partially exploited. For example, architecture involves considering the space of a home as having the potential to inspire people and motivate them to interact with their environment, in addition to providing a means of self-expression and aspiration. If designers/architects are excluded from the smart home discussion, it prevents the opportunity for critical aspects of the notion of home to be encompassed in the smart home paradigm.

6. Paradigm Shift towards Person-Centered Smart and Robot-Friendly Homes

User-centered design is a common and widely used method to place the user at the center of the development process [63]. This method typifies a group of users through different modeling techniques: feature-based, content-based, case-based, scenario- and goal-oriented, knowledge-based, demographic, etc., modeling [64,65]. Despite the potential benefits, their use for health technologies and, in particular, for aging persons and those with disabilities and multi-morbidities, including frailty, has not received as much attention.

There is a significant difference between user-centered design and human-centered design [66]. Human-centered design approach connects the material aspects of what is home with anthropological and ethnographic perspectives in the context of the physical and cultural community within which the physical home will exist. This approach is not widely adopted, partly because architects are not trained in it and partly because business and authorities are not aware or educated on its long-term impacts at the global level [67,68].

The user-centered design approach is very much interconnected with the concept of "persona", which is a term introduced into the design process in 2004 with the aim of distinguishing between different user groups by focusing on the user's needs instead of the user's capabilities [69]. Within that context, "*personas are not real people, but they represent them throughout the design process. They are hypothetical archetypes of actual users*" [70]. Their inclusion throughout the entire design process helps researchers and designers understand and effectively consider users' needs, abilities, and limitations. The combination of this "persona" design concept with other methodologies such as "goal" and "scenario" modeling (Persona–Scenario–Goal methodology) [71] represents a powerful tool to better understand and consider users' specific perspectives, goals, abilities, requirements, and contexts in developing design and performance specifications for "age-friendliness" in homes, including requirements for innovative technologies and, importantly, assistive technologies.

A recent article by Zallio and Clarkson [69] uses the term "Inclusive design", which includes key sociological and behavioral aspects such as sensory and cognitive needs. In this context, however, we need to note that in a technologically advanced home, the main inhabitant and persona is the human. In an environment in which robots operate semi-autonomously, perhaps we need to include robots in the personas, or at least as part of the decision-making. These methodologies can be used alongside other participatory design techniques and methods for more age- and frailty-friendly solutions.

The principles of designing accessible adaptive user interfaces are well-known today, with guidelines and standards providing testable criteria for their development, e.g., ISO 9241-171 [72]. Since these methodologies do not necessarily consider active involvement of the user during the design process, several complementary definitions and sets of principles have come up over the years. These practices have evolved towards a person-centered design paradigm that not only puts the users in the center of the design, but includes them in the overall process, following an iterative co-design approach from the beginning of the design to the development and validation stages, seeking full incorporation of users' requirements that address their real needs. The co-designing approach also allows the designers of sensorized homes—also referred to as "smart homes"—to take into consideration other non-technical aspects. The argument is that it should be possible to "state adaptation methods and techniques in terms of a cognitive aid vocabulary" [73]. The use of cognitive tools and techniques frees the designer and developer from having to make speculative suppositions or estimates about medical conditions and other related issues.

We need to consider non-humans as users, as they affect the functionality of the home, in terms of robot-friendliness. Research and innovation activity in the areas of ambient assisted living (AAL) and active assisted living for several years has demonstrated that technology can be designed to be adaptable and personalized for different user cases [74]. The "Design for All" paradigm accommodates this insight by ensuring that "***anyone, regardless of age, gender, capacities or cultural background, . . . has the wish, the need and the right of being independent and choosing the own life style without facing physical and social barriers***" [75] and noting that this requirement is applicable to technology innovations [76]. This capacity of "Smart Homes" to be designed with a personalized approach that includes health and wellbeing improvement provides the potential for economic and health gains as well as the establishment of multi-stakeholder alliances. Yet, even in this initiative, the possibility that there are limitations from the perspective of the built environment, and especially materiality and configuration, for the use of certain technologies like robots is not discussed.

7. Smart Home Technologies

Higher levels of brain activity and positive emotions have been recorded within participants with smart home technology when thinking about their homes than for those without any form of smart home system [77]. Some data suggest that emotive aspects, for example, laughing, can be supported by smart home technologies [78]. Technologies vary widely and include both physical devices, such as sensors, and a variety of other devices within the home and within the neighborhood infrastructure and Internet of Things (IoT), to maintain functionality and to collect data that can be analyzed with appropriate analytics (machine learning included) to provide information and feedback to the home's inhabitants. Therefore, the domain of a smart home extends well beyond the physical architectural habitat. This extension also raises significant issues regarding legal data ownership and the trust of residents living in smart homes [79,80].

