

RESEARCH ARTICLE

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The social issues of smart home: a review of four European cities' experiences



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Abstract

The urban industrialization trend and the increasing urban population have posed global and local concerns related to urban management. Today, scientists introduce the “smart city” concept, among many others. The primary concept purpose is to empower cities to enhance the quality of life of their residents. To achieve this, one of the smart city components named “smart living” has a direct connection to citizens' quality of life. This research aims to analyze the smart home as one of the sub-components of smart living. Consequently, based on the “smart home” residents' viewpoint, the main question is which social barriers are more critical?

To achieve this essay's objectives, the researcher conducts three phases: data collection, analysis based on the constructed conceptual model, and results. The researcher selected four leading smart cities in Europe, including Copenhagen, Berlin, London, and Barcelona, as case studies. The study collected primary data by cluster-random sampling by utilizing a questionnaire survey with 320 participants. In conclusion, according to the inhabitants, the research results list the most significant social challenges in smart homes. Eventually, suggestions offer for reducing the side effect of living in a smart home.

Keywords: Smart city, Smart home, Smart home technology services, Social barriers

Introduction

The world has witnessed an increasing accumulation of its people in urban areas since 1990. This trend is not new and represents a substantial increase in urban residents' number, from an approximate average of 57 million between 1990 and 2000 to 77 million between 2010 and 2015 [1]. It poses significant challenges for the environment and social sustainability. Also, the contemporary structure of cities is a source of environmental and social dilemmas. Cities consumed approximately 70% of the world's resources and are also significant users of energy resources. Hence, they became the main contributors to greenhouse gas (GHG) emissions. The growth of the urban population and the intensity of economic and social activities are triggering this crisis. It is also a consequence of the built environment inefficiency. Current research in urban and academic circles focuses on sustainability in urban planning. Besides, they try to

address the main urbanization challenges and the unsustainability of existing structures [2]. The smart cities concept emerged as an appropriate solution to this unprecedented urbanization and the need for sustainability. Therefore, this idea attracted plenty of academic interests in this field [3]. The International Telecommunication Union Focus Group on Smart Sustainable Cities (ITU-T FG-SSC) introduced a definition, which reads as follows: “A Smart Sustainable City is an innovative city that uses Information and Communication Technologies (ICTs) and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness while ensuring that it meets the needs of present and future generations concerning economic, social, environmental as well as cultural aspects” [4]. One of the components of the smart city concept is “smart living.” I will explain these criteria in the following sections. The smart home is one of the essential sub-components of this component, which splits into two sections: (1) state-of-the-art technologies and applications and (2) the behavior of the residents who live in

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these homes. It is crucial to note that city dwellers have contradictory comments about smart home applications. According to the research findings, the way to overcome the social barrier and to communicate with state-of-the-art technologies is the key worry of smart home residents. This research aims to find the most concerning social issues for smart homeowners. For this purpose, four European cities (Barcelona, Copenhagen, Berlin, and London) select as case studies. Finally, this study suggests several recommendations to reduce identified social issues.

Literature review

Smart city

The idea of smart cities was rooted in the 1970s when a digital configuration based on technology and non-material structures embedded in the urban physical spaces. Afterward, the new aspects of everyday life have been concentrating on more complex innovations. Broadband networks and collective intelligence determining the city development supported these new technologies [5, 6]. There are different views regarding the origin of the concept of “smart city” in the literature. According to Caragliu et al. (2009), “The city could be smart when investments in human and social resources combined with traditional and modern ICT infrastructures boost sustainable economic growth and high quality of life, with wise natural resource management through participatory governance [7].”

Globalization trends and emerging new technologies are increasingly influencing urban and regional environments. ICTs are also heavily involved in the management and governance of cities. Authorities and planners use these innovations as tools and services to promote the quality of life, promote a sustainable development, and create a more dynamic and innovative urban landscape [7]. Over time, scholars, institutions, and large corporations provide expressions such as digital, smart, ubiquitous, wired, hybrid, information, creative, learning, humane, knowledge, and smart cities. The significant purpose is to describe the renewed configurations adopted within the local context [8].

Smart city definitions

There are different views regarding the origin of the concept of “smart city” in the literature. According to Garby (2014), the roots of the concept date back to the 1960s, and in urban development plans, it figures in proposals for networked cities since the 1980s. Also, Dameri and Cocchia (2013) claimed that specialists introduced this concept in 1994 [9]. The roots of this term, according to Neirotti et al. (2014), can be traced back to the late 1990s smart growth trend [10]. That said, it involves growing urban efficiency-related to energy, transport,

land use, communication, economic development, service delivery, and so forth. A smart city is an effective strategy focusing on the ICT-based leadership of metropolitan areas [11]. The technological dimension is currently significant in the smart city definition: innovative approaches focused on the Internet network are the basis for a smart city. Besides, the development of a high-quality infrastructure for urban ICT is an integral part of a smart city. Coherent research produced by technology suppliers highlights the importance of this component. Furthermore, it claims that private companies engaged in telecommunications, transport, software, informatics, and electricity are pushing forward the smart city concept [12].

Two of the most relevant concepts will sum up the various variables that define the conceptualization of smart cities:

1. We believe that a city is smart when investments in human and social capital and conventional (transport) and modern (ICT) connectivity networks boost sustainable economic growth and high quality of life through participatory governance, wise management of natural resources.
2. The more recent interest in smart cities can be due to concern for sustainability and the emergence of new Web technologies, such as mobile devices, the semantic internet, cloud computing, and the Internet of Things (IoT), which facilitate the real-world user interfaces [13].

The central point posed by numerous scientists in the smart city concept is the role of ICT in today’s cities and the need to enhance emerging technologies. They claim that improving the quality of life of citizens is inevitable without access to these technologies.

Smart city features

The concept “smart city” is a bit fuzzy since it encompasses a wide range of dimensions and characteristics. According to Nam and Pardo, there are many definitions and considerations relevant to smart cities that contribute to technological, human, and institutional aspects (2011) [14].

Smart cities include the human capital variable as the main element of increasing interest in knowledge-based financial growth and innovation. In addition to being a “new engine” for sustainable development, the involvement of a trained and professional population and workforce is an essential component of this concept. The smart city’s employees should be well-trained and creative, with access to other knowledge-sharing opportunities [15–17]. The combination of technical and human dimensions allows for the development of a

technologically advanced and imaginative network. It is a common strategy to achieve urban development and de-industrialized finance. The utilization of development and social capital through “smart urban communities,” composed of firms, education, government, and individuals, depicts the smart city’s organization. These communities benefited from ICT and human capital to engage all participants to innovate and beneficially alter the urban environment [14, 18, 19].

