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Smart Home Technologies to Facilitate Ageing-in-Place: Professionals Perception

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Abstract: An ageing population is a global phenomenon. Like other developed economies, Hong Kong Special Administrative Region (HKSAR), China, also faces a severe ageing problem. One initiative to enhance the safe living and well-being of the growing elderly population is to assist them by building ageing-friendly living environments with the application of smart home technologies (SHTs). Therefore, this study focused on investigating the perception of professionals on the use of SHTs to improve and enhance the "ageing-in-place" (AIP) of elderly residents in HKSAR, China. A questionnaire survey was employed to obtain the perception of professionals with requisite knowledge of the older people facility needs regarding SHTs in achieving AIP for the elderly. The data retrieved were analysed with different statistical analyses. Based on the results of the analyses, all the professionals had similar perceptions of the use of SHTs for the safety and well-being of the elderly, except for the incongruence observed between the government employees, contractors and academic regarding how SHTs may not help to better monitor elderly daily activities. The possible reasons for the inconsistent opinions of the academics with other groups were linked to the knowledge of human behaviours and early dementia symptoms in gerontology. The findings will help care receivers, healthcare professionals, social workers, policymakers, smart home designers and developers to improve and enhance AIP in elderly residences in HKSAR, China.

Keywords: ageing-in-place; elderly; smart home technologies

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1. Introduction

To address some fundamental challenges related to the ageing of the elderly, experts and policymakers worldwide are calling for a revision of the current housing system [1]. The concept of "ageing-in-place (AIP)" for the elderly was emphasised explicitly in different policy directions. The concept of AIP expresses the desire to age in a familiar environment with dignity and a degree of independence [2]. The principle of "AIP" [3–7] highlights the need to allow the elderly to remain in a familiar locality [8]. This principle aims to avoid the risk of elderly people losing their sense of security when faced with relocation from a familiar physical and social environment. This principle aligns with the principle of the United Nations for the elderly, which designates five imperatives for any social policy for the elderly, i.e., independence, participation, care, dignity and self-fulfilment [9,10]. Gerontology professionals, experts and policymakers believed AIP suits the elderly [11]. Although there are various classifications of the elderly, namely, biological, chronological, economic, functional, mental capacity, physical or social [12,13], the chronological definition is mostly adopted [14]. However, there is a dichotomy on the chronological measure of classifying the elderly. The World Health Organization (WHO) uses a cut-off age of 60 and above to address the elderly [15], the United Nations considers the ages 65 and above [16], the Hong Kong Special Administrative Region (HKSAR), China, adopts age 65 and above for planning of medical and other services to the elderly [17]; and mainland China uses ages 60 and above [18]. Interestingly, the Social Welfare Department of HKSAR, China uses 60 years and above for their service delivery to the elderly [19]. Regardless of the age benchmark for classifying the elderly, AIP is considered useful and advantageous [20].

Previous studies reveal considerable evidence that many elderly prefer to live in a familiar environment—traditionally, the family home [21–25]. The American Association of Retired Persons (AARP) also found out that the vast majority (85%) of the elderly in the US prefer to remain in their own homes, as long as they can live comfortably with minimal danger [26]. In 2008, the Australian Housing and Urban Research Institute, through a nationwide survey, discovered that more than 91% of the elderly prefer to age at home with access to appropriate healthcare services [21]. Thus, social gerontologists and WHO believe that AIP is the most humane and cost-effective way for the elderly to avoid psychological trauma and other possible hassles [7,22,27]. AIP is not only economically desirable over institutional care homes [28] but could also bring happiness and better health outcomes to the elderly community.

In a survey to investigate the effectiveness of specific design elements for facilitating AIP in HKSAR, China, the majority of the elderly indicated that they prefer to live in their residence [29]. It is important to note that HKSAR, China, is one of the fastest-ageing populations in Asia [30]. Furthermore, there is also a shrinkage of the workforce in HKSAR, China, due to ageing [10]. In the 2017 policy address, the Chief Executive of HKSAR, China, emphasised the need to proactively improve the quality of life of the elderly in the region through gerontechnology to reduce the burden and pressure of caregivers [31]. However, suppose the benefits of smart home technologies (SHTs) (smart bulbs, smart thermostats, smart showers, etc.) for the elderly would be realised in HKSAR, China. In that case, there is a need to assess the professional's perceptions with requisite knowledge of the elderly facilities. This is important to provide an accurate picture of how SHTs would benefit the elderly since previous studies revealed that most elderly might likely provide some distorted information [32,33]. For instance, Courtney et al. [32] revealed that most of the elderly described themselves as "very healthy" or "blessed with very good health all my life", whereas the health history of these elderly included severe cardiac and pulmonary conditions; degenerative processes, such as osteoporosis and arthritis; records of joint replacements; fractures and falls. This implies that the perceptions of healthcare givers and professionals on SHTs would be helpful and more valid. Previous studies on perceptions of SHTs explored the opinions of the users who are not elderly [34], the elderly [35], parents' opinions on their child(ren) safety with the use of SHTs at homes [36], researchers' view of the associated ethical issues with the use of SHTs [37] and so on. Therefore, this study investigated professionals' perceptions of SHTs to facilitate AIP in HKSAR, China. This is considered important for experts who are knowledgeable of the health conditions of the elderly to provide opinions from professionals' points of view.

In other sections of this paper, a comprehensive literature review on SHTs for AIP and perceptions on the use of SHTs was conducted. A questionnaire was developed to determine the perception of professionals in HKSAR, China. Afterwards, the research methodology employed to collect the data and the analyses conducted are explicitly described. The research findings and practical recommendations that will contribute to the body of knowledge were discussed.

