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LONG PAPER

Usage and impact of the internet-of-things-based smart home technology: a quality-of-life perspective

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Abstract
The aim of this paper is to explore the usage and impact of the Internet-of-Things-based Smart Home Technology (IoT-SHT) in Malaysia. Face-to-face interviews were conducted with a total of eleven IoT-SHT users who had a minimum of 2-year usage experience. The semi-structured interview consisted of six questions which were compartmentalised into two sections. Common themes were identified through constant comparison of the inductive data in the coding process. The in-depth interview uncovered six uses of IoT-SHT. Mainly, it was used for real-time remote control, surveillance, sensing, home automation, entertainment, and family communication. It seems clear that the IoT-SHT helped people to save time, changed their lives, improved security, safety, environment condition, fun, convenience, and comfort within the home ground. It also facilitated better health tracking, family care, and energy conservation. Psychologically, the IoT-SHT also enhanced one's image, offered better companionship, and improved the sense of belongingness, and closeness within the family. This study fills the research gap by providing insights into how the IoT-SHT was used, thereby benefiting users in Malaysia. With the arrival of industrial revolution 4.0, a comprehensive knowledge on the usage of IoT is pertinent. The findings of this study may also serve as a foundation for future research in IoT-SHT adoption. Practically, this study accelerates IoT-SHT diffusion by providing insights to vendors in designing better IoT products and services, based on the popular usages and impactful benefits.

Keywords Internet of things · IoT · Individual quality of life model · IoT usages and impact · Quantitative interview study in Malaysia

1 Introduction

Being the most popular ultimate personal communication device nowadays, smartphones are crucial to people all over the world using them as the heart of interactions and controls of Internet of things (IoT) [1]. The IoT rises significantly in scope and functionality as smartphone use spreads making our lives better in so many ways [2]. The IoT is defined as an interconnected digital system that is made up of a variety of independent computing devices. It has a unique identity and is able to exchange data through the internet without human intervention [3, 4]. The field has gradually broadened as the total of connected IoT devices has surpassed 12 billion with a 8% growth compared to 2021, according to a report released in May 2022 [5]. This number is expected to increase more than twofold, which is 27 billion, by 2025, following the momentum of the current trend [5]. The IoT is widely deployed currently, playing a vital role in all aspects of people's life, based on the many applications available in the real world, for example smart manufacturing, smart health, smart transportation, smart city, and smart homes [6].

1.1 IoT-based smart home technology

Consumer IoT such as smart home technology is the second largest industry segment ($108 billion USD), following smart manufacturing ($119 billion USD) [7]. The IoT-based smart home technology (IoT-SHT) is defined as an information technology for home management; it proactively helps its users by promoting security, safety, comfort, convenience, and entertainment within the living environment [8].

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However, the worldwide adoption of IoT-SHT is still low (12.3%, 2021) because many people are still unaware of this technology, especially in developing countries [9]. Therefore, user-centric studies are important in directing its mass diffusion for the benefit of all [10].

This study was conducted in Malaysia which is a 128,000 square kilometres developing country located in Southeast Asia comprising two non-contiguous areas, namely West Malaysia or Peninsular Malaysia (borders Thailand and Singapore), and East Malaysia (borders Brunei and Indonesia) with Kuala Lumpur as the capital [11]. The economy of Malaysia is emerging but is still considered a developing country because it still not yet qualifies to join the Organization for Economic Co-operation and Development (OECD), due to a number of reasons, including: (1) its slightly lower GDP $12,200 compared to the average $13,530; (2) lower portion of service section stack (55%) than the OECD average which is 70%; and (3) uneven and nuanced education performance which is only 85% of OECD peers [12].

The Malaysian smart home market is worth $132 million USD in 2020, and revenues are expected to grow by 21.13% annually (CAGR 2021–2025), leading to a market volume of $421 million USD in 2025. However, household penetration in Malaysia in 2020 was only 10.7%, which is lower than the worldwide average and still far less than the leading developed countries like the USA (36.6%), UK (34.8%), South Korea (31.2%), and even its neighbour, Singapore (23.5%) [13]. Unfortunately, the penetration of IoT-SHT in Malaysia is considered low and unsatisfactory although the Malaysian government has allocated more than RM500 million since 2015 in order to upgrade fibre internet infrastructure, and to propel the digital transformation of Industry 4.0 (IR 4.0), including its core technologies like IoT, Artificial Intelligence (AI), and 5G [14, 15].

Malaysia is significantly slow in adopting the IoT-SHT. Up to 2021, Household penetration of IoT-SHT in Malaysia was only 12.2%, which is lower than the worldwide average (14.2%) and still far less than the leading developed countries like the USA (40.1%), UK (39.3%), South Korea (36.2%), its neighbour, Singapore (28%) [9, 16]. Therefore, IoT-SHT is considered new in Malaysia. The slow adoption of IoT-SHT in Malaysia motivates researchers to study the key determinants of successful usage for maximum benefits in the shortest time [10].

Statistics also showed that 96.8% of Malaysians are internet-connected and 98.7% of them connect using mobile devices [17]. Malaysians have good mobile technology readiness [18]. Malaysia has been ranked number nine in average amount of time per day spent on the mobile internet (3 h 14 min); number four in mobile social media (74%); number seven in mobile e-commerce (58%); number six in mobile e-banking (66%); number three in ride-hailing APPs (48%) [19]. In other words, IoT-SHT acceptance may not be a big challenge as it would be in other developing countries; however, this is not true in fact, and this increases the curiosity for further investigation.

Without IoT-SHT, convenience of modern technology is missing, leading to a lower quality of life [20]. On the contrary, AI-based home automation algorithms help to improve indoor comfort by automating the thermal, airflow, and lighting at home, offering its inhabitants a more comfortable and productive living environment [21]. Home automation frees people from repetitive and mundane tasks and promotes self-actualization by allowing people to focus on what is more important to them, which refers but is not limited to self-fulfilment, seeking personal growth, and peak experience. By modifying a home to a more liveable place, IoT-SHT indirectly realizes a person's potential in terms of productivity over the others who do not use any smart home technology [22]. Therefore, there is an urgent need to gather feedback from the actual users in Malaysia to cater for the technology adoption problems and resolutions.

2 Literature review

Data from a bibliometric analysis of 169 IoT-related studies worldwide published from 2015 to 2019 indexed on Web of Science suggest that the USA and UK have produced the most papers, 32 and 23 also being cited the most by 569 and 361 times, respectively. The most popular research area is IoT adoption for organizations (59 articles—35%), followed by IoT adoption by individuals (53 articles—31%), general reviews of IoT (20 articles—12%), issues of IoT security and privacy (17 articles—10%), IoT business models (9 articles—5%), and others (11 articles—7%). The most studied areas of IoT application among individual usage include *Smart Home* (19 articles—36%), *Personal IoT in General* (14 articles—26%), *Smart Gadgets* (7 articles—13%), *Home Healthcare* (6 articles—11%), *Home Energy Management* (3 articles—6%), and the less focussed areas, *Smart Appliances* (2 articles—4%), *Education* (1 article—2%) and *e-Government* (1 article—2%).

It appears the developed countries are the frontiers of IoT research and there is a need for developing countries to catch up [23]. Moreover, individual IoT application is trending and dominating the commercial IoT. Thus, scholars are encouraged to pay attention to the use of IoT in relation to the individual users among developing countries [23]. Based on an analysis using VOSViewer software on the keywords that were suggested by the authors to best represent their articles, the most commonly occurring author keywords related to IoT topics, excluding the common keywords like Internet of Things and IoT, were technology adoption related keywords such as technology adoption (12 times), adoption (8 times), technology acceptance model (6 times), technology

acceptance (5 times) and technology acceptance model (TAM) (4 times). When compared to topics that predate IoT adoption, it was found that keywords such as privacy (9 times), security (6 times), challenges (3 times), and trust (7 times) received relatively less attention.