Smart city characteristics

According to studies, a smart city would have five key components: contemporary technologies, buildings, utilities, transportation, and road infrastructure. In terms of technology, a smart city is a long-term collaboration between government, government institutes, and private companies to develop and implement computerized platforms. This cooperation is concerning with strengthening contemporary technologies, including mobile cloud computing, digital documents, networks, and emerging decision-making methods [20, 21].

Smart city notions are as broad as the number of smart cities. Besides the three dimensions explained in Table 1, the following six characteristics should include “smart economy,” “smart people,” “smart governance,” “smart mobility,” “smart environment,” and “smart living” Those three dimensions influence the outcomes of the six characteristics. Table 2 shows the theories and the characteristics of each of these six characteristics [14]:

Smart living is one of the characteristics of the smart city, according to the table, and the crucial purpose of this component is to boost citizens’ quality of life. There are also other aspects of smart living, such as education, safety, and social cohesion.

Smart home

As stated, the primary goal of smart cities—especially smart living component—is to improve the quality of life of citizens. In this regard, one of the practical

Table 1 Dimensions, concept, and factors of “smart city” [14]

Dimensions	Concepts	Factors
Technological	Digital city Intelligent city Ubiquitous city Wired city Hybrid city Information city	Physical infrastructure Smart technologies Mobile technologies Virtual technologies Digital technologies
Human	Creative city Learning city Humane city Knowledge city	Human infrastructure Social capital
Institutional	Smart community Smart growth	Governance Policy Regulations

recommendations for achieving smart living is the idea of smart homes. One of the realistic alternatives to implementing smart living is the “smart home” idea. Its principal goal is to combine system, service, and management to provide people with an efficient, comfortable, safe, accessible, and environmentally friendly living environment.

Smart home definitions

Scientists used multiple notions to describe and conceptualize smart homes (Table 3). Among various approaches, the definition by Aldrich (2003) and Lutolf (1992) dealt inclusively with the nature of smart homes. A smart home, according to Aldrich (2003), is “a house designed with computer and information technologies that anticipates and responds to the needs of the inhabitants, functioning to facilitate their comfort, ease, security, and entertainment through the management of home technologies and connecting to the world beyond.” This definition encompasses the phenomenon’s technical component, as well as the services and functionality it provides. It is worth noting that smart homes would respond to a wide range of attitudes [23]. Besides, Lutolf (1992) described a smart home as “integrating various facilities through the use of a communication scheme in a home. It ensures an economical, safe, and comfortable home operation and involves a high level of smart functionality and flexibility.” [24] Although the two definitions share similar viewpoints, they differ in terms of the technology’s capabilities and the types of customers it seeks to serve. Many academics associate smart homes with technological features in general [25].

As mentioned above, there are differing views on the idea of the smart home. The author’s point of view in this article is closer to the theories of Aldrich and Lutolf. According to these two scientists, the smart home theory is based on the use of ICT and houses equipped with computer and information technologies. Also, the author considers two factors of functionality and flexibility in this article.

_ Smart home types of services:

Researchers used practical analyses to evaluate these home technologies, which would provide a variety of services to residents. The below are some of the smart home’s core features:

- (1) The smart home has the potential to improve the consumer and power grid relationship. It assists in data collection on power use, energy costs, and an energy use plan establishment. Smart homes also monitor the efficient use of resources and promote family awareness of energy conservation and environmental sustainability.

Table 2 Smart city characteristics [14]

Characteristic	Theory	Feature
Smart economy	Regional competitiveness	Entrepreneurialism, innovation, International integration
Smart people	Human and social capital	Flexibility, creativity, tolerance, qualification level
Smart governance	Participation	Transparency, participation in decision-making, quality of political strategies
Smart mobility	Transport and ICT economics	Accessibility, ICT availability, modern and sustainable transport systems.
Smart environment	Natural resources	Sustainable resource management, natural attractiveness, lack of pollution
Smart living	Quality of life	Educational, cultural and health facilities, safety, housing, social cohesion, tourist attractions

- (2) A smart home can enhance the lifestyle by promoting home security, safety, accessibility, and interactivity.
- (3) A smart home could support remote payment.
- (4) Smart homes can use a computer, a mobile phone, and a remote network to monitor and connect with the house.
- (5) Smart homes consider the real-time meter reading and security service of the water meter, electric energy meter, and gas meter to provide more efficient and high-quality services.
- (6) Supporting the “triple networks” industry and providing the ideal smart service [26].

In recent years, numerous scientists have conducted studies on smart home services, functions, and devices, as seen in Table 4. The majority of the reviewed papers (41 articles) discussed ensuring a comfortable life. After that, most studies related to the monitoring service (31 references). In contrast, fewer articles focus on health

therapy and the supportive functions of smart home technology. Only two papers discuss the consultancy service that smart sensors provide [22].

“Smart city” and “smart home” connection

The connection between smart cities and smart homes requires multiple applications across numerous fields. There is a term that defines this connection unequivocally, and that is “big data” (<https://www.smartcity.press/how-smart-homes-can-connect-smart-cities/>). Data generates from multiple sources resulting in the formation of what is currently known as big data. Data sources are ubiquitous around us as smartphones, computers, environmental sensors, cameras, GPS (Geographical Positioning Systems), and even city dwellers. Multiple applications like social media, digital pictures and videos, commercial transactions, advertising applications, games, and many more exacerbated data generation in the past few years [27, 28].

Table 3 Definitions and characteristics of smart homes [22]

Definition based on a theme	Aldrich (2003)	Lutolf (1992)	De Silva et al. (2012)	Reinisch et al., 2011	Scott (2007)	Balta-Ozkan (2014)	Chan et al. (2008)	Diegel et al. (2005)	Alam et al. (2012)
Technology									
Sensors						*		*	
Devices					*	*		*	*
Integrated systems	*	*	*	*	*	*	*		
Services									
Control/monitor			*	*		*		*	
Energy management	*	*		*	*			*	
Support and assist							*		*
Anticipate and respond	*								
Users' needs									
Cost-efficiency		*		*	*		*		
Comfort	*	*		*	*				
Emotional	*								
Security	*	*							
Healthcare				*			*		*
Quality of life	*	*	*	*	*	*	*	*	*
Sustainability				*	*				

Table 4 Smart home functions and devices [22]