2. Literature Review

2.1. Smart Home Technologies (SHTs) for Ageing-Safely-in-Place (ASIP)

To better facilitate AIP and build up a risk-free and safe home environment for the elderly, experts and policymakers have attempted to embrace technological assistance over the past decade [38]. For instance, a new generation of technologies known as SHTs has been developed and used in developed countries for the benefit of the elderly community [39,40]. The concept "smart home" refers to a residence equipped with technology that assists in monitoring its occupants and/or promotes independence of the residents in either private and/or care and attention homes for optimum quality of life [41–43]. The technology is integrated into the residence's infrastructure and does not, in principle, require training to be operated by the resident because of the user-friendliness of its configuration [33,43]. Smart homes are purpose-built living spaces that provide interactive technologies and unobtrusive support systems to enable people to enjoy a high level of independence, activity, participation or well-being [44,45]. A smart home is a promising and cost-effective way of improving home care for the elderly and the disabled [46,47]. SHTs, also known as "Quality of Life Technologies", are basically "person- and/or context-aware technologies that maintain or enhance the physical, cognitive, social or emotional functioning of humans" (Schulz et al. [48], p. 725). The technology of SHTs involves both "software" (e.g., interactive websites, online telemedicine system) and "hardware" (e.g., assistive devices, sensor-based networks and smart homes technologies) [33,49], which are ideal tools to improve safety in the home and living environment of the elderly. Although there is no standard form of a smart home, the system generally includes monitoring systems, active and passive sensors, electronic aids in daily living and environmental control systems [29].

SHTs enhance AIP significantly by assisting the elderly to improve their performances in activities of daily living (ADLs) and instrumental activities of daily living (IADLs), while effectively addressing limitations on the physical functional abilities of elderly through a safety monitoring mechanism [50]. SHTs also enhance the independent lifestyles of the elderly through the provisions of reminder systems; emergency assistance; fall prevention/detection; medication administration; and assistance for hearing, visual or cognitive impairments [51,52]. SHTs particularly have the great strength and capacity to improve home-based health care facilities [53] and enhance AIP in three ways: (i) observing behavioural changes in the elderly's lifespan, (ii) addressing significant issues of the elderly and society (e.g., health and functioning), and (iii) empowering caregivers to provide support for the elderly [48]. SHTs also have a remarkable ability to monitor and manage the elderly's health conditions while providing them with greater privacy and dignity [54,55]. Moreover, SHTs' applicability was explored in various domains, including schools, workplaces, homes, hospitals [36,56–58], energy management, health monitoring, social care support, detection of anomalies, emergency response and facilitating AIP [59–62].

In recent decades, some developed countries have successfully used SHTs to further facilitate AIP while helping to reduce the reliance on institutional care services. For example, over 750,000 elderly in the USA and Canada benefitted from the Personal Emergency Response System (PERS) in 2011 [63]. PERS is a medical alert system that is designed to provide emergency services to the elderly who live alone in the community for 24 h a day, thus giving peace of mind to both the elderly and their relatives [64] and enhancing the independent lifestyles of the elderly [63]. Some SHTs also incorporate many advanced technological devices (e.g., automatic fall detection and blood pressure devices) for elderly people [65]. The importance and effectiveness of SHTs in enhancing the safety of the elderly were reported in developed countries. In the USA, SHTs helped to detect more than 70,000 falls of seniors every year, with around 30% of the cases requiring immediate hospital admittance [66]. Advanced PERS enables the elderly to receive emergency treatments in a quicker response time—reducing the response time from 2–72 h to an average of 22 s [66]. Studies also found that the mortality rate of seriously injured elderly could be reduced significantly from 67% to 12% if the time to receive medical treatments was shortened from 72 h to less than 1 h for the elderly [67]. Similarly, numerous cases reported in other countries, such as Singapore and Australia, showed how instrumental SHTs enhance AIP [68–72].

Previous researchers proposed different smart home systems for elderly care. For example, Wang et al. [73] suggested a fall detection system for smart homes and Fahim et al. [74] proposed daily activity tracking for smart homes. Mozer [75] developed a prototype using neural networks capable of monitoring and controlling the temperature, water, ventilation system and lighting in the house. Cook et al. [76] developed a smart home system called MavHome (Managing an Intelligent Versatile Home) that used several sensors to receive signals and analyse the home environment and the residents' actions. Soliman et al. [77] presented a comprehensive overview of smart home systems for monitoring elderly health and well-being. Yang et al. [78] also designed and implemented a mobile healthcare system (mHealth), particularly for wheelchair users. The researchers also designed an Android-based software interface to monitor physiological signs and control the home environment by activating the actuators. The software collaborates with third-party services to send text messages and voice calls in case of an emergency. Jacobs and Kaye [79] developed an advanced in-house health monitoring and assessment platform. It assessed occupants' overall health status based on parameters such as walking speed, sleep quality and activity. Ransing and Rajput [80] designed a wireless sensor network for elderly health care. The smart home comprises a set of wireless sensors, which facilitate monitoring the temperature and safety of the home. Woznowski et al. [81] developed a smart home platform for monitoring the home environment and residents' activities. Similarly, Pigini et al. [82] presented a smart home protocol that is capable of monitoring several physiological signs, such as blood pressure (BP) and blood oxygen saturation (SpO2), along with other environmental parameters and appliances. Through the advancement in technologies, the demand for SHTs by the elderly, their family members and the government is likely to increase considerably [83,84], and may continually reduce the expenses of caregivers [85]. Other researchers used a qualitative approach to explore perceptions about adopting SHTs [86,87]. Despite the tremendous benefits of SHTs to the elderly and general health management of humans, the adoption appears to be low due to various perceptions by the users [88–90].