The smart home concept offers strong options for wellbeing and social connectivity across one's lifespan. In addition, smart homes may assist in the evolution of "smart cities" and aid in efforts to address environmental challenges [81]. "*Smart home technology seems to be enabling people to visualize their homes more vividly, thus helping them to develop a stronger connection with them. As homes are currently undergoing one of the biggest* ***technological*** *transformations in recent history, you could say that smart homes are fast becoming part of the family*" [77]. Thus, social dimensions are now included in smart home studies, especially when caregiving and aging at home are concerned, as described in the eWare study. This study supports a socio-technical ecosystem that includes ethnographic, symbolic, and cognitive domains along with "domestication of technology" as a means for technology to become part of the family support system [82]. The current technological advancement towards ubiquitous technology is being integrated within houses that sense the environment and offer digital companionship [83].

Technology can also be anthropomorphized within the home [83,84]. Utilizing socially assistive robots is emerging as a viable option at scale and is predicted to be commonplace within the near future [84,85]. Unlike pets, socially assistive robots come without the associated drawbacks, and recent research suggests they can effectively serve in a companionship capacity, potentially replacing pets [86,87]. Although studies show that socially assistive robots are efficient in assisting the elderly [88,89], their widespread acceptance and adoption remain limited. Social barriers still remain an active area of research and require further citizens' involvement in the co-creation of the infrastructure of "smart home" technologies. The social dimension of upscaling smart home is extensively discussed by Aagaard [90]. Moreover, recent research has also highlighted that "smart devices" at home are associated with stigma in the process of aging across the life cycle; therefore, creating a "smart home" may need to be a stepwise process [91]. In addition, assistive robots are often tested in spacious labs, without the usual clutter of a real residential setting. Also, their size in many cases may not be appropriate to fit in a real home. According to Beer et al. (2012), physical attributes to assistive robots such as footprint, height, and mass are recommended elements by older people and should be taken into account in the design process. If robots are meant to part of the everyday life of older people, they need to be able to move around in rooms filled with furniture, carpets, and thresholds [92,93].

Modern sensorized homes—also referred to as "smart homes"—aim not only to assist people with reduced physical functions, but also to reduce social isolation, with the intention to improve their quality of life. It is also worth observing that in-home services are increasingly recognized: For example, palliative care management for persons with chronic disease is shifting from hospital-based clinics to home-based services [94]. Thus, a "smart home" could easily be adapted to meet these new needs for living at "home" despite chronic diseases and disabilities across one's lifespan [95].

The continuous advancement of technology and its integration with information technology, such as machine learning and artificial intelligence-based solutions, further increase the opportunities to suit these technologies to very specific user needs and requirements [18]. The technology trend with regard to homes for older users (aged > 65 years) and people with frailty is mainly addressing issues concerning users' daily activity assistance requirements, healthcare provision in the home, and domestic services. The latter is a well-established, market-ready sector in which many companies are providing systems to assist occupants in the use and control of house appliances (i.e., remote activation of shutters, automatic control of lighting and temperature, activation of motorized hoover machines, voice-controlled lighting, etc.) [96,97]. Less developed, but with some products already available off the shelf, are assistive technologies for older persons' homes. In such cases, the main trend is toward the use of information technologies for the safety and assistance of residents with neuro-degenerative pathologies, as well as for stimulation of health-supportive lifestyles and behaviors, especially in relation to daily life activities and diet.

Convenience is the major driving force for smart home owners, as discussed by Aagaard [90]. However, in addition to convenience, smart home owners, end-users, and builders' technologies are becoming aware that home, and the technologies within it, may have a significant impact on other domains of our world habitat, for example, energy consumption and climate impact [95]. Thus, we see that the boundaries of smart homes are broadening [98].

In an era punctuated by rapid technological advancements, the infusion of technologies within domestic environments has become inevitable. From smart home systems to health-monitoring devices, technology is steadily reshaping our domestic landscapes. However, the success of these technologies is intrinsically linked to their acceptance by end-users. The technology acceptance model (TAM) is emerging as a pivotal tool to gauge this very acceptance, offering insights into the behavioral intentions and actual usage of new technologies [99]. The foundational pillars of TAM, perceived usefulness (PU) and perceived ease of use (PEOU), serve as significant predictors of user acceptance. In the context of home-integrated technologies, these constructs can provide profound insights. For instance, an older individual might find a health-monitoring device useful (high PU), but could struggle with its complexity, leading to reluctance to adopt it due to low PEOU [100]. Recent studies have increasingly highlighted the need for more user-friendly interfaces, especially across one's lifespan, including people with frailty or those not natively accustomed to digital technologies. As we innovate and develop more intricate technologies, expanding the TAM to include factors like trust, social influence, and personal innovativeness could provide a more comprehensive understanding of user acceptance. Such extensions are paramount, especially when considering the private nature of homes and the intimate role technology plays in them.

