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Research article

Perceived usefulness of Internet of Things (IOT) in the quality of life of special needs and elderly individuals in Saudi Arabia

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A B S T R A C T

Smart home technologies (the Internet of Things [IoT]) are increasingly being implemented in human life, and a growing body of evidence demonstrates their usefulness for people with disabilities and elderly people. To fully benefit from their use, these individuals must know the different existing tools and their potential and be trained and motivated to use them. The current study aims to evaluate the factors that promote the use of smart home technologies (IoT) in people's lives. Data were gathered from 130 Saudi individuals via a survey questionnaire. Mean, standard deviation, and MANOVA were calculated. According to the results, the participants showed a moderate perception toward IoT technologies, with a mean score of ($M = 2.06$ and $SD = 0.328$). Moreover, no statistically significant differences were found in the perceived usefulness of the IoT and its dimensions (usage, skills, obstacles, and inclusion) among participants, based on gender, education level, category, experience, and devices used. While elder participants demonstrated higher perceived usefulness and perceived obstacles than the younger participants, as evidenced by the statistically significant differences in the results ($MS = 0.432$, $F = 4.197$, Sig0.017 < 0.05; $MS = 0.545$, $F = 4.615$, Sig0.012 < 0.05), the usage, skills, and inclusion dimensions showed no significant differences by participants' ages ($MS = 1.080$, $F = 3.035$, Sig0.052 > 0.05; $MS = 0.584$, $F = 2.882$, Sig0.060 > 0.05; $MS = 0.255$, $F = 1.939$, Sig0.148 > 0.05, respectively). The results support the relevance of providing knowledge and enhancing skills, thereby fostering a positive perception of IoT technologies. This study is one of the few addressing IoT technologies in special needs settings in the Middle East region. It has the potential to support evidence that IoT technologies are especially significant for people with special needs and elderly individuals.

1. Introduction

Technology advancements have permeated everyday life and are widespread across different sectors, including health, education, and the economy [1–3]. Among these emerging technologies is the Internet of Things (IoT), whose presence has become prevalent in various aspects of life and eventually led to the fourth industrial revolution [4,5]. Recent literature has investigated the usefulness of modeling algorithms, learning-based sensing technologies, and the IoT in assisting urban and city sustainability [6]. A smart home is a vital area in IoT applications. It is an interconnected home where various digital devices interact with each other over the Internet, thereby aiding in automating the home by making it smart and connected [7]. Literature has demonstrated the influence of IoTs on different areas of psychology, including special needs [1,2]. In essence, IoT is an emerging technology that relates various devices and systems that are used daily, such as sensors, appliances, actuators, computers, and cellular phones, with other relevant devices and people [8,9]. Now more than ever, the IoT plays a key role in ensuring that the current quality of life is better, easier, and more comfortable than it was before [10]. Smart home technologies, which are a form of IoT, assist people with and without special needs to carry out their day-to-day activities, thus providing independence for an enhanced quality of life [10,11].

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In addition, a smart home refers to a residence that is fitted with a high-tech network that connects sensors and home appliances, devices, and features for remote monitoring, accessing or controlling, and provision of services to meet the needs of the residence [12]. In the case of people with disabilities, IoT technologies can be viewed as aids for the family, caregivers, and healthcare provider to provide care for and oversee the needs of those with special needs and solve their challenges [13]. People with special needs can make use of smart home technologies to improve their quality of life and promote their independence and participation in day-to-day activities [13,14]. Many people worldwide suffer from a disability, of whom are consequently unable to perform their daily activities [13]. This issue is being compounded by the aging population and the increase in global chronic diseases [15]. In Saudi Arabia, approximately 7.1 % of the total population has been reported to have disabilities ranging from visual, personal care, hearing, and mobility difficulties to memory and concentration disabilities and communication and understanding disabilities [16]. The literature supports the idea that people could use assistive technologies to facilitate their independence and ability to conduct personal activities for an enhanced quality of life [14]. In this regard, IoT smart home technologies can assist such individuals with their daily activities. IoT support and enhanced life quality have been evidenced in the literature among people suffering from difficulties related to sight, hearing, and physical ability [13] along with the role of IoT in supporting independence and participation among the demographic [14]. Nevertheless, a clear consensus on and the limitations, benefits, and definitions of IoT smart home technologies are still elusive [16]. Despite the presence of work concerning such technologies for people with disabilities, the level of adoption thereof among these individuals remains low [17,18].

Previous studies have indicated that IoT technologies are important in people's lives in general and for people with special needs in particular. Moreover, IoT and smart homes are relatively novel concepts; hence, a lack of understanding thereof and of other new innovative solutions as well as their costs may have a hand in their low adoption level [18,19]. Although previous studies have found that IoT technologies contribute to enhancing people's quality of life [13], daily activities, and independence [14], they must be understood to leverage smart homes; however, studies in this regard are still scarce, gaps remain in practice, and the technologies are still under-researched [18,20,21]. Therefore, it is useful to expand the literature to provide insight into the perceptions and experiences of people with special needs who live with IoT tools. This study thus evaluates the factors promoting or hindering the use of IoT smart home technologies for people with disabilities and identifies the variables relating to different usefulness perceptions. The objectives of the present study are as follows:

1 To identify the perceived usefulness of IoT technologies among individuals with special needs and elderly people.
2 To determine the differences in the perceived usefulness of IoT technologies among individuals with special needs according to their gender, age, education level, usage experience, category, and devices.
3 To explore the differences in the dimensions of perceived usefulness of IoT technologies among individuals with special needs according to their gender, age, education level, usage experience, category, and devices.