2.2. Perceptions of Smart Home Technologies (SHTs)

Previous studies in different countries investigated the perceptions of various SHT users [88,91]. Exploring the perceptions was essential to identify the fear attached to using SHTs and proffer possible mitigating measures [92]. It is worth noting that Marikyan et al. [93] revealed that the transformation of traditional care attention of the elderly into digital-based care that facilitates AIP requires an extensive evaluation of people's perception of the emerging trend. Thus, studies on users' perceptions of SHTs provide answers to the perceived benefits, obstacles and motivational influences of technological acceptance [94,95]. Users of SHTs revealed the assistive capabilities of technologies in enhancing independent living, safety and quality of life [96,97]. Meanwhile, there are other concerns, namely, usability, receptibility, reliability and accessibility in the use of SHTs [56,98]. To reduce the risks with the help of SHTs, policymakers are expected to play a crucial role to support designers, operating standards, guidelines of data security and quality control [99], as well as encourage the installation in retrofitted existing elderly homes and new private and public apartments through policies [100–102]. In the study of Demiris et al. [35] on the perceptions of the elderly on the installation and operation of SHTs, most of the respondents had positive views of the technological devices. The study further revealed that the elderly suggested the need for SHTs that monitor sleep patterns and other activity levels. In other studies, it is interesting to note that the perceptions of the elderly on specific SHTs, such as bed sensors, gait monitors, motion sensors and video sensors were a concern for their privacy [103]. It is worth noting that Zheng et al. [104] revealed that different countries, even developed ones, had various views about privacy. The Americans were more receptive to releasing their private data to the industry than the Europeans [66,104]. Thus, the views of SHT users in different countries and their beliefs about privacy could be a significant factor in the wide acceptance of technologies for the elderly.

The study of Zhai et al. [105] used a questionnaire survey and interviews to compare the perceptions of elderly residents in Europe and Asia. They found that most respondents were willing to live in a smart home; however, they were worried about reliability, practicability, cost and privacy. Sponselee et al. [106] compared the perceptions of different stakeholders, i.e., caregivers, care receivers and designers, regarding using SHTs. They found that designers were interested in achieving the desired goals of installing SHTs, while the caregivers were concerned about the workload and quality of care. Some studies on the perception of the elderly discovered that the elderly explicitly expressed their unhappiness over the SHTs installed in their residences, majorly because they were not consulted prior to the installation [35,107]. Therefore, understanding the perceptions of various SHT users could guide the manufacturers in their designs towards meeting the requirements of the elderly [108,109]. Interestingly, Courtney et al. [22] discovered that the perceptions of the elderly in the Mid-Western USA continuing care retirement communities on the use of SHTs were different from those of their family members, caregivers and health workers. Despite the elders' various health challenges, most of them opined that they did not need SHTs to monitor their daily activities. The views of the elderly on SHTs in the study of Courtney et al. [32] were not in congruence with the submission of Demiris et al. [35], although the studies were conducted in the same country. In sum, the barrage of scholarly articles indicated that SHTs would improve the quality of life and safety of the elderly [96].

Considering that there is no standard form of smart home, as designs vary and are tailor-made according to the user's characteristics and needs [28], the need to identify specific challenges and concerns that would hinder the effective use of SHTs in elderly residences is essential. For example, Lê et al. [110] identified two issues: accessibility and ethical considerations. Accessibility includes (i) financial accessibility (e.g., affordability), (ii) technical accessibility (e.g., user-friendliness) and (iii) psychological accessibility (e.g., acceptability and trust). Many elderly households expressed their concerns over the affordability of such expensive SHTs [35,56], while the ethical concerns involve the privacy of the elderly person's data generated through the use of SHTs. Furthermore, installing and maintaining SHTs with innovative technological devices can be very costly to many elderly households [35]. Thus, the lack of proper financial support for lower-income elderly families can lead to greater social inequality, as the benefits of such technology may not be available to them [35]. The other issue is that the elderly are generally less comfortable using smart technologies due to (technical) operational difficulties. For instance, the study of Van Berlo [111] revealed that the elderly participants in a smart home trial project in the Netherlands had requested step-by-step enlightenment on each device installed. Hence, SHTs should be user-friendly with minimal or no operational efforts from the users [56]. However, numerous studies reported that most respondents expressed a positive attitude towards the sensor technologies installed in their homes [56,112–115]

The elderly psychological reluctance to accept smart technologies was the most important issue to the successful implementation of SHTs in their residences. Generally, among all age groups in society, the elderly group is the last to accept innovative products, services and ideas [116]. The level and speed of acceptance of medical care technologies, particularly the usage of SHTs in health care, have always been relatively low among the elderly population [117]. This is mainly due to mistrust, uncertainty and fear of losing one's privacy [32,118]. For example, some of the respondents in past studies showed their concerns about privacy and reluctance to use medical technology based on video monitoring systems [112,119,120].

Most of the previous studies were conducted in the West and primarily focused on the technical possibilities of using SHTs. Very few have studied the perception of the elderly for adopting smart home applications, especially in Asia. There is still a gap between the desires of smart home residents and what is obtainable [107]. The professionals' perceptions are, therefore, of utmost importance in successfully implementing SHTs in various residences of the elderly. A list of the perceptions of SHTs obtained from extant literature is captured in Table 1.

Table 1. Perceptions of using SHTs for safety and well-being and their sources.

Code	Perceptions	Sources
P1	All stakeholders (designers, caregivers, social workers, doctors, and end users) should be involved during feasibility studies of smart home technologies installation projects	[32,35,106,107]
P2	In case of emergency, smart home monitoring technologies can alert concerned parties (caregivers, doctors and firefighters)	[78]
P3	Smart home technologies can help provide a safe and secure home environment to the elderly	[76,78]
P4	Smart home technologies can help better monitor elderly daily activities	[78,79,82]
P5	Smart home technologies can be useful in elderly care homes	[43]
P6	Training programs can enhance seniors' capabilities in technology usage	[47]
P7	Installing smart home technology devices in retrofitted existing senior housing should be encouraged	[100,114]
P8	Seniors are less receptive to adopting new smart home technologies	[98]
P9	Smart home technologies devices are expensive to install	[35,56,98]
P10	Proper health and safety monitoring of seniors living alone in a smart home so that medical expenses can be reduced due to there being fewer accidents and injuries	[79–81]
P11	Smart home technology devices will be useful for enhancing senior citizens' social interactions/activities	[64]
P12	Awareness should be created about the multiple benefits of smart home technology devices for elderly care	[98,111]
P13	Smart homes technologies demand will likely increase due to the rising ageing population	[83,84]
P14	The government should provide a financial incentive for the installation of smart home technologies for elderly safety and well-being	[110]
P15	Smart home technologies devices should be installed in both public and private new buildings	[35,103]
P16	Caregiver expenses can also be reduced due to the remote monitoring of the elderly	[83,88]
P17	Private personal data collected through smart home technologies can be secured and kept confidential	[63,64,119]
P18	Smart home technology devices are not very user-friendly	[43]
P19	Smart home technologies can help to ensure maximum independence for the elderly to move around	[41,42]