A challenging problem which arises in this domain is that the studies on IoT adoption may constitute the greater body of literate at present, and therefore, any future research should look at post-adoption studies, such as the impact of usage and issues relating to it (such as privacy, security, and trust) [23].

In Malaysia, IoT-SHT-related behavioural and social sciences research mainly focuses on technology acceptance [24], technology adoption [25], purchase intention [26], and behaviour intention [27]-related studies. Zaidan [28] found that energy saving and health care functions have successfully attracted people to use IoT-SHT. Similarly, Alaa et al. [29] stated that people tend to use IoT-SHT because it satisfied their basic needs including money saving, comfort, and entertainment. On the other hand, Rasyidah et al. [30] found that factors like energy saving, time saving, and pricing are the main reasons influencing its adoption. User-groupwise, Wei et al. [31] found that the younger generation and people with higher education are more likely to use smart homes. On top of that, Aziz and Nasir [32] observed that many people in Malaysia are still unaware of the IoT-SHT due to the absence of IoT application providers. This made it a major challenge for those who already know about the IoT-SHT but are yet to adopt due to their worries and concerns about the new technology especially regarding its security and privacy issues [31]. In the negative way, IoT-SHT impacts user privacy, data security and raises ethical challenges to service providers and vendors [33].

In terms of positive impact, previous studies conducted in developed countries found that the IoT-SHT brings a variety of benefits to its users, for example comfort, convenience, security and safety, joy, time saving, energy saving, and even psychological well-being [8, 34, 35]. More specifically, Mtshali and Khubisa [36] argue that IoT-SHT as an interactive user centric IoT application has promisingly improved people's Quality of Life (QoL) to a great extent through its efficiently AI-based and home automation and revolutionary voice control features [37]. QoL is defined as the perception of how people think and feel about their circumstances and position in life in relation to standards, conditions, and concerns [38]. People are said to have a 'good' QoL when they have a positive evaluation and rating of themselves, relationships with others, and the social—cultural context they are living. Good life would be achieved when needs and resources are matched and fit [39]. Likewise, [40] also point out that IoT alleviated people's QoL. Also, Rasyidah et al. [30] conducted a study on Malaysian millennials and found that IoT-SHT improved their QoL as well. Few studies indicate that IoT-SHT improved people's QoL in general, but not in detail [41–43]. The IoT-SHT literature still lacks an in-depth explanation on what aspect of QoL was impacted and how QoL was influenced [44].

Complementing a study by Sequeiros et al. [39], who found that the IoT-SHT improved the psychological well-being of people, this study aims to get a bigger picture of how IoT-SHT could impact people's QoL based on an individual QoL model grounded on Maslow's Hierarchy of Needs (MHoN) [45]. This is important to encourage people to use the technology by letting them know the benefits embracing the technology, and also helping the IoT vendors to improve and make better IoT products and services in the future to cater for the trending and missed demands in real life [46].

Thus, this paper aims to fill the gap by further enriching the literature as there has been less previous evidence for how the IoT-SHT impacts QoL based on a variety of well-being perceived through its usage in everyday life [41–43].

In addition, based on searches on the Web of Science and Scopus databases, IoT literature is dominated by technology-focussed studies such as application developments, system security advancements, and architecture [47]. Nevertheless, it still lacks post-adoption data which can be used to examine how well a technology performs in real life, an important contribution to society. In order to address the above-mentioned research gap, a post-adoption (impact study) approach is required. Based on these anticipations, the current research thus aims to answer the following research questions: (a) What is the usage of the IoT-SHT among Malaysian consumers? and (b) how does the usage of the IoT-SHT impacts QoL? Understanding the various usages purposes of IoT-SHT among consumers and its actual impact on the QoL of people would help technology developers to further enhance their products and services accordingly in order to accelerate the adoption of the IoT-SHT in Malaysia [48, 49]. This study is also expected to serve as a reference for future empirical studies.

3 Theoretical perspective

QoL is a broad concept that represents the overall well-being of people in a society. QoL studies can be approached from three theoretical perspectives, namely Happiness and Life Satisfaction Approach, Needs Satisfaction Approach, and Life Satisfaction based on Need Satisfaction Approach [50]. Life satisfaction is interrelated with QoL and can be evaluated based on the individual measures on the different life domains [51]. Similarly, a certain level of QoL can be achieved when an individual's needs matching the Maslow's Hierarchy of Needs are met [45, 52].

QoL evaluation is complex and yet to have a specific definition and approach in measuring it, but there are agreements about its attributes; QoL is multidimensional with a variety of domains and indicators, it includes both subjective and objective components, it is influenced by both personal and environmental aspects, and is the result of physical, psychological, and sociological state of a person [53]. Supplementing the previous IoT adoption studies, this paper conceptualizes the impact of IoT-SHT usage as the consequences of use-behaviour. While previous studies hypothesize the benefits as motivation towards the use-intention, the present study rationalizes the benefits of IoT-SHT usage (area being improved) on people's QoL based on Alborz [38] Individual QoL Model (IQM). The IQM is a framework that is grounded on Maslow's [45] Hierarchy of Needs. It encompasses the elements of life choices which can affect one's QoL [38]. Needs Satisfaction Approach [50] and IQM [38] were selected to follow as the behaviour of buying and using IoT-SHT products or services is to meet and satisfy users' needs for certain purposes in their every day's life. A 'good' QoL is experienced whenever an element of the QoL is obtained [38]. The impact of the IoT-SHT usage on people's QoL is rationalized into four facets based on the IQM, namely foundational well-being, psychosocial well-being, status, and autonomy. Foundational well-being combines level one and level two of Maslow's Hierarchy of Needs, covering physiological needs and safety [45]. This is defined as the critical need of a biological entity to feel safe, and to survive without threats in life [38]. Psychosocial well-being encompasses the need to maintain one's mental health by seeking interpersonal relationships, companionships, and intimacy like attachment and partnership with friends and family since human beings are largely, social in nature [38]. Status is mapped with esteem, level four of Maslow's Hierarchy of Needs, which is related to the higher needs of human beings, involving how people positively estimate themselves, and are given the freedom to express their feelings of self-worth so as to maintain competence within their community [38, 45]. Finally, autonomy is aligned with the highest need of human beings as per the definition in Maslow's Hierarchy of Needs, which concerns people's self-actualization within their aestheticism [38, 45]. Self-actualized people are seeking for fulfilment which can be described by desires and doing with fullest potential what they are capable of, to be "true self" [45]. Individuals are intrinsically motivated when freedom and support are available for them to pursue their aspirations [38]. In short, the QoL of the person will be improved as long as any of the elements stated in the IQM is attained. Therefore, to obtain a deeper understanding on IoT-SHT impact, this study uses the Need Satisfaction approach and Individual QoL model (IQM) as a base to investigate how various aspects and facets of users' QoL could be improved upon utilization of particular IoT products and service.

4 Research methodology

In order to gather in-depth information based on people's experiences, opinions, and knowledge, individual actual users had to be approached inductively. Therefore, the study employed the semi-structured interview method in order to understand how actual IoT-SHT usage impacted their daily life answering research question one and two [54]. With the purpose to collect qualitative data for exploratory analysis, a total of six semi-structured, open-ended questions, and discovery-oriented interview questions according to the research objectives were designed to tackle "what", "why", and "how" regarding the actual IoT-SHT usage and impact in participant's every day's life (Appendix 1) [55, 56]. Section one of the interview aims to explore the IoT-SHT usages in the users' daily life. Section two ascertains the impact of long-term IoT-SHT usage, especially the benefits which were realized through the usage, and the areas in their daily life which had been improved.