Service	Function	Device	Source	
Comfort	Automation of daily routines	Dishwasher Washing machine Refrigerator Cooker	Chan et al. (2008); Arunvivek et al. (2015); De Silva et al. (2012); Alam et al. (2012); Diegel et al. (2005); Scott (2007); Chen et al. (2017); Balta-Ozkan et al. (2013b); Lach & PUNCHHEWA (2007); Martin et al. (2008); Kleinberger et al. (2007); Zwijsen et al. (2011); Kerbler (2013); Masuda et al. (2005); Das et al. (2002); Demiris et al. (2008); Demiris & Hensel (2009); Kyriakopoulos & Arabatzis (2016); Kiesling (2016); Aye & Fujiwara (2014); El-hawary (2014); Rahimi et al. (2011); Darby & McKenna (2012); Hargreaves et al. (2013); Faruqi et al. (2010); Park et al. (2017); Brandt et al. (2011); Yang et al. (2017); Jacobsson et al. (2016); Alsulami & Atkins (2016); Sun et al. (2010); Kim & Shcherbakova (2011); Fuchsberger (2008); Friedewald et al. (2005); Stringer et al. (2006); Wu & Fu (2012); Wilson et al. (2017); Bregman & Korman (2009); Cutler (2006); Triboan et al. (2016); Yusupov & Ronzhin (2010)	
	Remote home management	Closet/drawer/mirror Window/door/gate Mailbox/garden devices		
Monitoring	Intelligent environmental and sustainable services	Heat/gas/electricity/light		
	Smart leisure	TV/radio/home cinema		
Health therapy	Health and lifestyle monitoring	Infrared sensors Wearable sensors Wearable accelerometer Internal sensors (to monitor physiological signs) EGG (epileptic seizure, sleep disorder) Heart rate Blood oxygen level Blood pressure Blood glucose level Temperature	Chan et al. (2008); Arunvivek et al. (2015); Chan et al. (2009); Patel et al. (2012); Ranasinghe et al. (2016); Amiribesheli et al. (2015); Peetoom et al. (2015); Kim et al. (2013); De Silva et al. (2012); Demiris & Hensel (2008); Alam et al. (2012); Scott (2007); Martin et al. (2008); Kleinberger et al. (2007); Zwijsen et al. (2011); Kerbler (2013); Demiris et al. (2008); Kiesling (2016); Andoh et al. (2004); De Silva & Darussalam (2008); Kim & Shin (2015); Rahimpour et al. (2008); Steele et al. (2009); Percival & Hanson (2006); Damodaran & Olphert (2010); Chan et al. (2012); Kozt et al. (2009); Diegel (2005); Theoharidou et al. (2016); Courtney (2008); Chiang & Wang (2016)	
	Remote interaction	Telehealthcare	Chan et al. (2008); Chan et al. (2009); Patel et al. (2012); Amiribesheli et al. (2015); Alam et al. (2012); Brownell & Bradley (2003); Brownell & Hawley (2005); Kerbler (2013); Rahimpour et al. (2008); Percival & Hanson (2006); Damodaran & Olphert (2010); Chan et al. (2012); Kozt et al. (2009); Diegel (2005); Demiris (2004); Matlabi et al. (2012); Chang et al. (2009); Wells (2003); Hanson et al. (2007)	
	Remote therapy	Tremor delivery Drug delivery Hormone delivery		
	Support	Support patients with hearing issues	Alarm system based on visual signs Teletype machine Special electronic display screen Hearing-disabled persons Special display screen	Chan et al. (2008); Chan et al. (2009); Amiribesheli et al. (2015); Dorsten et al. (2009); Kleinberger et al. (2007); Zwijsen et al. (2011); Kerbler (2013); Masuda et al. (2005); Kyriakopoulos & Arabatzis (2016); Kiesling (2016); Alsulami & Atkins (2016); Sun et al. (2010); Fuchsberger (2008); Friedewald et al. (2005); De Silva & Darussalam (2008); Matlabi et al. (2012); Meng & Lee (2006)
		Support during a home rehabilitation	Robotic devices for rehabilitation	
	Support	Assist patients with mobility issues	Tailored interface Companion robot Mobility devices (electric wheelchair) Computerized voice generation (to communicate)	
		Support with socialization Patients with Visual disabilities	Robots Audible beacon Tailored screen Specially designed remote control (voice recognition)	
	Consultancy	Suggestions	Sensors	Paetz et al. (2011); Hargreaves et al. (2013)

The significance of big data is undeniable. In other words, big data has a critical effect on several aspects of smart cities and, eventually, on citizens' lives [29]. Smart city applications store information, and big data networks utilize this information. Also, big data systems gather information and process it to enhance the multiple services of smart cities. Big data will also help authorities to plan the development of smart city services. There are numerous instances of big data applications that serve the smart cities:

1 Smart education: Through education facilities, ICT offers solutions for improving the quality, efficiency, and profitability of educational systems. These facilities are adaptable in their use of information, better monitoring, and evaluation and expanded learning opportunities for citizens and stakeholders [30].

2 Smart traffic lights: one of the main features of smart cities is effective traffic flow control, which will improve transportation systems and improve the traffic patterns of citizens and the city as a whole [31].

3 Smart Grid: Smart grid is a vital component of smart cities. It is a reconstructed network that gathers and operates on existing data, such as information about suppliers and customers' behaviors, utilizing information, and communication technology in an integrated manner to incorporate values [32].

Smart cities and big data are two modern approaches. Hence, numerous scientists have begun integrating them to develop smart city technologies that will enhance sustainability, improved resilience, efficient government, quality of life, and resource management. Big data applications have the potential to serve many sectors in a smart city. It provides clients improved experiences and lets businesses improve their performance (e.g., higher profits or market share). Also, improve healthcare by improving preventive care services, diagnosis and treatment tools, healthcare records management, and patient care. Big data will significantly help transportation networks to optimize roads, accommodate varying demands, and be more environmentally friendly. Deploying big data applications requires the support of adequate infrastructure for information and communication technology (ICT). Smart cities benefit from ICT since it provides appropriate solutions that would not be available without it [33].

On the other hand, some of the issues that smart cities face while using big data include:

- Data sources and characteristics
- Data and information sharing
- Data quality
- Security and privacy
- Cost
- Smart city population [34]

Some features of the smart city concept related to big data are mentioned in this section. Consequently, big data is an essential subject in smart cities to support the residents' security, safety, education, and application. These features are part of the smart living sub-components. One of the six characteristics of the smart city concept—which includes many features including safety, housing, and education—is smart living. The findings of the study revealed that big data and smart living are inextricably connected.

This research aims to assess the social barriers in smart homes, one of the sub-components of smart living. As reviewed, big data interweaves to smart homes and smart cities. Consequently, we can achieve the smart city's established objective by developing big data services.

Pros and cons of smart homes

Smart homes are one of the EU's ten main fields in the strategic energy technology plan: "Create technologies and services for smart homes that provide smart solutions to energy consumers." The commission aims to promote creative ideas and manage consumers and authorities to optimize their energy consumption (and production). It also enables cities to manage energy usage, relying on smart grid services, through a more interactive/smart system [35].