3. Materials and Methods

Empirical investigation requires selecting the most suitable research design [121]. According to Flynn et al. [122], this helps to determine whether single or multiple source respondents are suitable for the research design. To investigate the perception of professionals on SHTs, obtaining data from multiple stakeholders was crucial to this study. Therefore, a survey design approach was adjudged suitable to have a wide opinion poll of professionals on perceptions of SHTs.

A structured questionnaire survey focusing on professionals was conducted to gather valuable professional insights on elderly care services, particularly the need and the applicability of SHTs in elderly residences. Moreover, the research team attempted to identify more qualified professionals to enhance the sample size using a snowball sampling technique. The snowball sampling was primarily used to determine the suitable respondents who met at least one of the following selection criteria: (1) working experience with the elderly community, (2) academics in the field of gerontology with knowledge of smart technologies and related policy issues, and (3) policymakers in formulating elderly policies for the HKSAR, China. A pilot study was also conducted with three academics to seek their advice about the contents and structure of the questionnaire. The questionnaire was revised after receiving their comments. The questionnaire had three sections: (i) the respondents' demographic information, (ii) the level of awareness about SHTs and (iii) their perceptions of using SHTs. The questions on the perceptions of using SHTs were asked on a 5-point Likert scale in which one represented "strongly disagree" and five meant "strongly agree". Through the snowballing technique, the designed questionnaire was administered to 301 professionals in HKSAR, China. Out of which, 119 responses were received, representing a 39.5% response rate. The retrieved data were carefully checked to identify any irregularities such as incompletely filled sections. Then, the data from the 119 valid responses were subjected to various statistical analyses to draw relevant inferences.

The background information of the respondents was analysed in terms of frequency and percentage, while the level of awareness of SHTs was analysed with cross-tabulation and chi-square. The cross-tabulation helped to determine the actual number of respondents with hand-on experience in SHTs and those without practical experience. The professionals' perceptions of SHTs were analysed with a relative importance index (RII). Interrater agreement analysis (IRA) and significant level analysis (SLA) were further used to determine the importance level of the respondent's perception. Both IRA and SLA were adopted in past studies to denote the importance level of variables for drawing relevant inferences [123]. To determine whether a parametric or non-parametric test would be appropriate to identify the significance difference between the categories of the respondents, a Shapiro–Wilk normality test was first conducted [124]. The results of the Shapiro–Wilk test revealed that the significant level (p-values) of the perceptions was less than 0.05, indicating that the data were not normally distributed. Hence, non-parametric tests were suitable for further analyses of the data in this study. Therefore, the Kruskal–Wallis H test, which is a non-parametric test, was conducted to determine the significant differences in the data between the different groups of respondents [123,124].

4. Results

Based on the 119 questionnaires retrieved from the professionals, 24.4 percent were aged between 20 and 30, 29.4 percent were aged between 31 and 40, and the others were above 40 years of age (see Table 2). The majority of the respondents, i.e., 69.7 percent, had above 5 years of working experience in their profession. Fourteen (11.8 percent) of the respondents had certificates/diplomas, while others had bachelor's or postgraduate degrees. In addition, most of the respondents were married, while 38.7 percent were single. Twelve (10.1 percent) of the respondents were government employees, 10.9 percent were project managers, 43.7 percent were contractors, 7.6 percent were engineers, 3.4 percent were architects, 13.4 percent were academics, 8.4 percent were property/facility managers, 1.7 percent were health experts and 0.8 percent were social workers.

The respondents' awareness of SHTs was also investigated (see Table 3). Most of the respondents, i.e., 111 (93.3 percent), had been involved in SHTs projects in the past. The number of SHT projects the respondents had participated in varied: 43.7 percent had participated in the execution of one SHT project, 27.7 percent had participated in two SHTs projects, 10.9 percent had participated in three SHTs projects and the others had participated in more than three SHTs projects. One hundred and thirteen (95 percent) of the respondents indicated that they had heard about SHTs before, while 5 percent stated that they had not previously heard about SHTs.

To determine the actual number of respondents who neither participated in SHTs projects nor heard about SHTs projects before, a cross-tabulation analysis was conducted (see Table 4). Cross-tabulation is a suitable analysis for indicating the true categorisation of nominal questions [125]. The results of the cross-tabulation analysis showed that only two respondents had not participated in SHT projects, while four had not heard about SHTs before. This implied that some respondents who participated in SHT projects unknowingly ticked "not heard about SHTs before".

Table 2. Background information of the respondents.

Background Information	Categories	Frequency	Percentage
Gender	Male	55	46.2
	Female	64	53.8
Age	Less than 20 years	1	0.8
	20–30 years	29	24.4
	31–40 years	35	29.4
	41–50 years	27	22.7
	51–60 years	18	15.1
	61–70 years	8	6.7
	71–80 years	1	0.8
Marital status	Single	46	38.7
	Married	72	60.5
	Widowed	1	0.8
Education level	Diploma	14	11.8
	Bachelor's	82	68.9
	Postgraduate	23	19.3
Profession	Project manager	13	10.9
	Contractor	52	43.7
	Engineer	9	7.6
	Architect	4	3.4
	Academic	16	13.4
	Property/facilities manager	10	8.4
	Health expert	2	1.7
	Government employee	12	10.1
	Social worker	1	0.8
Working experience	Less than 5 years	36	30.3
	6–10 years	33	27.7
	More than 10 years	50	42.0

Table 3. Background information about the respondents' awareness of SHTs.