Eleven interviews (average 40 min each) were conducted, from May 2020 to l November 2020. The conversations were recorded with an audio recording app, namely Voice Memos. The audio recordings were then exported to a computer for transcription purpose. Audio was manually converted into text by typing on Microsoft Word while listening to the audio playback seconds by seconds. Transcribed conversations were gone through sentence by sentence for open coding process. The answers to the questions "what smart products are you using?" and "What is the purpose of using this smart product?" were coded based on conceptual similarity. For example, "I can control my curtains, to open and to close it with my iPhone (P1)" and "When I am about to leave my office, I will turn on the air conditioner at my room so it will be cool when I reach home (P2)". The usage of remote control of curtain and air conditioner was retrieved based on the similar purpose of IoT-SHT. Likewise, IoT-SHT impact was coded by detecting the keywords about the consequences of IoT-SHT usage in every day's life for example, "For people who are not good in using smartphones, especially older adults like my parents, voice control smart home is very convenience for them (P2)"and "It is very convenient especially when I am away from home, I still can control my lights and access to the surveillance cameras (P1)." The impact of improved convenience in everyday life was refined based on the similar benefits through IoT-SHT usage. Analysis which attempted to reveal the meaningful themes and subtexts that were related to the research topic was then performed. Based on Schulenberg's [57] recommendations, the transcripts were

carefully read, and the statements were categorised according to the appropriate categories, which ranged from a few words to several paragraphs in length [58]. The statements were then grouped into themes to answer the research questions set up in Sect. 1.

The measures of credibility, confirmability, transferability, and dependability of data were assessed to ensure the validity and reliability of the qualitative data retrieved from the interviews [59]. Credibility was established as interview conversation recordings that represent what was being conveyed by the participants which were replayed multiple times for verbatim transcriptions to ensure the accuracy [59]. Content analysis for major themes of IoT-SHT use and impact was performed, and relevant literature was reviewed prior to the interview for question design. Also, the transcripts were ensured to be free from researcher bias by attaining verification from the participants via emails. Thus, confirmability of the data was established [59]. Authenticity of the conversation contents was attained, and the data can be applied on other contexts or settings by providing a broad description and purposeful sampling. Hence, transferability was established. On the other hand, by following the same semi-structured interview guide, all participants were asked the same questions and thus the dependability of the results was established [59]. Therefore, the data are considered valid and reliable as the four required conditions mentioned were satisfied [60].

4.1 Samples

In order to get the most out of informational interviews, only users with more than two years usage experience were invited, because the longer the period of use, the higher the impact in their everyday lives [61]. A total of 19 permission-granted contacts of actual users were obtained from two engineers who have worked in four different smart home companies in Malaysia (approved by the company management and acknowledged by the customers). The identified users were then contacted via phone calls. The users were well informed about the objective of the study and the type of information that would be collected. Eight invitations were rejected, and finally, only 11 users (eight males and three females who were using more than five IoT-SHT systems, with at least two years of use experience) agreed to participate. They were further contacted for interview appointments at their convenience [62]. IoT-SHT is still new in Malaysia, actual users are limited, and thus, it was challenging to find a large number of participants for an impact study. Furthermore, the study was conducted during the COVID-19 pandemic, where the on- and off- of the Movement Control Orders (MCO) increased the difficulty of reaching the participants. Some interview appointments were declined due to the above-mentioned reason.

According to some qualitative research guides, a purposive sample of around 10 experienced interview participants could provide sufficient information for a study [63–66]. The participants (early adopters) are the heavy smart home users (one to five years of experience) using multiple smart home products (five to nine types of products). Their response is highly informative covering all aspects of their everyday life and sufficient to develop the concept of IoT-SHT use and impact-on-QoL (based on their intentions and purposes of use the technology). In this case, data saturation was reached at the eighth interview and confirmed with three additional interviews (the stopping criteria) [67]. Ethical approval was also obtained from the University of Malaya Research Ethics Committee for data collection.

The demographic profile of the 11 interview participants is further summarized in Table 1.

Table 1 Demographic Profile of Interview Participants

No	Age	Gender	Marital status	House type	Occupation	IoT-SHT systems in-use	Year of usage initialized
1	26	Male	Single	Condominiums	Programmer	5	2017
2	28	Male	Single	Terrace	F&B Manager	7	2018
3	31	Male	Single	Condominiums	E&E Engineer	8	2017
4	30	Female	Married	Terrace	Property Agent	8	2017
5	35	Male	Married	Terrace	M&E Engineer	9	2017
6	36	Male	Single	Terrace	Manager	5	2015
7	40	Male	Single	Terrace	Programmer	6	2017
8	21	Female	Married	Terrace	Housewife	6	2018
9	35	Male	Married	Condominiums	Businessman	6	2017
10	35	Female	Married	Condominiums	Business Process Specialist	6	2017
11	29	Male	Single	Condominiums	ELV Engineer	7	2019

5 Results

The study results show that most of the participants were using wireless IoT-SHT, and the most popular brand among them was Xiaomi Mijia, a smart home product maker in China who was ranked number one by the unit volume of products shipped during the third quarter of 2020 [68]. For the majority of them, the most comfortable price for an IoT-SHT product would be around RM100 (equivalent to $ 22.20 USD at the rate of 4.5), and the most popular e-commerce platform which they used to survey, compare, and purchase an IoT-SHT product is shopee.com.my, an e-commerce platform which ranked number one in Malaysia by the monthly traffic landed on its official website [69]. Participants expected to see more intelligent features like being able to learn and predict their needs, such as Jarvis (the AI virtual assistant) in the 'Iron Man' movie. They wished to have a smart home that needs very minimum configuration, and a smart carekeeper to manage their homes, and to take care of them. Overall, all the participants have positive thoughts about the IoT-SHT, and they were willing to purchase more, and open for new products in the future.

5.1 IoT usage

The findings on the usage of the IoT-SHT were then categorized into six groups:

(1) Remote control is defined as the control of equipment, devices and appliances located at home, environmentally remote in distance when using smartphone applications (APP) through the internet, from anywhere, and at any time [70]. The most common appliance to control is lighting equipment, followed by air conditioners, and door locks. This was endorsed by many participants like P2 and P3:

> I use voice control to turn on my TV and change channels (P2).

> I use smart home for access controls, I can unlock my door remotely (P3).

(2) Remote surveillance is defined as the observation from a distance through live streaming videos of objects or people, for the purpose of investigation or protecting them [71]. Smart CCTV and smart cameras were used to monitor their homes and family for security and safety purposes. According to the interviews, remote surveillance is one of the most mentioned IoT-SHT usage. By comparing this to the household penetration rate by segments in the USA where the security products are secondary after control and connectivity. In other words, the low IoT-SHT penetration in Malaysia could be due to the inappropriate marketing strategy which hard selling products that might not be suitable for the locals as the conditions and needs for Malaysian users are different from the users in developed countries like the USA. Malaysia (65.56) has a higher crime index than its neighbours like Vietnam (53.45), Cambodia (52.72), and Indonesia (52.16), according to the Crime and Safety Report 2016 [72]. By tackling this issue with IoT-SHT, remote surveillance products could significantly accelerate the adoption of IoT-SHT among Malaysians.

The video footage is accessible ubiquitously; it is recorded for replays when needed, as endorsed by some participants like P9 and P11:

> I use iPhone app to check the CCTV at home (P9).

> If my shoes got stolen. I can check the recording to find out who steals (P10).

(3) Home automation is the automated control of the building's electrical devices with the objective of improving the comfort of the occupants, increasing energy efficiency, and reducing operational costs [35]. It is noted that home automation is different from the remote controls because home automation is activated by computerized algorithms or programmed routines while remote controls were initialized by humans. This was also confirmed by some participants like P7:

> Smart thermostat monitors the temperature at home, it turns on the air conditioner for me automatically. So, I do not need to touch anything to control (P7).