8. Conclusions and Future Actions

The European Commission's Silver Economy study highlighted the need for investment that is focused on preparing current and future homes for independent aging [101]. The implementation of accessibility and smart homes are at the forefront as solutions that help with active aging, providing people across the lifespan, including people with frailty, with tools and intelligent mechanisms that enable the maintenance of their autonomy and independence in carrying out day-to-day tasks.

In practical terms, it is interesting to further develop a concept of habitat, investigating and developing vertical solutions that ensure the capacity of the built space to adapt and respond to the specific needs of each stage of people's lives; for this purpose, and in addition to the "traditional" dimension of space (approached through architecture, materials, furniture, etc.), another dimension is also addressed—the technological dimension—in the sense of exploring the potential of new technologies for maximizing space automation and customization. But there is also a third dimension in the sense of endowing the inhabitants with greater autonomy and bringing them closer to their network (contacts, formal and informal caregivers, etc.), creating a concept of home. However, there is also a need to focus on how emotive needs can be met, as pointed out by Mallett [102], who feels that the question of home still remains open: ". . . whether or not home is (a) place(s), (a) space(s), feeling(s), practices, and/or an active state of state of being in the world?" [102]. Christakis (2019) goes even further to suggest that "for better and for worse, robots will alter humans' capacity for altruism, love, and friendship" [103]. "*Not since the Age of Reason have, we re-envisioned our approach to economics, order, security, and even knowledge itself. Now, the Age of AI is changing nearly everything about how we navigate the world—and what it means to be human.*" [104].

A smart home may indeed be a part of the solution for meeting emotive needs, which have been highlighted by the high rates of mental illness during the COVID-19 pandemic [105]. For this goal to be achieved, crucial innovations are needed that ensure end users' autonomy over technological devices. The devices and IoT and their physical and analytical tools need to be trustworthy and include the direct input of end users. The future development of the smart home technologies, therefore, has to be grounded in a multidomain, multilevel, transdisciplinary work that is substantiated by theory but driven by citizens' and healthcare professionals' needs, expectations, and capabilities, as well as matched by the ability of businesses to bring innovation to the market [80,106,107].

As homes increasingly incorporate Internet of Things (IoT) devices, from smart thermostats to security cameras, the volume of sensitive data generated is potentially vast. Through minimizing the amount of data sent to and stored in central clouds, the exposure to potential data breaches or unauthorized access is significantly reduced. Thus, edge computing, when integrated into smart homes, serves as a formidable ally in preserving the sanctity and security of personal data within IoT ecosystems.

In most societies, what happens inside of homes is often culturally determined by gender [108]. However, research suggests that when the adoption and use of smart home technologies is approached, homes are usually studied as neutral, sterile, and bland places rather than complex spaces of relationships [109,110]. Further exploration of household dynamics would appear prudent, as homes are one of the most gendered spaces [111]. Considering the gender dimension and the ever-changing notions of family and household dynamics in research ought to allow for a more in-depth understanding of how needs, behavior, and attitudes are gendered [110]. At the same time, this should enhance the societal relevance of knowledge [112], providing a better understanding of the use, adoption, services, and markets linked to smart home technologies and gender stereotyping [113].

In conclusion, technological advances within homes need to have multidisciplinary input and stronger involvement of those who understand the potential of space in shaping people and societies. This is important in the context of the smart home environment, especially since what is currently conveyed by that term "smart home" translates closer to the term smart house, rather than a notion of home. As home-integrated technologies burgeon in popularity and sophistication, grounding future research in the technology acceptance model (TAM) becomes ever more salient. It is imperative for academicians, technologists, and industry stakeholders to collaborate and ensure that these innovations are not just technically advanced, but also widely embraced by the end-users. Only through such comprehensive evaluations can we hope to achieve a harmonious blend of technology and domestic life. Whilst evolution of a new holistic approach towards smart homes, smart neighborhoods, and smart cities remains open and promising, to sustain our world and our "home", we need to establish a well-defined mechanism where the impact of these technologies is evaluated for all ages and cultures ahead of its wide dissemination as needed [114]. Finally, in order to make these changes implementable, we need to interlink them with other challenges that our society faces: the aging of the population and its increasing needs for accessible environments and the targets for net zero.

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