Background Information	Categories	Frequency	Percentage
Involvement in SHT projects	Yes	111	93.3
	No	8	6.7
Heard about SHTs	Yes	113	95.0
	No	6	5.0
Number of smart home projects they were involved in	One (1) project	52	43.7
	Two (2) projects	33	27.7
	Three (3) projects	13	10.9
	Four (4) projects	9	7.6
	Five (5) projects	8	6.7
	More than five projects	4	3.4

Chi-square (χ^2) values were also generated in the cross-tabulation to further determine the relationships between the respondents that had participated in SHTs and those that only heard of SHTs (see Table 5). The generated χ^2 at a degree of freedom of 1 and asymptotic significance value of 0.008 was 7.135. This generated χ^2 value was greater than the critical χ^2 in the statistical table at the 0.10, 0.05, 0.025 and 0.01 significant levels. Meanwhile, the generated χ^2 value was less that the critical χ^2 in the statistical table for 0.001. These χ^2 results implied that the responses of the two respondents who had neither participated in SHTs nor heard about them were negligible and would not affect any further analysis conducted in the study at a 99.9% confidence level. Therefore, the 119 responses received were valid to achieve the aim of this study. Thus, the background information of the respondents and the level of awareness of SHTs showed that they were professionally and academically qualified to give valid responses to achieve the aim of this study.

Table 4. Cross-tabulation of involvement in SHTs projects vs. heard of SHTs before.

			Heard of SHTs Before		Total
			Yes	No	
Involved with SHT project(s)	Yes	Count	107	4	111
		% within involved with SHTs project (s)	96.4%	3.6%	100.0%
		% within heard about SHTs before	94.7%	66.7%	93.3%
	No	Count	6	**2**	8
		% within involved with SHTs project (s)	75.0%	25.0%	100.0%
		% within heard about SHTs before	5.3%	33.3%	7.5%
Total		Count	113	6	119
		% within involved with SHTs project (s)	95.0%	5.0%	100.0%
		% within heard about SHTs before	100.0%	100.0%	100.0%

Table 5. Chi-square of involvement in SHTs projects vs. heard of SHTs before.

	Value	df	Asymptotic Significance (2-Sided)
Pearson's chi-square	7.135	1	0.008
Linear-by-linear association	7.075	1	0.008

4.1. Perceptions of Using SHTs for the Safety and Well-Being of the Elderly

The relative importance of professionals' perceptions of using SHTs for the safety and well-being of the elderly were computed (see Table 6). The relative importance was calculated for each perception using the RII formula (see Equation (1)), where RII is the relative importance index, W is the weighting given to each factor by respondents (ranging from 1 to 5), A is the highest weight (i.e., 5 in this case) and N is the total number of respondents. The RII value ranges from 0 to 1; the higher the RII, the more important the item (i.e., perception in this study). Later, the RIIs were ranked in descending order of their values.

$$RII = \frac{\sum W}{(A * N)} \quad (1)$$

Table 6. Perceptions of using SHTs for the safety and well-being of the elderly.

Perceptions	Code	RII	Rank
All stakeholders (designer, caregivers, social workers, doctors and end users) should be involved during feasibility studies of smart home technology installation projects	P1	0.806	1
In case of emergency, smart home monitoring technologies can alert concerned parties (caregivers, doctors and firefighters)	P2	0.776	2
Smart home technologies can help to provide a safe and secure home environment for the elderly	P3	0.774	3
Smart home technologies can help to better monitor elderly daily activities	P4	0.766	4
Smart home technologies can be useful in elderly care homes	P5	0.764	5
Training programs can enhance seniors' capabilities in technology usage	P6	0.764	5
Installing smart home technology devices in retrofitted existing senior housing should be encouraged	P7	0.764	5

Table 6. *Cont.*

Perceptions	Code	RII	Rank
Seniors are less receptive to adopting new smart home technologies	P8	0.764	5
Smart home technology devices are expensive to install	P9	0.764	5
Proper health and safety monitoring of the elderly living alone in a smart home can lead to their medical expenses being reduced due to fewer accidents and injuries	P10	0.760	10
Smart home technology devices will be useful for enhancing senior citizens' social interactions/activities	P11	0.760	10
Awareness should be created about multiple benefits of smart home technology devices for elderly care	P12	0.750	12
Smart homes technologies demand will likely increase due to the rising ageing population	P13	0.742	13
The government should provide a financial incentive for the installation of smart home technologies for elderly safety and well-being	P14	0.742	13
Smart home technology devices should be installed in both public and private new buildings	P15	0.740	15
Caregiver expenses can also be reduced due to remote monitoring of the elderly	P16	0.734	16
Private personal data collected through smart home technologies can be secured and kept confidential	P17	0.722	17
Smart home technology devices are not very user-friendly	P18	0.722	17
Smart home technologies can help to ensure maximum independence for the elderly to move around	P19	0.678	19

Note: RII—relative importance index.

Table 6 shows that "all stakeholder (designer, caregivers, social workers, doctors, and end user) should be involved during feasibility studies of SHTs installation projects" ranked highest with an RII of 0.806, followed by "in case of emergency, smart home monitoring technologies can alert concerned parties (caregivers, doctors, and fire-fighters)" ranked second with an RII of 0.776. The third-ranked perception was "smart home technologies can help provide a safe and secured home environment to elderly" with an RII of 0.774, while the least-ranked perception on the use of SHTs for the safety and well-being of the elderly was "smart home technologies can help ensure maximum independence of elderly to move around" with a RII of 0.678.