(4) Entertainment is defined as the on-demand live streaming features of IoT-enabled home appliances used for the purpose of obtaining multimedia contents from the internet, such as TV shows, movies, and music for entertainment at home [73]. Smart TVs and speakers were used to play their favourite videos, music, and even games, by using the internet as the source. The entertainment experience is personalized with recommendation systems which can make predictions by learning the past behaviour of users; it can suggest relevant contents that are desirable to the users [74]. This was also verified by some participants like P10:

> My Sony smart tv is integrated with Netflix, a press of a button on the remote control (the Netflix button), it will play my favourite drama series immediately (P10).

(5) Remote sensing is defined as the acquisition of necessary data, and useful information from objects or the environment without physical contact, but through internet-enabled sensors [75]. Temperature, humidity,

and particulate matter pollution sensors were used to monitor the environmental condition of their homes and surroundings. Motion, contact, and smoke sensors were used to monitor the security and safety at home. Smart weight scale, and smart watches that have built in activity tracker, heart-rate monitor, and blood pressure monitor were used for health monitoring purposes. This was further captured by some of the participants like P3, P4, and P11:

> My air purifier is useful in beating the haze which happens every year due to the forest burning in Indonesia. The air purifier is made by Xiaomi, and the reason I buy this is because of the carbon activated HEPA (High Efficient Particulate Air) filter which claims to be able to remove harmful particles and odour in the air. The air purifier monitors the air quality PM 2.5, temperature, and humidity at home, and will be turning on automatically when the air quality is poor. With the Xiaomi smart home app, I can check the air quality at home in real time, and control the on, off, fan speed and timer as well. The app will also alert when the filter needs a change. The reason I choose to use HEPA filter over the others because it claims to be able to remove 99.9% of the pollutants in the air (P3).
>
> I use smoke detectors to ensure the fire safety at my kitchen (P3).
>
> I am pregnant now, so I measure my weight everyday with the connected weight scale and monitor it with an APP on my iPhone (P4).
>
> I use smart watch to record and monitor my health conditions, like heart rate and blood pressure (P11).

To be noted that, the so called smart health tracking products in the market to-date, such as the smart wearables, are designed mainly for personal monitoring and tracking use only, and the collected data have no claim on the accuracy. For example, Samsung stated on their smart watch official website that "the gadget is for fitness and personal reference only, please do consult a medical professional for advice if needed" [76]. Apple stands apart from the competition as they claim that their smart watch is designed for both medical professionals and patients to use, and their health platform is compatible with third parties professional health equipment which allows users to monitor, store, and share their personal health data with the experts [77].

(6) Family communication is defined as the communication between a family member and another for inconsequential conversation, keeping in touch, sharing of everyday life matters, sharing of information, and even requesting for help among the family [78]. Voice control assistants, smart cameras, and smart watches were used for such communication with loved ones. The IoT-SHT enabled real-time conversation in the form of chats, voices, and videos by using the internet. This was endorsed by some of the participants like P1:

> Since no meeting in person is allowed during MCO (movement control order due to Covid-19 pandemic), so I video call my girlfriend using smart camera (two-way video and voice streaming feature) (P1).

Table 2 further summarizes the six IoT-SHT uses.

On top of that, participants agreed that they were aware and concerned about the threats and potential risks that come along with the IoT-SHT. However, they manage to overcome that after careful thoughts. Therefore, they bought and used the smart products. Service providers and vendors play a key role in clearing doubts and worries of potential users at this point. Users provided feedback that trust in vendors is important to them, encompassing the brand of the smart products, the reputation of the IoT service provider, and the credibility of the local installers.

Concerns over IoT vulnerability may be a problem for people who do not yet adopt the technology but not for the actual users who are already using the technology, especially the early adopters. IoT-SHT is considered new in Malaysia, and according to Rogers [79], it is the early adopters of IoT-SHT who have higher education and are younger in age who are more willing to take a higher risk compared to the ordinary users (the age of the interview participants is ranging from 26 to 40 and all of them are university graduates).

Table 2 IoT-SHT Usage Retrieved from the Interviews

Usages	Interviews											Freq.
	1	2	3	4	5	6	7	8	9	10	11	
Remote control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11
Remote surveillance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11
Home automation		✓	✓	✓	✓	✓	✓		✓	✓	✓	9
Entertainment	✓		✓	✓	✓	✓			✓	✓		7
Remote sensing		✓	✓	✓	✓				✓	✓	✓	7
Family communication	✓	✓		✓	✓							4

Therefore, the IoT-SHT vulnerability which could lead to threats and potential risks is considered as manageable to these users.

However, it is still important to note that IoT-SHT products like smart cameras for video surveillance-related purposes are a double-edged sword that can cut both ways. It can be used to prevent crimes or help a crime. Connected cameras might be exposed to malware and cyber intruders who may easily access the camera using some common guessable passwords. Privacy is an important issue that people might be unaware of or ignore. Especially the non-tech savvy users need to know and understand the risks of using smart cameras at home and the cybersecurity precautions to improve digital security.

5.2 Impact of IoT usage

The participants were asked for negative consequences caused by the use of IoT-SHT; however, no user yet reports any problem that negatively affected their everyday life. The impact of the IoT-SHT usage was categorized into 15 groups:

(1) Improved convenience is defined as the enhanced agility, reachability, and availability of services, which are mobile temporally and geographically [80]. The ubiquity of the IoT-SHT has enabled the accessibility of home management like never, and this has been noted by many participants, like P6, and P10:

> I can remote access my smart home system anywhere anytime if I have access to the internet (P6)." "I always forgot to bring keys with me when rushing to work, and so I locked myself out of the house. But this no longer happens again with smart door lock installed. It is convenient now, unlock and access even without keys (P10).

(2) Improved home security is defined as the enhancement of surveillance monitoring, detection of unauthorized access, and more effective alerting process during an intrusion [81]. The real-time connectivity of the IoT-SHT has strengthened the security level of homes. IoT-SHT detects potential intrusion with motion sensors (or other sensors), sends an alert to the user's smartphone, warns the stranger with voice and alarm. Immediately, users are able to check who is hanging around or what is happening at home, via the connected smart cameras. With the built-in mic and speaker, users can even talk to the stranger via the two-way communication feature if needed. This mechanism increases the difficulty for a stranger to enter the premise and reduced the response time when backup needed. Therefore, IoT-SHT improves home security and was noted by many participants, like P9:

> An Internet connected home security system is better than the traditional ones as it can tell exactly which sensor is warning together with real-time video, instead of only telling that an alarm was triggered. So, IoT-SHT enhanced my home security overall (P9).

(3) Time-saving is defined as the enhancement of time utilization for other activities [82]. This has been noted by several participants, like P10:

> After using a robot vacuum, I have lesser household works to do now. So, I can do other things with the extra time earned (P10).

(4) Fun is defined as the experience of amusement, enjoyment, resulting in pleasure [83]. This has been noted by several participants like P5:

> I can simply play any song by just saying the song name to my smart speaker, it is so easy and fun, I enjoy using it (P5).

(5) Improved family care is defined as a higher chance for informal caregivers to offer superior support to their family members [84]. IoT is like an enhanced version of the human senses; it enables people to see and hear even when thousands of miles away. IoT-SHT allows people to take care of their family members even when they are not physically around. This has been noted by some participants like P8:

> I use a baby camera to watch my baby girl while she is sleeping in the bedroom. The camera is built-in with mic so I can hear if she wakes up or cries. It reduces my anxiety when having a shower or getting kitchen chores done. The camera free me from stress while baby's safety is still ensured (P8).