Smart home technologies (SHTs) incorporate sensors, monitors, interfaces, appliances, and mobile devices to enable household environment automation and remote control. Sensors and monitoring systems control environmental variables like temperature, light, movement, and moisture. Computer applications (smartphones, tablets, laptops, PCs) or specialized hardware interfaces (e.g., wall-mounted controls) support the control systems. The main goals, vital advantages, and the most relevant problems of smart homes are listed in Table 5 [36]:

Smart homes' social barriers

Despite the advantages and disadvantages of new technologies in current urban areas, the use of smart homes is inevitable. We concentrate on the most significant smart home issues in this article. Generally speaking, these problems can divide into two parts: (1) Technological and instrumental concerns and (2) obstacles raised by users of such tools. This paper aims to analyze the challenges of smart homes (especially societal barriers). Table 6 shows the research findings of several articles on this subject.

Multiple social barriers have been found in previous research, according to the table. In this research, a group of urban planners and social scientists looked at these obstacles and divided them into four categories. These components are as follows:

Table 5 The main features of smart home technologies [36]

The main purposes	<ul style="list-style-type: none"> - Managing energy use - Controlling appliances - Controlling heating systems - Making life at home more convenient - Improving security and safety - Enhancing entertainment and communication - Supporting assisted living or health - Detecting faulty appliances
The potential benefits	<ul style="list-style-type: none"> - Save energy - Make things less effort - Save time - Save money - Improve security - Provide comfort - Provide peace and mind - Improve the quality of life - Enhance leisure - Provide care - Increase property value
The Potential Risks	<ul style="list-style-type: none"> - Increase dependence on technology - Increase dependence on electricity networks - Non-essential luxuries - Increase dependence on outside experts - Make household members lazy - Monitor private activities - Invasion of privacy - Intrusive - Result in a loss of control - Make households worry more - Disrupt daily routines

1. Privacy and security
2. Reliability
3. Satisfaction
4. Trust on device controlling.

Conceptual model

The previous reviews and the author’s findings support the conceptual model in this study. The following graph depicts the study’s conceptual model and, essentially, the researcher’s perspective. The “smart city” concept, according to scientists like Carlo Carpa, consists of six components, each of which is composed of several theories and features (Table 2). Smart living, among these different indicators, aims to improve the quality of life idea. And its features include education, culture and health, facilities, safety, housing, social cohesion, and tourist attractions. This research aims to analyze smart living and especially the social barriers of smart homes. In this regard, previous studies identified several factors as the most significant social issues of residents. These criteria include privacy, security, reliability, satisfaction, and device control. Finally, the author of this article selects these factors as criteria for assessing residents’ satisfaction with living in smart homes. Figure 1 describes the conceptual model in detail.

Case study

This paper needs to examine its set indicators in a case study to achieve the research objectives. For this purpose, four European cities (Copenhagen, Berlin, Barcelona, and London) are selected as the case studies. It is worth noting that this paper aims to recognize the social barriers based on resident’s experience in smart homes. The author defines four criteria to measure the social issues, then conducts interviews with residents to assess the effect of these criteria. Finally, based on the residents’ comments, the significant social barriers of smart homes are identified.

In 2018, the Eden Strategy Institute ranked smart cities in the globe base on multiple criteria. This study rate

Table 6 Social barriers presented in articles

Essay	Social barriers
Insights on Smart Home concept and occupants’ interaction with building controls [37].	<ul style="list-style-type: none"> ● Retrofitting of existing homes ● Interoperability ● Reliability ● Privacy and security ● Usability
Smart homes and their users: a systematic analysis and key challenges [38].	<ul style="list-style-type: none"> ● Privacy ● Control
Social barriers to the adoption of smart homes [25].	<ul style="list-style-type: none"> ● Fit to the current and changing lifestyles ● Administration ● Interoperability ● Reliability ● Privacy and security

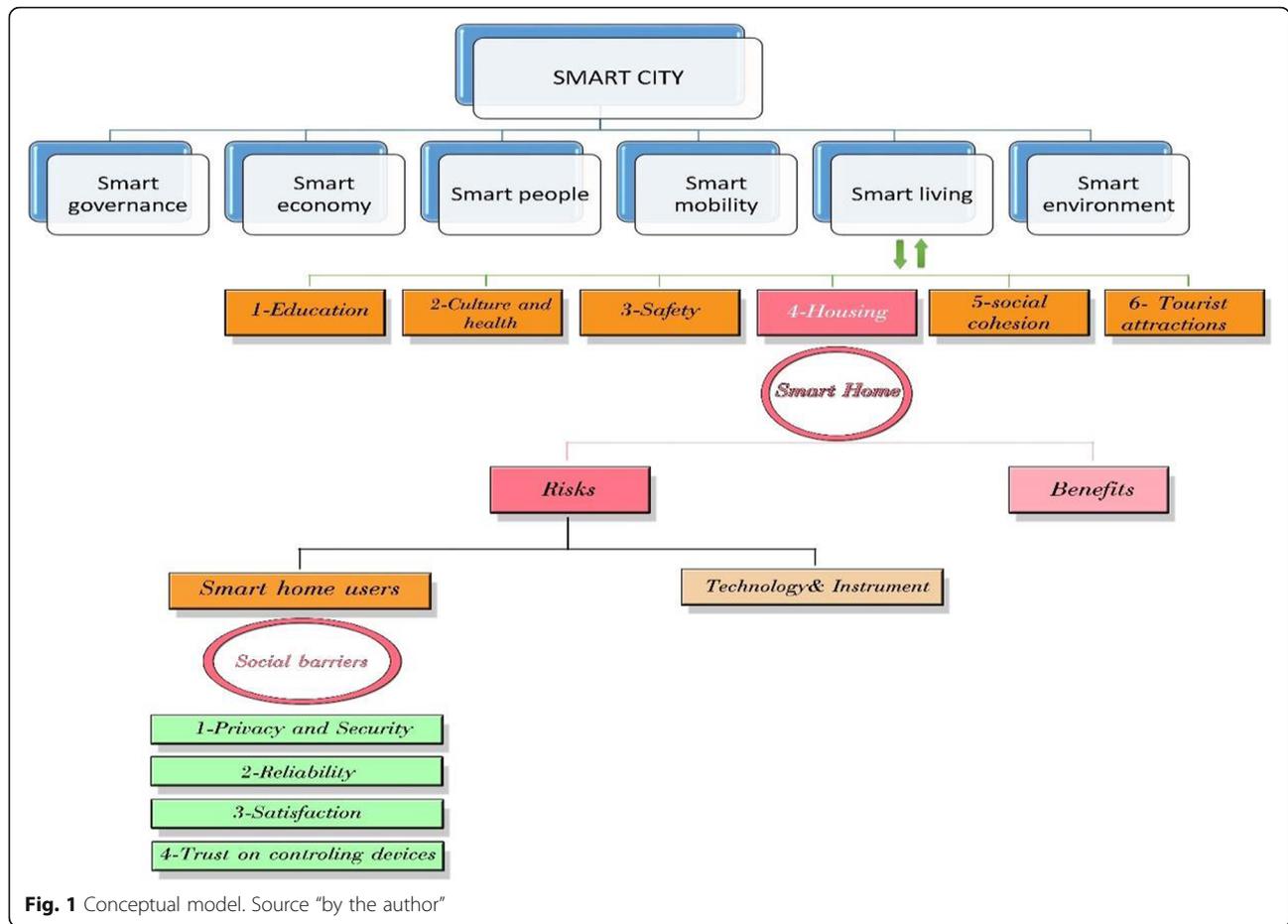


Fig. 1 Conceptual model. Source "by the author"