4.2. Interrater Agreement Analysis (IRA), Significant Grading Level and Kruskal–Wallis H Test

To further determine the importance of the perceptions of SHTs, an interrater agreement analysis (IRA) and significant grading level (SGL) analysis were conducted (see Table 7). The coding (Equation (2)) adopted for the IRA analysis was deduced by Lebreton and Senter [126]. The coding was employed to determine the level of agreement on various phenomena among professionals in previous studies [123,127]. In Equation (2), SD is the standard deviation, A is the maximum scale value (i.e., 5), B is the minimum scale value (i.e., 1), M is the mean value from SPSS output and n is the sample size of the respondents (i.e., 119 for this study). For the IRA ($a_{wg(1)}$), 0.00–0.30 indicates a "lack of agreement", 0.31–0.50 indicates a "weak agreement", 0.51–0.70 indicates a "moderate agreement", 0.71–0.90 indicates a "strong agreement" and 0.91–1.00 indicates a "very strong agreement".

$$a_{wg(1)} = 1 - \frac{\left(2 * SD^2\right)}{\{(A+B)M - (M^2) - (A*B)\} * \frac{n}{n-1}} \quad (2)$$

Table 7. Interrater agreement analysis (IRA), significant grade level (SGL) and Kruskal–Wallis H test of the perceptions.

Code	Interrater Agreement Analysis (IRA)				SGL	Sig
	Mean	S.D.	a_{wg}(1) Score	Agreement Level		
P13	3.71	0.68	0.74	Strong agreement	Very important	0.302
P12	3.75	0.69	0.72	Strong agreement	Very important	0.075
P15	3.70	0.73	0.70	Strong agreement	Very important	0.383
P10	3.80	0.72	0.69	Moderate agreement	Very important	0.251
P6	3.82	0.73	0.68	Moderate agreement	Very important	0.496
P8	3.82	0.74	0.68	Moderate agreement	Very important	0.885
P14	3.71	0.76	0.67	Moderate agreement	Very important	0.631
P4	3.83	0.76	0.65	Moderate agreement	Very important	0.005 *
P7	3.82	0.77	0.65	Moderate agreement	Very important	0.091
P11	3.80	0.78	0.64	Moderate agreement	Very important	0.267
P16	3.67	0.80	0.64	Moderate agreement	Very important	0.599
P19	3.39	0.83	0.64	Moderate agreement	Important	0.207
P3	3.87	0.78	0.63	Moderate agreement	Very important	0.262
P5	3.82	0.82	0.60	Moderate agreement	Very important	0.900
P9	3.82	0.82	0.60	Moderate agreement	Very important	0.180
P17	3.61	0.88	0.57	Moderate agreement	Very important	0.528
P1	4.03	0.81	0.56	Moderate agreement	Very important	0.553
P18	3.61	0.93	0.53	Moderate agreement	Very important	0.714
P2	3.88	0.90	0.50	Weak agreement	Very important	0.659

Note: S.D—standard deviation; SGL—significant grading level; *—significant at the 0.05 level.

The SGL, on the other hand, was proposed by Li et al. [128] and was used in previous studies [123,129]. The significant grading adopted was as follows: "not important" ($M \leq 1.50$), "somewhat important" ($1.51 \leq M \leq 2.5$), "important" ($2.51 \leq M \leq 3.50$), "very important" ($3.51 \leq M \leq 4.50$) and "extremely important" ($M \geq 4.51$). M represents the mean score value of a given perception.

Table 7 also shows the mean values, SD, IRA score, agreement level, SGL and Kruskal–Wallis H test of the perceptions of professionals on SHTs. The perceptions were arranged in descending order of the IRA score. Based on the analysis, three perceptions (P13, P12 and P15) indicated "strong agreement", 15 perceptions were denoted as "moderate agreement" and P2 indicated a "weak agreement". The SD shows the variability of the dataset [130], and thus, contributed to the final value of the IRA. In addition, the mean values of all the perceptions were above the minimum threshold of 3.00 posited by Harada et al. [131] to determine the importance of an item in statistical analysis. Furthermore, all the SDs of all the perceptions ranged from 0.68 to 0.93 (i.e., less than 1.00). This implies a consensus between the professionals on the perceptions. This was also confirmed in the "SGL", in which eighteen perceptions were denoted as "very important", while "P19" was the only perception denoted as "important".

Based on the results of the Kruskal–Wallis H test, it is interesting to note that only "smart home technologies can help better monitor elderly daily activities (P4)" was statistically different at the 0.005 significance level (see Table 7). This implies that the professionals in this study had the same views as the remaining 18 perceptions of SHTs.

4.3. Post Hoc Test

Based on the Kruskal–Wallis H test results, it was essential to determine the group that contributed to the significant difference in perception, i.e., "smart home technologies can help better monitor elderly daily activities (P4)". Therefore, a post hoc test was conducted at $p < 0.05$. Post hoc tests are a posteriori tests that are used to determine the group where the differences occurred among three or more groups [132,133]. Post hoc analysis using pairwise Mann–Whitney tests and applying a Bonferroni adjustment to control for type 1 errors were undertaken for the perception where the Kruskal–Wallis H test indicated significant differences [134,135]. The post hoc test results showed differences between the government employee and the academic at the 0.000 significance level, and between contractors and the academic at the 0.000 significant level (see Table 8). The adjusted significant levels of 0.017 and 0.014, respectively, were obtained in the statistics based on Bonferroni correction for multiple tests for the pairwise comparisons between the government employees and the academic and contractors and the academic. It is important to note that Table 8 is an abridged version of the table generated in the post hoc analysis. The main table consisted of 36 interdisciplinary relationships denoted by the analysis, out of which only two significant relationships, i.e., between "government employees and the academic" and "the contractor and the academic" were obtained simultaneously. Therefore, the authors deemed it appropriate to present only the two significant relationships denoted in the post hoc analysis.

Table 8. Post hoc test results of "smart home technologies can help better monitor elderly daily activities (P4)".