(6) Improved self-image is defined as others' improved perception of one self's abilities, characteristics, limitations, and personality [85]. The IoT-SHT has created a futuristic atmosphere for modern living, and this makes its occupants feel technologically advanced, and subsequently, it won the positive evaluation of the others [86]. This was also verified by some participants, like P7:

> After demonstrating to my friends, my voice controllable and automated smart home, they feel happy for me because I can live in a futuristic house like Tony and Jarvis in the movies (Ironman and his AI powered virtual household butler). It is sci-fi to my friends, but already a reality for me.

(7) Improved Living Environment is defined as the improved condition of the living environment for occupants to live a healthier life at home [87]. The

IoT-SHT not only monitors the quality of air and water at home, but also improves it by providing a cleaner and healthier place to live. According to P3, the air smells bad during haze season caused by the forest fires. But after using the air purifier at home, the in-door odours are gone. The air purifier effectively improved his living condition:

> A clear benefit during the haze season is the smart air purifier which helped to remove the bad smell in the air. Its activated-carbon HEPA filter effectively improves the in-door air quality. The unpleasant hazy smell gone in around 30 min after the air purifier is started.
>
> According to P5, he cleans the floor three times a week. But after using the vacuum robot, the floor was cleaned every day, at least once a day. Therefore, the cleanliness at home has been improved significantly after using the robot: Vacuum robot was scheduled to do cleaning every morning and it did increase the cleanliness of the floor significantly (P5).

(8) Improved health tracking is defined as a better health monitoring practice supported by electronic devices and communication. It refers to a broad range of health care aspects including remote monitoring, and health knowledge management [88, 89]. This has been noted by some participants, like P2 and P5:

> My smart watch will alert if I sit for too long and tell if I need to move more by measuring the steps I taken, distance travelled, and fat burned. It even motivates me by comparing my activity data with my friends and family. Slowly, the smart watch leads me to a healthier lifestyle (P2). As shortness of breath is a possible symptom of COVID-19, I bought an Apple smart watch which is built-in with oximeter, and so I can get help immediately if my oxygen level is getting low, which means I could be infected by the virus (P5).

(9) Improved companionship is defined as the stronger feeling of participation in each other's life through ease of daily activity sharing [90]. The real-time video streaming and voice calling features of the IoT-SHT eased the communication between members of the family, thereby enhancing their involvement in each other's life. This has been noted by some participants like P1:

> During the pandemic, we work from home. I make video calls to my girlfriend 12 hours a day using a smart camera and computer. We accompany each other by keeping the video call alive and we do our own work, respectively. I feel like she is just sitting beside me (P1).

(10) Improved sense of closeness with someone is defined as a stronger sense of closeness established between family members [91]. Smart home serves as an infrastructure and a medium for people to establish, maintain, and enhance relationships, with friends and family [92]. The IoT-SHT shortens the psychological distance, making people feel closer with each other [93]. This was confirmed by few participants, like P5:

> Amazon Echo Show is a device like a camera but with a screen, mic, and speaker on it. When I am busy working in the office and I miss my son, it allows me to watch, video call, and even interact with him, like I can remotely turn on the light, air conditioner, and TV for him with the app. I feel close with my son even I am away from home (P5).

(11) Energy-saving is defined as the constant improvement of energy consumption which aims for better energy conservation and efficiency [94]. IoT-SHT can reduce energy use at home by turning off unused lightings, and home appliances automatically. This has been noted by some participants, like P6:

> On average, the system reduces about 10% to 20% power usage of my home every month. It can show the energy consumption one by one, and I can check when there is a spike in usage. MAybe something is broken, or maintenance is needed (P6).

(12) Improved home safety is defined as the reduced danger or risks at home so that occupants can have better self-protection, be more cautious, careful, and better able to stay in a safer state, both physically and emotionally [95]. This has been noted by a few participants like P5:

> The smoke detector and gas sensors installed at my kitchen make me feel safer especially when I go overseas. Because I have had a bad experience with cooking fire. My wife forgot to turn off the fire before leaving home, and it burned out, luckily the system warns instantly by sending notifications on my smartphone. Immediately I call my neighbor for help. I remotely unlock the smart door lock for her to enter and put the fire off (P5).

(13) Comfort is defined as the state of mind that expresses satisfaction with a living environment [96]. This has been noted by a few participants, like P2:

> … The sensor-activated lightings and air conditioners maintains the level of comfort at home (P2).

(14) Improved lifestyle is defined as a more favourable living pattern at home with more optimized daily routines [97]. Smart home is not only a technological product or service, but also a place where people lead

their everyday life, and it could affect one's lifestyle [98]. This has been noted by participants such as P5:

> Last time before I use smart home system, when I reach home, I press the buttons one by one to switch on the lights and air conditioners. Now, before I reach home, I use smartphone to activate the Welcome Mode, so everything will turn on automatically before I open the door (P5).

(15) Improved sense of belongingness to a family is defined as having a clearer family identity [99], or a stronger sense of unity [100] that psychologically ties people together [101]. This has been noted by participants like P3:

> ... I got three sisters and they are married. We are all living at different places, no one living together with my parents. But we all have access to the smart cameras installed at parents' home. This helps us to keep in touch and gives us more topics to talk and discuss about our parents with each other. The smart camera makes us feel that we all still living together like last time when we still a kid (P3).

datasets generated during and/or analysed

Table 3 summarizes the 15 benefits (impact) based on the frequency of being mentioned during the interviews.

6 Discussion

By interviewing the actual users, various common IoT-SHT uses among Malaysian consumers were identified. The study found the consumers mainly use IoT-SHT for home automation, remote control, remote surveillance, remote sensing, and entertainment purposes. Aligned with previous studies, home automation is a very popular core function of smart home system and it is defined as the automated controls of building's electrical devices with the objectives to improve comfort of the occupants, increase energy efficiency, and to reduced operational costs [35]. On the other hand, this study grouped the identified IoT-SHT usage for remote surveillance and remote sensing into one, namely remote monitoring, as both observe the environment either in the form of video footage from the surveillance cameras, or data from sensors [102]. Similarly, this study further grouped IoT-SHT usage for remote control and remote monitoring into one, namely real-time remote operations since they were sharing a similar concept, which is to enable its users to operate some devices at home remotely, or from a distance in real-time via the internet. Real-time remote operation is defined as the process of operating, controlling, and monitoring of devices that were installed at a field in real time, from a remote location [103]. Importantly, this study identified a less popular but potentially trending usage which was missed from previous studies, namely Family Communication [104, 105]. Family Communication is defined as the social communication between a family member to another for inconsequential conversation, keeping in touch, sharing of every day's life matters, and sharing of information

Table 3 Impact Retrieved from the Interviews

Impact	Interviews											Freq.
	1	2	3	4	5	6	7	8	9	10	11	
Improved convenience	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Improved home security	✓	✓	✓		✓	✓	✓		✓	✓	✓	9
Time saving		✓					✓		✓	✓	✓	5
Improved family care			✓	✓				✓			✓	4
Improved self-image					✓	✓	✓				✓	4
Improved living environment			✓		✓				✓		✓	4
Improved health tracking		✓		✓	✓						✓	4
Improved companionship	✓	✓		✓							✓	3
Improved sense of closeness with someone			✓		✓			✓				3
Energy saving	✓				✓	✓						3
Improved home safety			✓		✓						✓	3
Improved comfort		✓	✓		✓							3
Improved lifestyle		✓	✓		✓							3
Improved sense of belongingness to a family			✓		✓			✓				3
Improved fun					✓	✓	✓					3

[78]. Therefore, the research question 1 (usage of IoT-SHT in Malaysia context) was thus answered, and the summary of the coding, unitization, and categorization of the main themes of IoT-SHT usage is further visualized in Fig. 1.