50 smart cities across the globe. The Berlin city is rated 29th in the report, Copenhagen 24th, Barcelona 9th, and London 1st. In this article, the researcher chose 4 European cities. Each of these countries made significant strides as a leader in the smart city concept. While residents are willing to embrace state-of-the-art technologies, several issues have created obstacles among these residents. The questionnaires will help evaluate the components after choosing the case studies to answers the research questions.

To accurately analyze these four components, a group of experts from various fields identified several sub-components. The group includes seven experts in the fields of urban planning, regional planning, urban design, and architecture. Also, these experts have extensive expertise in the area of urban planning and management. Table 7 is a list of the expert group criteria.

Table 8 presents the indicators and sub-indicators analyzed in this study. The author addresses these variables in the questionnaire questions.

Table 7 Introducing the characteristics of experts and their field of activity

	University degree	Field of academic Study	Field of activity	Professional work experience (year)
Expert number 1	Master	Urban planning	Urban engineering company	8 years
Expert number 2	Master	Urban design	Urban engineering company	14 years
Expert number 3	PhD	Architecture	University faculty member	7 years
Expert number 4	Bachelor	Architecture	Urban engineering company	5 years
Expert number 5	PhD	Urban and regional planning	University faculty member	9 years
Expert number 6	PhD	Urban planning	University faculty member	5 years
Expert number 7	Master	Urban design	Urban engineering company	15 years

Table 8 Components and sub-components of the social problems in the smart home

Indicators	Sub-indicators
1- Privacy and security	<ul style="list-style-type: none"> - Smart systems for surveillance - Smart system for detection - Smart system for identification
2- Reliability	<ul style="list-style-type: none"> - Smart system for forecasting emergencies - smart system for environmental situations - smart system for remote control devices - Privacy protection
3- Satisfaction	<ul style="list-style-type: none"> - Safe internet connection - Reducing energy consumption - Saving time - Reduce the cost of housing construction - Easier access to services - Better education - Increasing the health of residents
4- Trust on controlling devices	<ul style="list-style-type: none"> - Operation of different devices with each other - Owners ability to change smart device settings

The questions in the questionnaire comprise sub-components determined by the expert group. In this way, we will identify the social issues that trigger dissatisfaction among smart home residents. The questionnaire is composed of two parts. Part one contains socio-demographic questions (age of respondent, the gender of the respondent, profession, household income) and a specific question regarding smart homeowners' academic studies. The screening question seeks to find the best people's responses to the assessment. The screening query was "What are digital home technologies?" Options of response range from "no idea," "primeval information," and "good Information." Respondents who replied "no idea" removed in this part. We will need residents who are knowledgeable regarding smart appliances to find the research goal. To this end, the research did not analyze the views of those who believed they lacked expertise in this field. The next section of the survey begins with an open-ended question asking respondents to give a few phrases about "What first comes to mind when you think of smart home technologies?" This question allows us to get a deeper understanding of how respondents think about smart home technology. Finally, the researcher assessed the interviewees' opinions, and the responses were graded in the range 1 to 10 to evaluate each sub-indicator.

The research gathers primary data from 320 smart homeowners through random-cluster sampling via the adoption of a questionnaire study. So the researcher filled out 80 questionnaires at each sample city. The selection of interviewees is a crucial part of this research. Smart homeowners living in houses fitted with the latest

technology are the interviewees in this study. Accordingly, the research group distributed the questionnaires to residents of the smart home in the four cities surveyed. Researchers select 80 residents of smart homes in each of those four cities. The investigator identified these families by associates in each of these cities. He contacted them and explained the goal of this study, and sent the questionnaire to them. To receive diverse viewpoints, the researcher chose interviewees with different characteristics. The characteristics of the people who filled out the questionnaires illustrate in Table 9. It should mention that the author emailed the questionnaires to identified people due to the dispersion of the case studies. Then, the interviewees sent the completed questionnaires to the researcher.

The author picked the respondents from different age groups and genders as well as various social groups. The following tables provide some information about all 320 interviewees. Also, Fig. 2 presents the gender distribution:

Table 10 shows the number and percentage of respondents by age group.

The details of the interviewees' academic rate are set out in Table 11

The author of this study explores four metrics as criteria for measuring social issues within smart home residents. The following graph depicts residents' concerns regarding smart homes in four cities. The least concerning factor of these four indicators, according to the interviewees, was privacy and security. This measure has the highest percentage, meaning that residents are the most satisfied with it. In contrast, they

Table 9 Information about the respondents to the questionnaires

	London (England)	Berlin (Germany)	Copenhagen (Denmark)	Barcelona (Spain)
Interviewees	80	80	80	80

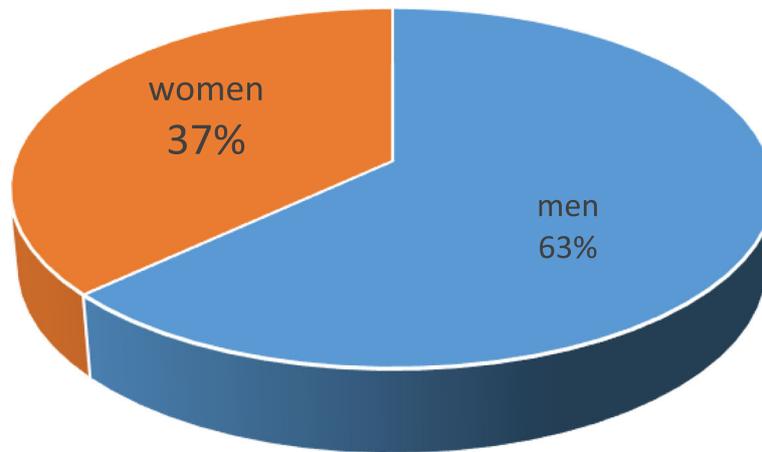


Fig. 2 The distribution of respondents by gender. Source "by the author"

state that their significant concern is trust in controlling devices (Fig. 3).