	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Government employees—academic	–42.719	12.206	–3.500	0.000	0.017 *
Contractors—academic	–32.373	9.138	–3.543	0.000	0.014 *

Note: *—significant at the 0.05 level.

The incongruence in the opinions of the government employees and the academic and the contractors and the academic on the "smart home technologies can help better monitor elderly daily activities (P4)" could be linked to the knowledge of human behaviours by the academic. Professionals in academic institutions understand the unpredictability behaviour of the elderly for not using SHTs provided in their homes and the possible symptom of early dementia among the elderly, which could make monitoring the elderly daily activities not feasible [136–139]. The elderly may be deliberate in using SHTs if given education on the benefits of the usage and the provision of someone, e.g., domestic caregivers, who are saddled with assisting the elderly.

5. Discussion

The RII analysis indicated that all the perceptions (P1–P19) had considerable importance levels. The mean score values of the perceptions also surpassed the minimum threshold for showing the importance of an item in previous studies [131,140]. The results of the IRA and SGL also gave similar views on the importance of the perceptions of professionals on SHTs. Therefore, the perceptions could be considered critical and vital to ensuring quality daily living and safety for the elderly in HKSAR, China.

The respondents opined that all stakeholders that are concerned in one way or the other with caregiving to the elderly should be involved in SHTs installation projects. This implies that the installation of SHTs in care and attention homes or private residential apartments of the elderly should not be seen as the sole responsibility of engineers and other construction professionals. Medical practitioners, caregivers and the elderly also have a crucial role to play. This could be as a result of the practical experience of medical practitioners and caregivers, which would be helpful to provide some valuable ideas and suggestions to construction professionals, such as the most suitable place in the building where a particular SHT should be installed for easy accessibility or usage. It is also crucial to note that medical practitioners also understand the change in the body frame and anatomy of the elderly more than construction professionals, who are often saddled with the installation of SHTs. This corroborates the findings of Courtney et al. [32] in which the elderly could not adequately link the importance of SHTs to their medical history. Thus, the collaboration between the professionals and the users would be more beneficial to the elderly [96,141]. The inputs of the elderly (users) are also crucial in determining where SHTs are to be installed. Individual seniors may prefer to have a distinctive feature in the installation of the SHTs. Moreover, the height of the elderly also varies, and their state of health is also different. Therefore, the installation of SHTs should be preceded by a discussion with all the relevant stakeholders to have optimal outcomes and satisfaction of the elderly. The pre-installation meeting between the elderly and the professionals could be a good platform to provide adequate answers to the questions and fears of privacy, along with other concerns of the elderly [98,142–144].

The study also showed that SHTs could alert the concerned parties, such as medical doctors and firefighters, in the case of an emergency (P2). This perception also implies the involvement of a firefighter in the installation process of SHTs in elderly homes and private residences is crucial. In a situation where the service of a firefighter is urgently required in an elderly home, the firefighter service needs to be acquainted with the SHTs that were installed in the building to provide the right service. With the involvement of all relevant stakeholders, the safety and healthy living of the elderly will be guaranteed at all times with the minimum onsite presence of care attention givers. Thus, enhancing AIP and the peace of mind of the relatives of the elderly. In addition, for the elderly in care attention homes, the installation of SHTs brings effectiveness to the caregivers' services. First, the movement and other activities of the elderly can be monitored. Second, the health status of the elderly can be simultaneously checked by medical practitioners to proffer solutions for any impending abnormalities noticed in the elderly. Lastly, the elderly could also send a report of any queries to the concerned caregiver through the SHTs. Therefore, a unique cycle of communication is created, and the safety of the elderly is assured. The analysis also rated the importance of SHTs in reducing medical service fees as a result of accident or injuries if proper safety monitoring devices are installed (P10). This implies that SHT installation would not only reduce the ghastly accident rate, the safety of the elderly and a swift response in the case of an emergency can be guaranteed.

The analysis also revealed the perception of conducting training programmes to enhance the elderly capability in technological usage (P6). Previous studies indicated that training is essential to achieve the expected outcomes in the use of any technological innovations [28,144]. Therefore, training the elderly on the importance of SHTs, their usage and the possible outcomes of their usage must be considered by the caregivers and other concerned parties. Moreover, training should be conducted in the traditional language of the elderly to aid the assimilation of the elderly and the interaction with the trainers simultaneously. The training would help to reduce the unwillingness of the elderly in embracing the usage of technology and the advancement it has brought. In sum, the training would be an excellent platform to sensitise and educate the elderly, caregivers, medical practitioners and so on. Through training and education, the acceptance level of SHTs by the elderly and their usage could be improved [145].

SHT installation should not be limited to new care attention homes; retrofitting existing elderly housing could also be encouraged to install SHTs. Since the safety of the elderly is not limited to the elderly living in newly built apartments, every apartment housing the elderly should have SHTs installed. The installations of some SHTs could be expensive, and thus, some elderly with their relatives may not afford the high expenses of the installation. This finding on the cost of installing SHTs agrees with several studies that indicate the affordability of SHTs for the elderly and their relatives as a significant greatest predictor [88,146]. However, it is crucial to underscore the fact that the initial capital outlay of an SHT installation would be paid off through the reduction in the service fee paid to caregivers since the relatives of the elderly could monitor the activities of the elderly seamlessly. Furthermore, the safety of the elderly could be guaranteed, and quick medical attention could be provided in the case of an emergency. The huge capital required could also contribute to the unwillingness to install SHTs in old buildings that may be due for demolition in a few years. Therefore, the thought of having to re-install SHTs in another building after moving out of the old buildings could discourage the elderly or their relatives in due time. Interestingly, the respondents submitted that the installation of

SHTs should be encouraged in both public and private buildings to ensure the safety of the elderly at all times.