With respect to impact, the findings of this study are consistent with previous studies. IoT-SHT had improved the living environment at home by providing cleaner air and water with smart filters, enhancing home security with real-time intrusion detections, improving home safety with a variety of IoT sensors, and improving the quality of health, wellness, and fitness with real-time monitoring using wearable gadgets [106–108]. Hence, areas being improved, such as home security, home safety, health tracking, and living environment were classified under the "foundational well-being" facet of the IQM because it is critical for the biological entity to feel safe, be healthy and to survive without threats in life. This finding is consistent with the smart city concept which aims to provide a sustainable habitable ecosystem to its citizens [109].

During the COVID-19 pandemic, smart cameras are playing a vital role to maintain distance relationships of couples, enabling companionship with a 24/7 real-time video communication that allows them to share their daily living activities with each other, from time to time [91]. Connected cameras provide family members or other caregivers some comfort, especially if built in with microphones and speakers are used for two-way communication in real time as audio chatting is a great way to stay connected with them. The pandemic and MCOs created an opportunity for IoT-SHT to penetrate and accelerate the adoption and use of IoT-SHT [110]. The IoT-SHT is defined as a virtual community, which can create a virtual reality space for a family to live in, regardless of where they live in real-life, whether under the same roof or apart [78]. In other words, IoT-SHT helped people to form a family identity [99] which can psychologically house them together in a virtual home environment [101]. Therefore, the improved companionship, improved sense of closeness to someone, and improved sense of belongingness to a family were grouped under the "psychosocial well-being" facet of the IQM. This finding is aligned with Wilson's (2018) study, which found that personal use of digital technologies did improved sense of belonging to society, family, and friends, subsequently lead to higher life satisfaction and successful independent living in their later life [111].

The study results also show that IoT-SHT has changed how people live at home by optimizing their daily routines like never before [97]. For example, IoT-SHT users can pre-cool their house in advance before reaching home; the system can authorize access for delivery men to the front yard even if owners were away from home. In other words, IoT-SHT improved people's lifestyle, making the interactions between users and their homes more efficient compared to people who do not have a smart home system installed [112]. Moreover, IoT-SHT also efficiently reduces energy consumption and carbon dioxide emission, thereby benefitting the environment in the long run [113]. The use of IoT-SHT like AI-based energy management automation [114], and solar powered control systems [115] not only reflects their personal competence in helping the environment by saving energy, but also in winning them positive evaluations through sustainable living [10]. Subsequently, using the IoT-SHT improved occupants' self-image due to novelty of this innovation [98]. According to the interviews, IoT-SHT further improves a person's perceived usefulness, thereby enabling cyber-physical family care to their elderly parents and children like never before. This can be achieved through the ubiquitous remote sensing, surveillance, and control functions [116]. For example, access can be authorized during emergency and doors can be unlocked when needed like for their children who had just returned from school. TVs can also be turned off for their parents who live apart, when they fall asleep after watching for hours. In contrast to the common impact on energy saving and people's lifestyle, family care was unveiled as an alternative usage of smart cameras other than its traditional security purposes. Interestingly, this study found that psychologically people tend to feel proud and lavish for having IoT-SHT. Therefore, improved lifestyle, improved self-image, improved family care, and energy saving were classified under the "status" facet of the IQM. This finding is consistent with a review paper of smart home and communication technology for disabled people which found that IoT-SHT did improved people's self-esteem, self-usefulness, and self-identity through assisted independent living, reduced caregiver's burden which subsequently lead to higher QoL [117].

Consistent with previous studies, this study also found that time saving is one of the most impactful benefits of IoT-SHT [118], which helped people to maintain efforts to reach their own goals, thereby enabling them to follow their own interests (music and video entertainment), gain pleasure (convenience), and obtain more comfort from the surroundings they live in [38]. The ubiquitous characteristics of the IoT-SHT enabled people to remote access their homes at any time, from anywhere, and whenever they want to. Likewise, the AI-powered virtual assistant which is always on stand-by, permits users to control their homes through voice control, without even lifting a finger [119]. The findings of the study show that IoT-SHT has empowered home management, bringing convenience to its users [120]. The automated home appliances like vacuum robots [121], and cooking robots [122] helped people to save time and be able to use the time to do other tasks, thereby allowing them to follow their own interests or hobbies. Based on the study results, IoT-SHT also created joy to homes, offering an on-demand multimedia entertainment contents sourced from the internet via connected home appliances like smart