The bar figure below illustrates each city's score depending on the chosen measures. The city with the highest score is Copenhagen, while London has the lowest score. On the other hand, the two cities of Berlin and Barcelona also rank second and third respectively. It is worth noting that the lower a city's ratings, the less effective it is in terms of social concerns, and residents face more social issues.

Copenhagen placed in the fifth position based on the world's happiest cities in the World Happiness Report (WHR) 2020. The satisfaction of citizens living in this country is at a very high level. The survey included criteria such as life expectancy, security, and satisfaction with living in cities, which indicates a high level of quality of life in this city. On the other hand, in this research, the author aimed to make sure that the resident's satisfaction in different cities does not affect how they react to the questionnaire. And only their concerns about the social factors mentioned in the questionnaire should analyze. Instead of dwelling on whether or not they are happy with living in their cities, the questionnaire focuses on the most significant social obstacles they face in their smart homes (Fig. 4).

Table 10 The number and percentage of respondents by age group

	Numbers	Percentage
25 years and less	60	18.8
Between 25 and 35 years	98	30.6
Between 35 and 45 years	77	24.1
Between 45 and 55 years	65	20.3
Over 55 years	20	6.3
Total	320	100

Source "by the author"

The bar figure below illustrates the scores for each indicator in 4 cities. Each indicator's value was determined using a 1 to 10 ratio. It means that the higher a criterion's indicator score is, the less worried residents are about it. Overall, Copenhagen outperformed the other three cities in each of these measures. Another point to remember is the low level of confidence in control devices. The privacy and security parameter, on the other hand, was the least troubling indicator. The following sections go into the details of each city's situation:

Copenhagen: The "privacy and security" component in this city has the lowest level of concern among the smart home's residents. Also, they state that "trust in controlling devices" is the significant troublesome among the indicators analyzed in this research. Also, the other two components are in a better position.

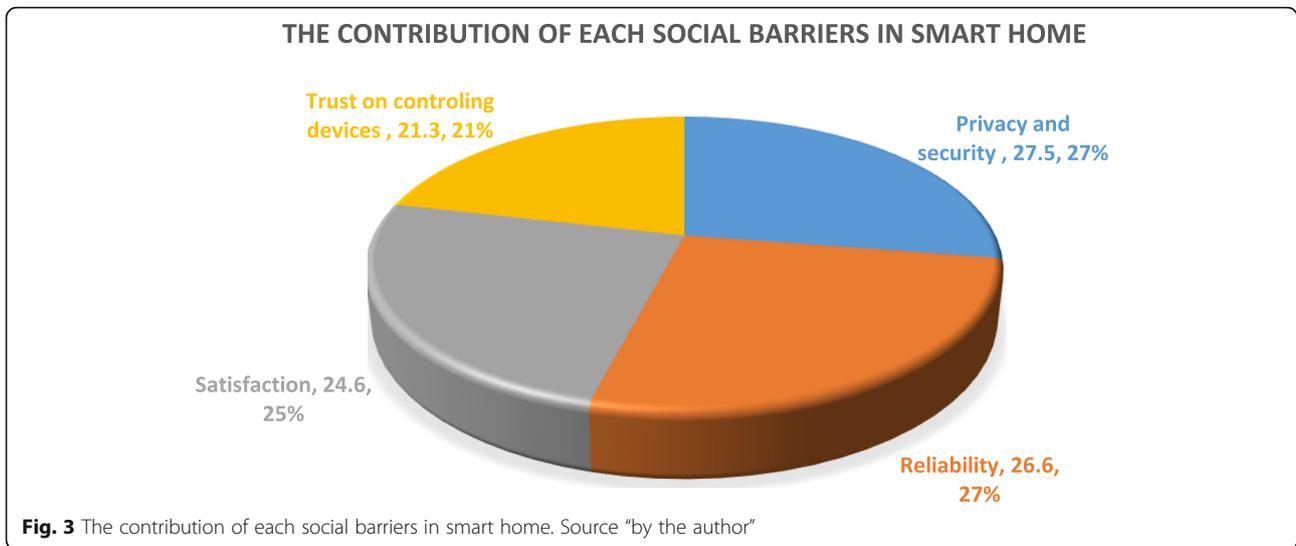
Berlin: "Privacy and security" in this city have a lower score than in Copenhagen. However, this component has more favorable conditions than the other two cities. In this city, "trust in controlling devices" has the lowest level of satisfaction among respondents.

Barcelona: The equality of the scores of the two components—"privacy and security" and "reliability"—is a significant point in this city. As a result, these two components have the highest level of satisfaction.

Table 11 The number and percentage of participants according to the level of education

	Numbers	Percentage
No academic education	10	3.1
Bachelor degree	123	38.4
Master degree	157	49.1
Ph.D. degree	30	9.4
Total	320	100

Source "by the author"



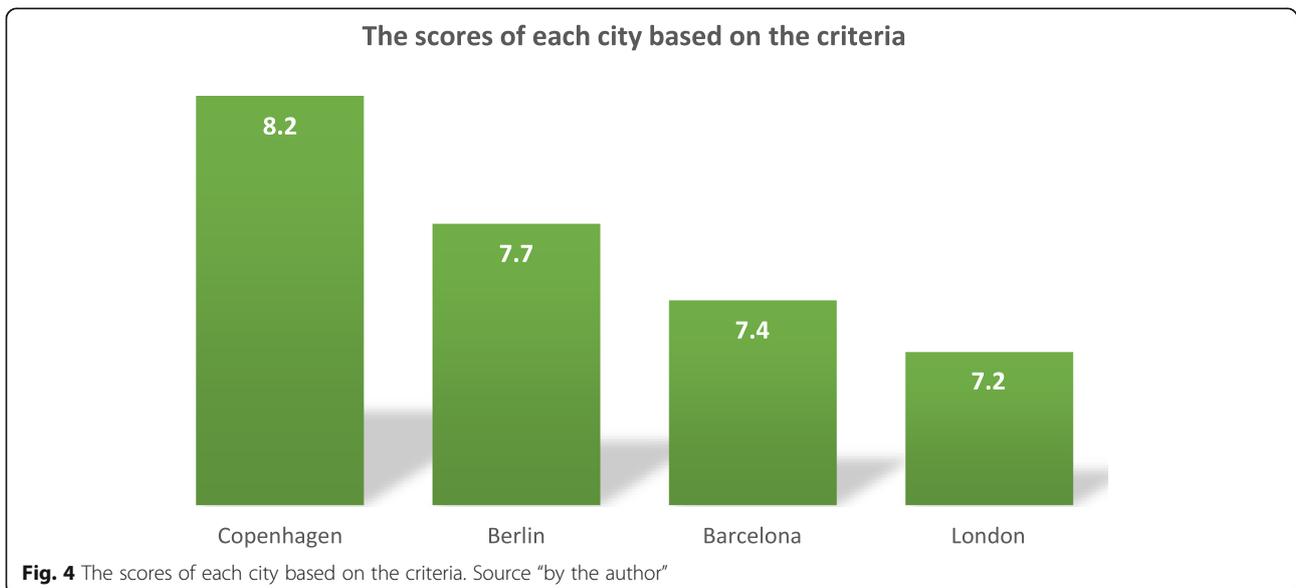
While “trust in controlling devices” has the lowest level of residents’ satisfaction.