The analysis results also revealed that SHT devices would be helpful for enhancing elderly citizens' social interactions/activities (P11). The monitoring capability of SHTs makes it possible for the elderly to move about and interact with one another freely. This would improve the liveliness and enthusiasm of the elderly to participate in other activities in the community without fear or prejudice. Thus, the physical, social and psychological well-being of the elderly could be greatly improved through social interaction [48]. Considering the importance of SHTs to the quality of life, safety of the elderly, and the financial requirement for the installation, the respondents indicated the government's role in providing financial incentives for the installation (P14). The input of the government would provide a cushion effect to the elderly with relatives that are not financially capable and the citizens at large. This also confirms the indispensability of the government in achieving AIP and the wide acceptance of SHTs through the provision of subsidies [30,147], which would, in turn, reduce the demand on state-funded care homes.

Finally, the rank of the respondents on "SHTs devices are not very user-friendly (P18)" indicated that they did not believe this assertion. SHTs are designed to be user-friendly to achieve optimal performance. It is also significant to note that the designers considered the categories of users (i.e., the elderly) in the manufacturing process; thus, some SHTs are configured to send automatic text messages to the relevant stakeholders for monitoring purposes [68,78]. In addition, the confidentiality of the data of the elderly transmitted via SHT devices (P17) was also one of the least ranked perceptions among the respondents. This implies that professionals may not trust the end-to-end encryption of SHT devices.

6. Implications of the Study

The study investigated the perceptions of professionals on SHTs in HKSAR, China, with the use of different statistical analyses, namely, the RII, cross-tabulation analysis, IRA, the SGL and the Kruskal–Wallis H test. The results of the analyses revealed that all the perceptions were critical to discussing SHTs in the study area. Therefore, the following recommendations were posited from the study.

First, the professionals believed that the installation of SHTs requires the involvement of all relevant stakeholders. Therefore, it is recommended that a brief meeting should be convened before installing SHTs in care attention homes or private residences of the elderly [106]. The meeting would be a good platform for communication among the stakeholders, namely, the medical doctors, caregivers, firefighters, relatives of the elderly, and the elderly, regarding the importance of the SHTs, how to operate the devices and so on. It is also proposed that the elderly be allowed to practically use the SHTs in the presence of the stakeholders. This collaboration among all the stakeholders would help the engineers and other construction professionals to know the specific place in the building to install the SHTs. The fear of the elderly regarding the use of SHTs could also be addressed at the pre-installation meeting.

Second, the study also revealed the importance of the government in providing financial assistance for the SHT installation to enhance the safety of the elderly. Therefore, it is recommended that the government provide schemes to assist various categories of citizens that cannot afford SHT devices for their elderly [110]. In fact, the elderly should be given top priority, as the installation of SHTs plays a crucial role in achieving safety performance, timely health monitoring, quick medical attention and social interaction. The government and private care homes should be furnished with SHTs as well to realise equitable access to essential medical services for the elderly across the country.

Third, the study also showed that the respondents indicated concern about the confidentiality of the personal data generated via SHTs. Therefore, it is suggested that the manufacturers of SHTs should ensure that the end-to-end encryption of SHT devices is seriously ensured [91]. The manufacturers can also constantly assure the users of the confidentiality of their data via social media. It is also crucial to note that the data of the elderly are crucial to medical practitioners, research institutes, government, etc., for assessment and to propose commendations/recommendations for improving the well-being of the elderly. Therefore, it is advised that necessary research ethics be considered when research institutes or government officials need the data of the elderly for evaluation. This would boost the confidence of the elderly regarding the data generated through the use of SHTs.

Finally, the study revealed the importance of training and awareness programmes on SHTs to enjoy optimal benefits. Therefore, it is recommended that sensitisation programmes be conducted to train all caregivers and professionals on the importance of SHTs to the safety of the elderly. The elderly should also be sensitised to the benefits of SHTs, and training should be conducted for the elderly in their local languages. The training should also have a practical session for the elderly to demonstrate the use of SHTs. In addition, the relatives of the elderly should also be trained on how to use SHTs with an appropriate practicum.

7. Conclusions

AIP with the use of SHTs is widely believed to be advantageous for seniors' self-fulfilment and is considered economically viable. Meanwhile, some seniors are oblivious to their present health status and may have wrong perceptions of SHTs. Therefore, the opinions of multiple professionals who are conversant with their health condition are considered imperative to investigate the various perceptions of SHTs to facilitate the AIP of the elderly in HKSAR, China. The perceptions on SHTs were sourced from extant literature and used to develop the questionnaire. A total of 119 copies of questionnaires retrieved from government employees, project managers, contractors, engineers, architects, academics, property/facility managers, health experts and social workers were subjected to descriptive and inferential statistics. The results of the analyses indicated that all the perceptions were critical to facilitate AIP of the elderly in HKSAR, China. The Kruskal–Wallis H test found that the professionals had the same view on most of the perceptions, where only "P4—smart home technologies can help better monitor elderly daily activities" has a significant difference in the study. A post hoc test was further conducted to identify the group of respondents between whom the divergent opinion on P4 occurred, and the possible reasons were linked to the gerontology knowledge of academics on behavioural change and symptoms of early dementia of the elderly.

Further, IRA and SLA revealed that the use of SHTs will likely increase due to the rising ageing population (P12). Thus, awareness should be created about the multiple benefits of SHT devices for elderly care (P13) and the need for their installation in both private and public new buildings (P15).

Based on the analysis results, recommendations to the professionals, government, manufacturers of SHTs, the elderly and their relatives were proposed. While the results of the analyses conducted in this study are valid and reliable in this context, it is important to note that the opinions of the elderly were not considered in this study. This study aimed to have professionals' views on the subject matter since previous studies revealed that some elderly information does not correlate with their health history. However, future studies could qualitatively investigate the perceptions of the elderly via interviews. This would be important to have a basis for comparison and achieving triangulation in the study. In addition, the perceptions can be classified into smaller groups using statistical tools, such as factor analysis. Moreover, the bivariate relationships between the groups of perceptions can also provide interesting findings for drawing new conclusions and recommendations.

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