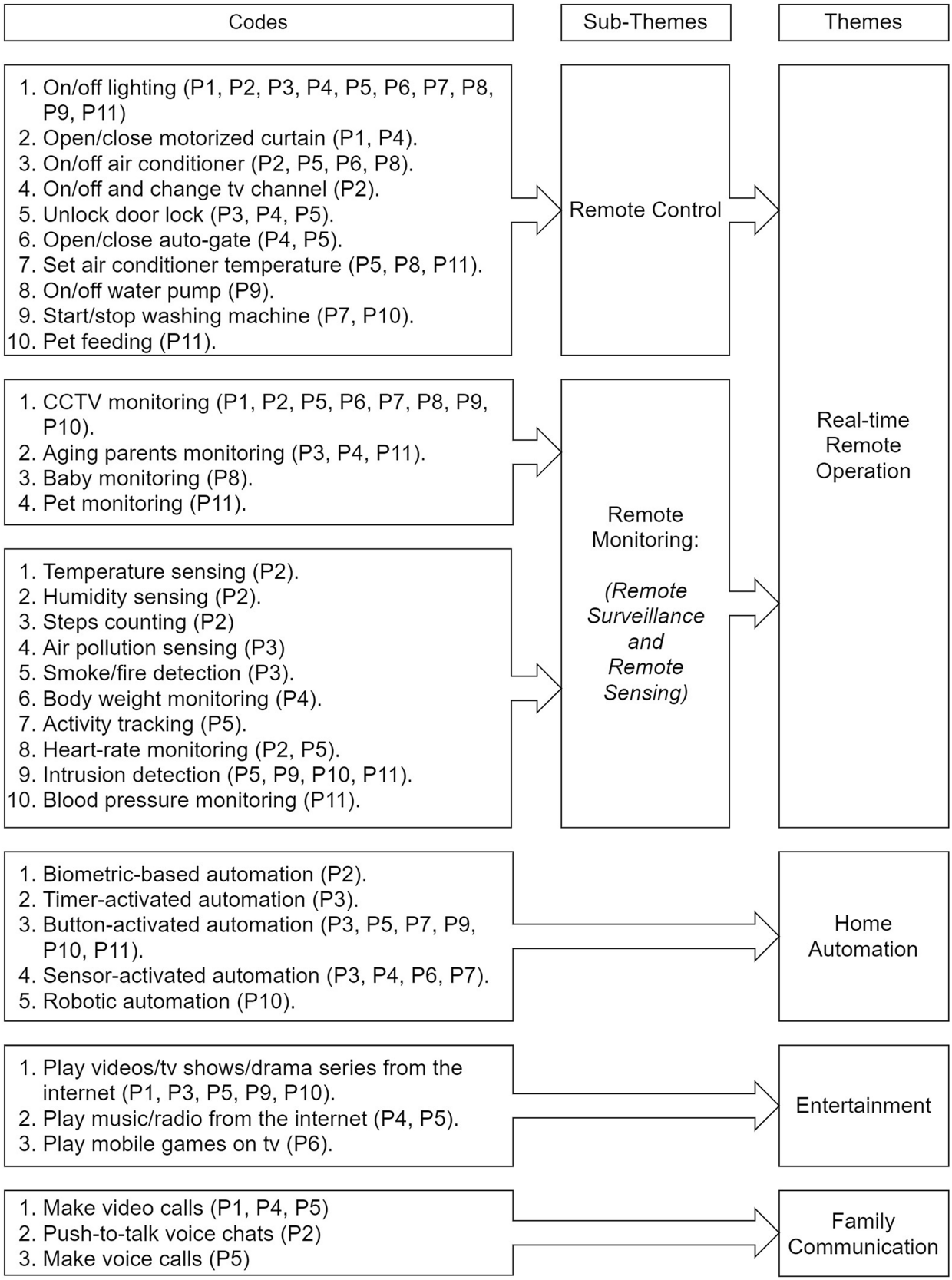

Fig. 1 Initial codes, subthemes, and themes of IoT-Usages

TVs [123], and smart speakers [124]. For example, Netflix, the most popular subscription video-on-demand service provider [125], uses machine learning algorithms to learn their customers' interests and recommend videos that are relevant to users. Although AI has improved the customer experience, it may also centre a narrow selection of videos which overrepresents the actual interests of a user [126]. Also, streaming services could deny people from accessing broadcast television programmes which they used to watch, and the situation becomes worse due to inflation, when people have to cut back on subscription services as cost-of-living rises.

Home automation offers a variety of IoT-SHT sensors which were created to offer a highly comfortable living environment through auto-adjusted lightings [127], climate controls [128], and automated shades [129]. Therefore, the study identified several benefits of IoT-SHT usage such as improved comfort, improved convenience, time-saving, and fun were parked under the "autonomy" facet of the IQM. These benefits were highlighted in a study by130 who investigated the smart home acceptance among older adults and found that older adults prefer technology that provide benefits like comfort, convenience, time, and cost efficiency which can lead to better QoL.

Research question 2 (IoT-SHT impact on QoL) was thus answered, as visualized in Fig. 2.

According to the participants, the remote surveillance feature is the most used IoT-SHT function as home security is a big worry for most Malaysians. There were 14,040 break-in and theft cases in 2020 [131] all over the country. The findings show that IoT-SHT is effective in keeping homes extra secure, capturing every moment and pop-up message on the user's smartphone when motion is detected. Moreover, although IoT is a communication technology, the family communication feature turns out to be the least used function among Malaysians compared to the others. This may be due to their service limitation in Malaysia. For example, the Google voice assistant can make free calls between the smart speakers while for local calls, it only works in the USA and Canada but not Malaysia at the moment [132]. The adoption and use are expected to increase when the smart product makers expand their service area coverage to Malaysia.

Drawing from the input by the participants, it was found that the use of smart products for power management or energy saving is not common in Malaysia because in general, there is a lack of energy saving awareness among Malaysian households [133]. Due to the same reason, the use of IoT-SHT exerted a relatively weaker impact on the users and this is in line with the findings by Alkawsi et al. [134].

The system prevents energy waste by controlling the air conditioners, lights, and home appliances intelligently, but it consumes energy too to maintain the functions of smart home systems that need continuous energy supply to power all the smart equipment and IoT sensors 24/7. Energy saving can be achieved only if the net balance between energy saving for the use of home appliances and the energy consumption by the IoT-SHT system itself is accounted appropriately.

By comparing the areas being enhanced after using the IoT-SHT, improved home security has a powerful impact on people's every day's life. It shows that security and safety is very important to the people in Malaysia. Using Maslow's hierarchy of needs as a metaphor for the development of a country, Malaysia is still at the foundational level. More resources are needed to be allocated to the above-mentioned issue for the benefit of all. As mentioned, 87.4% of Malaysians are internet-connected and 93.1% of them are connected using mobile devices [135]. Compared with other countries worldwide, Malaysia was ranked number nine in average amount of time spent per day on the mobile internet (3 h 14 min). With the great mobile technology readiness, potentially Malaysians will pick up the adoption and use of IoT-SHT with appropriate localized marketing strategies and products [18].

7 Study implications

7.1 Theoretical implications

Previous studies on IoT adoption and impact found that smart home could improve people's QoL in general [136–139], whereas this paper extends on the current knowledge body in the smart home domain by retrieving in-depth information from the real experiences of actual users. First, this study proposed an IoT-SHT usage-impact model that unveils the relationship between the actual usages of the technology and QoL areas that being improved among actual users in Malaysia. Second, the model rationalized the impact in terms of QoL to four aspects of the Individual QoL model which is grounded on the Theory of Motivation by Maslow's hierarchy of needs [45]. The outcome helps to understand how QoL of users in developing countries like Malaysia can be increased by leveraging on the IoT-SHT into their daily lives. It is useful and important to know psychologically the elements that were perceived, valued, and prioritized by people in IoT-SHT adoption. Third, IoT-SHT can be considered as an all-rounder technology which is able to fulfil users' needs from the fundamentals to the higher ones, leading to QoL improvement. Therefore, perceived quality of life as a construct is suggested to be included in future IoT-SHT adoption studies [140, 141]. The rationalized findings are visualized in Fig. 3.