London: The point that clear in this city is that almost all the components scored fewer points than the other three cities. Also, the residents’ satisfaction trend in this research is similar to the other three examples. As a result, the highest level of satisfaction is associated with “privacy and security,” while the lowest level of satisfaction is related to “trust in controlling devices” (Fig. 5).

The author appropriates several sub-components in this research for an accurate analysis of the components. These sub-components are the result of discussion and consultation obtained from the expert group. The

conclusions derived from the sub-component analysis illustrates in the following diagram (Fig. 6).

Table 12 represents the scores of the sub-component by city. Furthermore, a separate column shows the average score of each component. Based on the average scores, the “privacy and security” component has the highest score (8.4), therefore has the highest level of satisfaction among smart home residents. In contrast, “trust in controlling devices” has the lowest score (6.4), reflecting resident frustration with smart homes. It is worth noting that among all the sub-components, “smart surveillance systems” with a score of 9.5 have the highest level of satisfaction in Copenhagen. In contrast, several sub-criteria in the two “satisfaction” and “trust on controlling devices” criteria scored the lowest.



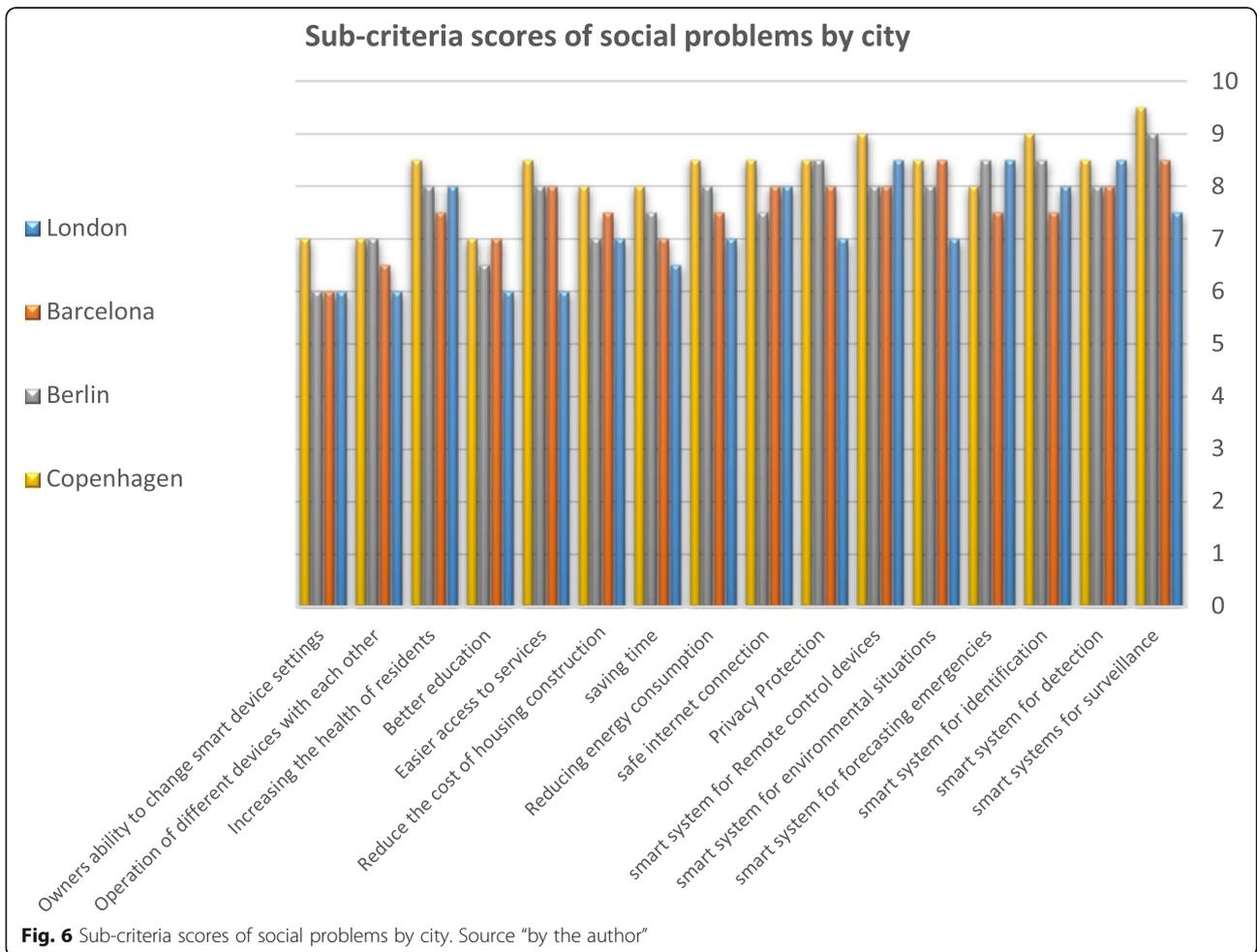
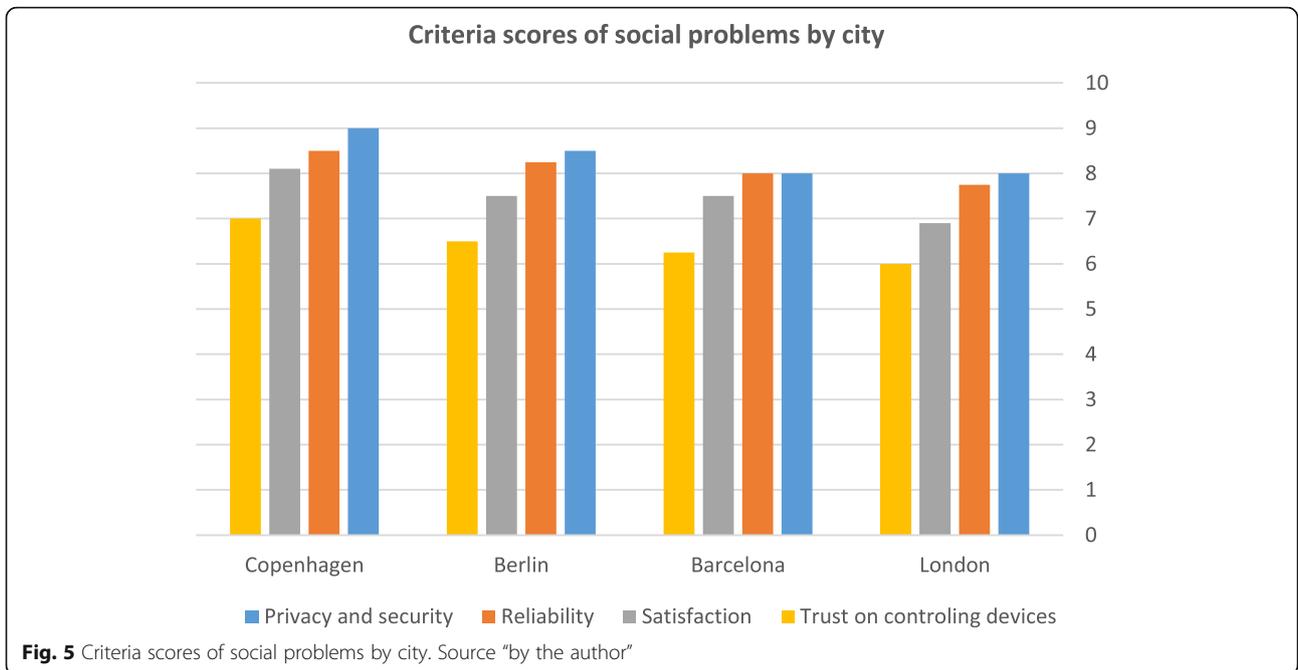