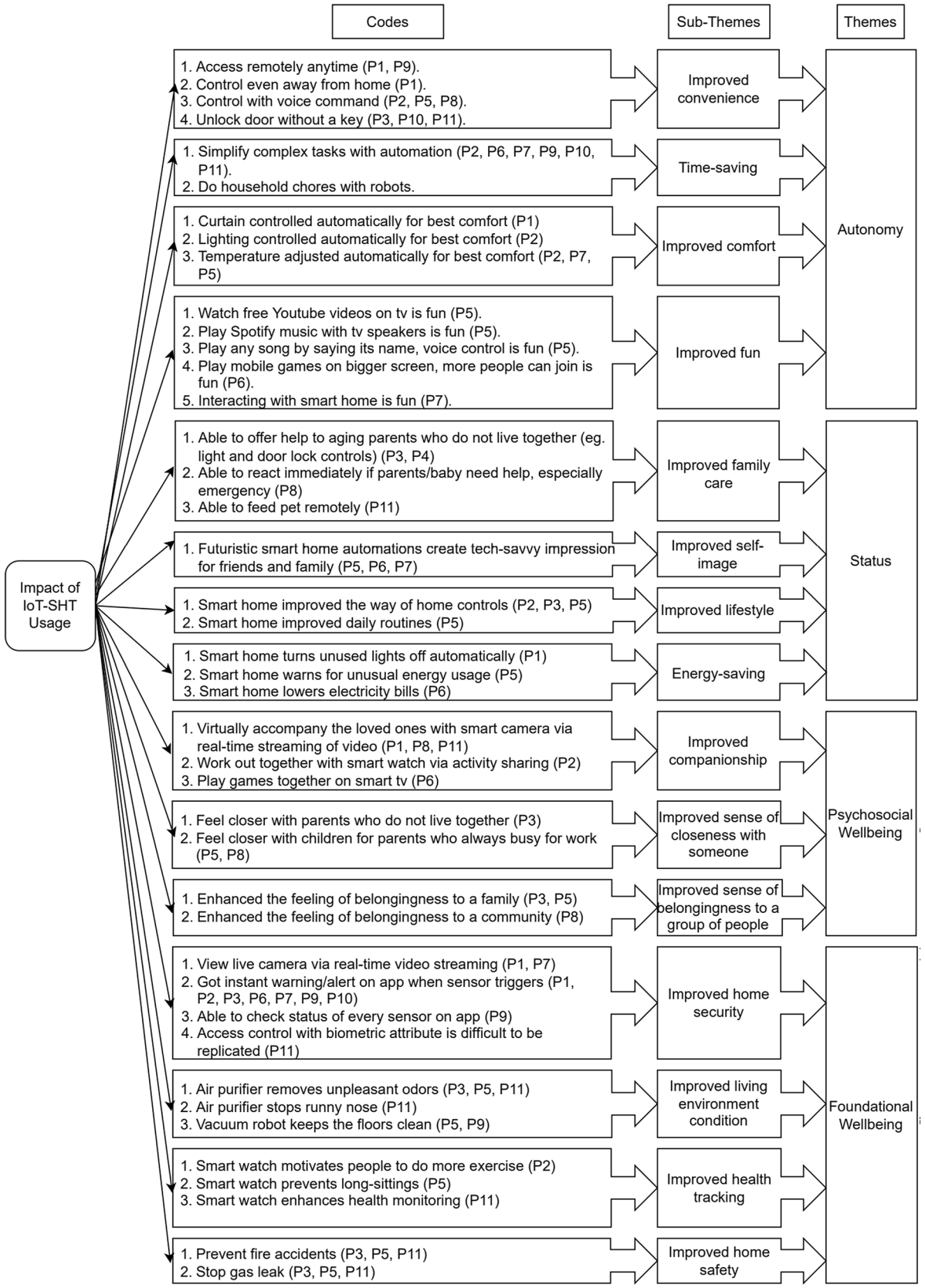

Fig. 2 Initial codes, subthemes, and themes of IoT-Impact

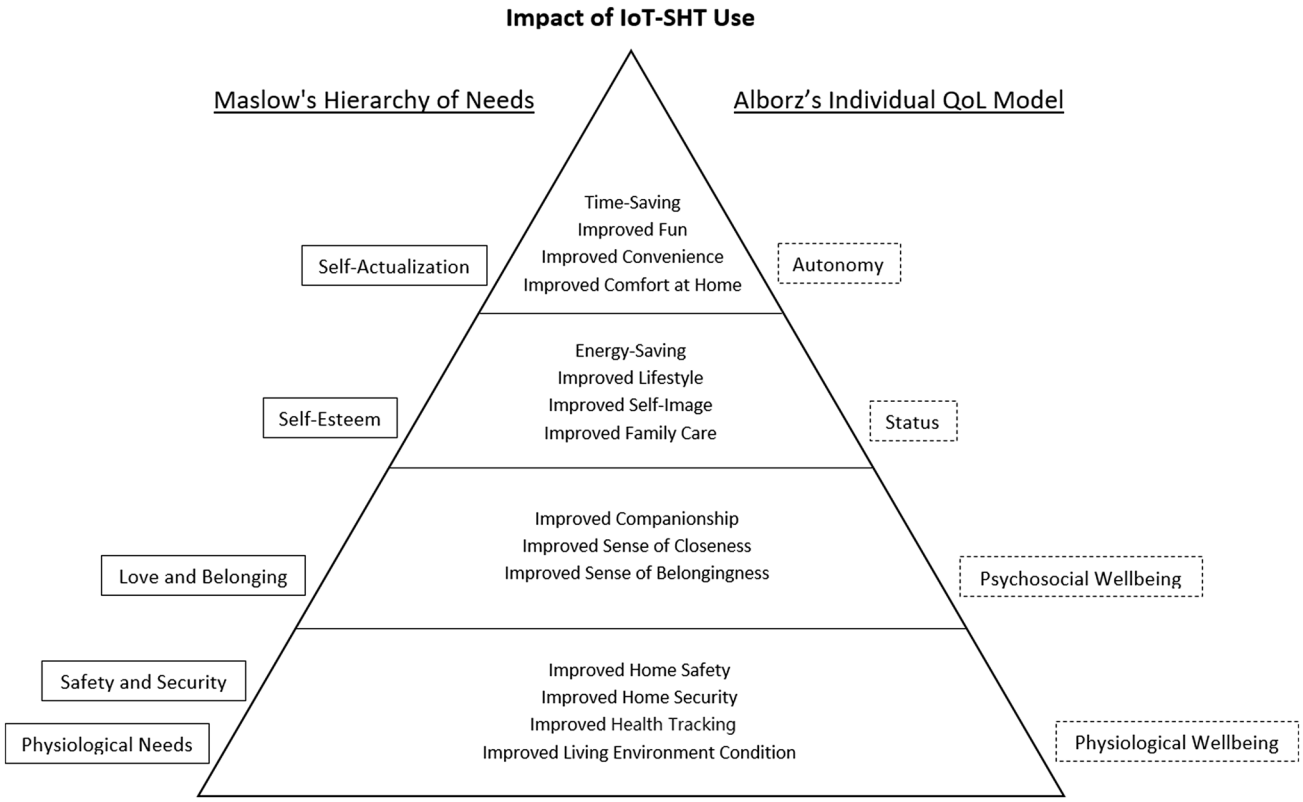

Fig. 3 IoT-Impact based on Alborz's Individual QoL Model and Maslow's Hierarchy of Needs

7.2 Practical implications

The data derived from the interviews have shown that the usage of IoT-SHT fits into the lifestyles of the users in the context of Malaysia; the usage also benefitted the users by adding value to their lives and homes. First, this information thus offers insights for improvements of the IoT-SHT products, services, and designs. In this regard, the IoT-SHT makers and vendors can expand the range of the IoT-SHT so as to suit more user segments of the Malaysian market, thereby accelerating its acceptance and usage overall. Second, technology makers are strongly recommended to focus, highlight the remote control, and remote surveillance related functions in R&D and marketing for better business results, as they are the most common and popular IoT-SHT usages among users in Malaysia. Third, the majority of participants did not experience improvement in companionship, closeness, and belongingness with family members; thus, technology makers are suggested to enhance these IoT-SHT features which are important in improving the social aspect of their QoL. Fourth, the energy saving feature is available in Malaysia, but its effect is not significant according to the findings; immediate enhancement is needed as energy saving is one of the most popular usage in some other countries like UK, and it could be the same to Malaysia [142].

8 Limitations and future work

The strength of this paper is also its weakness since this study focussed on people who are the actual users with a minimum two-year usage experience of IoT products and services. In other words, the IoT products and services used by the interview participants could be outdated and this implies that the latest information regarding IoT could be missing since the IoT is evolving very rapidly due to quicker product development and iterations. Although purposive sampling may lead to information bias, this is suitable for the context of the present study which requires an in-depth investigation of actual usage experience [143]. With regard to sample size, 11 participants represent a small sample size, nevertheless acceptable based on qualitative interview guides [63–66]. IoT-SHT is still new in Malaysia, and it was difficult to get a large number of experienced actual users to participate in the interviews. For better understanding, this study suggests the use of statistical techniques like structural equation modelling to model and quantify the usage-impact relationship in order to determine the IoT-SHT QoL indicators, develop measures, and assess the users' QoL, to confirm the results on the level of QoL through the usage of IoT-SHT.

9 Conclusion

The IoT has emerged to be a part of people's everyday life in today's digital era. It also serves as one of the drivers for IR 4.0; it has influenced every aspect of the human life. Due to its enormous benefits to humankind, the IoT-SHT should be the focus of all researchers. A total of four usage types and fifteen impact factors were identified from this study, and the impact of the IoT-SHT usage was rationalized into four facets in order to provide details on how the QoL of people can be improved through the IoT-SHT. In order to attain greater knowledge interpretation of a social context, it is suggested to conduct quantitative studies such as questionnaire surveys which involve more people to understand statistically the relationship between the use behaviour and consequences in order to generalize the findings of this study across wider group of people. Due to the rising concern around consumer data and privacy, this study also suggests investigating the negative influencing factors such as the uncertainty of the IoT network and change resistance of lifestyle in order to clear the worries and doubts of potential inexperienced users to start using the technology. The same applies to impact study: researchers are encouraged to delve into the negative consequences like the development of laziness habit and the addition of smart technology [144].

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Data availability statement The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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