Table 12 The average rating of each of the criteria and sub-criteria

Average	Copenhagen	Berlin	Barcelona	London	Sub-criteria	Criteria
8.4	9.5	9	8.5	7.5	Smart systems for surveillance	Privacy and security
	8.5	8	8	8.5	Smart system for detection	
	9	8.5	7.5	8	Smart system for identification	
8.1	8	8.5	7.5	8.5	Smart system for forecasting emergencies	Reliability
	8.5	8	8.5	7	Smart system for environmental situations	
	9	8	8	8.5	Smart system for Remote control devices	
	8.5	8.5	8	7	Privacy protection	
7.5	8.5	7.5	8	8	Safe internet connection	Satisfaction
	8.5	8	7.5	7	Reducing energy consumption	
	8	7.5	7	6.5	Saving time	
	8	7	7.5	7	Reduce the cost of housing construction	
	8.5	8	8	6	Easier access to services	
	7	6.5	7	6	Better education	
	8.5	8	7.5	8	Increasing the health of residents	
6.4	7	7	6.5	6	Operation of different devices with each other	Trust on controlling device.
	7	6	6	6	Owners ability to change smart device settings	

Source "by the author"

According to interviews findings in Copenhagen, the reason for their high level of satisfaction is the government's monitoring of smart surveillance systems. In other words, government agencies' oversight of the non-governmental service providers has increased public satisfaction. On the other hand, some residents in the other three cities are dissatisfied with the smart services provided by private and public companies. They suppose that the operation of several smart devices at the same time will cause issues due to the lack of monitoring of these systems.

Conclusion

According to smart home definitions, scientists state that such houses seek to utilize up-to-date technologies such as the internet to create more beneficial homes. It is important to consider that smart homes aim to improve the inhabitants' quality of life besides their satisfaction. The advantages of designing smart homes are increasing economic growth, security, time savings, and pollution mitigation. On the other hand, the utilization of such services raises multiple challenges and concerns. One of the obstacles is the residents' satisfaction with the use of these services. For instance, dependency on the Internet, interference in people's privacy, and high expense of accessing such services. The most significant purpose of this article is to analyze the social issues of smart home residents. The primary goal is to identify such barriers. Also, what is the most significant social obstacles for residents? The most concerning social

barriers describe below according to the case studies findings.

- 1- Trust on controlling devices.
- 2- Service satisfaction.
- 3- The reliability of the services.
- 4- Privacy and security.

According to interviews, the most significant issue is related to devise management. Respondents are concerned about how several devices operate simultaneously. To prevent such disorders, control officials must supervise the accurate performance of each of these smart devices. Also, experts should perform experiments to examine how multiple devices interact at the same time to identify potential troubles. This surveillance would improve consumer's trust and lead to the increased utilization of these technologies in non-smart homes. Besides, companies should have periodic checkups to inspect the equipment to resolve any new issues. Eventually, through these approaches, citizens' services improved to offer people satisfaction with smart home services. The last section provides the most significant recommendations to mitigate the challenges and facilitate the safe and effective use of smart home applications.

User recommendations

Home energy services are primarily responsible for appliance power consumption data, performing energy

efficiency assessments of household appliances, and making recommendations about household power consumption. The technology-based systems present recommendations for users to reduce energy consumption. A device provides suggestions for mobile users when an intruder is detected. To decrease power consumption and the cost of household appliances efficiently, we recommend that users commit to the set runtime.

Health recommendations

Health institutions are primarily responsible for assisting and ensuring high-quality medical applications in smart homes and healthcare in general. Health institutions support the elderly (at home) by providing correct instructions, such as appropriate exercises through TV tutorials. Recommendations are given to patients in smart homes, including medical guidelines, patient diagnoses, and assistance for the elderly and people with disabilities. Such technologies can also determine and predict unexpected incidents such as fall injuries in smart homes.

Safety recommendations

Another advantage of using technology-based devices in smart homes is increased safety. People of all ages require specific healthcare, especially the elderly, and children often need guidance and help from those around them. Using a monitoring system provides appropriate supervision for homeowners if they are not at home. Also, ensuring that strangers do not enter smart homes are other benefits of using these homes. As a result, homes equipped with these applications will bring higher satisfaction to homeowners. Furthermore, smart devices provide instructions on how fire systems and electrical appliances are utilized and managed. A recommendation system to manage IoT–network relationships between IoT devices, networks, and operation techniques helps implement appropriate schemes, diagnose errors in smart homes.

Limitations

The most crucial section in this research was designing the questionnaire and assessing questionnaire data. Several experts evaluated the questionnaire indicators, then sub-criteria were identified for a more detailed study. It should note that this process was very time-consuming. Another obstacle in this research was finding informed people about smart homes to fill out the questionnaire. To sum up, smart home technologies face serious challenges. Further study and practical solutions to address the problems that lay ahead would pave the way for such technologies extension.

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Author's contributions

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Availability of data and materials

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Consent for publication

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