2. Literature review

2.1. Internet of things (IoT)

The IoT is a concept that was coined by Kevin Ashton in 1999. Its aim is to connect objects at a specific time and place to service people in any way or network type. It involves the ongoing monitoring of daily activities, enhances health, and prevents diseases. Accordingly, IoT devices (e.g., wearable devices) are fitted with sensors for measuring and gathering data in a specific field. This is done using sensors for measuring signals such as the following via an electrocardiogram (ECG) skin temperature, rate of respiration, electromyogram (EMG) muscle activity, gait (posture), brain waves, blood pressure, and eye disorders, among others. In addition, the IoT allows for the remote control of objects, with data gathered by such objects relayed to another mediating device for analysis and use. The user needs the data to be supervised and controlled when required, and the mediating device thus mostly takes the form of a smartphone since the user can have it on their person at any time [22].

2.2. People with disabilities and elderly individuals

In the past four decades, disability models have played a prominent role in shaping disability politics, disability studies, and human rights for people with disabilities [23]. Disability is a broad term that encompasses impairments and limitations in activities and participation [24]. Based on the 2006 United Nations (UN) Convention on the Rights of Persons with Disabilities (CRPD), disability refers to persons with disabilities who suffer from long-term physical, mental, intellectual, or sensory impairments that prevent them from fully and effectively participating in society, similar to others [25]. The increase in disabilities has been attributed to several factors, including aging, surviving birth, and injuries from accidents.

2.3. Importance of IoT for the elderly and people with special needs

In the special needs field, the IoT has been progressively being applied, especially for the elderly, although its advantages and disadvantages must be documented. On the one hand, IoT smart home technologies have been found to benefit the quality of life, psychological well-being, learning processes, and social participation of people with disabilities. Studies have shown that IoT smart home technologies facilitate security, safety, comfort, convenience, and entertainment in the living environment and enhance psychological well-being. IoT-SHT is an interactive user-centric IoT application that has been proven to enhance quality of life, perceptions, and feelings [26–28]. On the other hand, based on findings from Ref. [29], challenges that stem from IoT smart homes include detailed complexity, while [30] mentioned cost and a lack of user experience.

More importantly, IoT smart home technologies have been shown to enhance the participation of people with special needs and the elderly in life activities [19] as well as in other aspects including learning [22] and communication [31]. Specifically, the IoT is useful for people with attention deficit hyperactivity disorder (ADHD), as it connects smart objects with sensors and software; these objects are also connected to the Internet for real-time information and data concerning the individual's behavior and feelings and assist in disseminating knowledge concerning ADHD while promoting awareness of the disease [32]. In the case of autism, IoT research supports the relationship between (1) autistic children and their behaviors and (2) their documented preferences, communication, and feelings [32]. Relevant IoT devices such as rings, phones, and speakers assist people with sensory disabilities to communicate effectively with others.

Overall, IoT smart home technologies have increasingly been integrated into residences with special needs to facilitate positive experiences. It is consequently important to examine the advantages and disadvantages of the IoT in this context and the perceptions thereof among the people responsible for special needs care. In other words, the degree to which caretakers are responsible for individuals with special needs leverage the potential of IoT smart homes in the long term depends on their perceptions of the technologies. This is crucial because, based on recent studies, despite many people being aware of the advantages of IoT technologies in special needs settings, they are still hesitant to adopt and use such devices, mainly because of the associated designs, services, costs, security, experiences, and complexity, as noted by Refs. [29,33].

3. Methodology

The present study utilized a cross-sectional quantitative research design to capture the perceived usefulness of IoT technologies in the daily lives of individuals with special needs and elderly people. It employed a survey as the primary data collection instrument to determine respondents' attitudes to and perceptions of IoT tools in smart homes.

3.1. Study participants

This study recruited a total of 130 participants categorized as disabled or elderly and who had experienced the use of IoT devices at home. The study setting was in the southern region of Saudi Arabia and was considered suitable because of its availability and ease of access to the researchers. Of the 130 participants, 79.2 % (103) were disabled and 21.8 % (27) elderly category, and 60 % (78) and 40 % (52) were male and female, respectively. Furthermore, 18.5 % were aged 15–25 years, 38.5 % were 26–35 years old, and 43.1 % were over 36 years old. In addition, 24.6 % of the respondents stated that they had been using IoT technologies in the last 3 years, 48.5 % in the last 3–6 years, and 26.9 % for more than 6 years. Other demographic variables of the respondents are listed in Table 1.

3.2. Instrument

A questionnaire containing two sections was used as the instrument in the current study. The first section gathered respondents' personal information and experience with IoT, along with information concerning their disabilities. The second section covered a 24-item perceived usefulness measure of four dimensions for assessing the perceived benefits of using the IoT, all of which were adapted from Refs. [34,35] to ensure content validity. These dimensions included usage (three items), skills (eight items), inclusion (eight items), and obstacles (five items). All items were measured using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Considering that the participants' proficiency in English may not have been sufficient for them to understand the

Table 1
Participant demographic.

Variable	Value Label	N	Percentage %
Gender	Male	78	60
	Female	52	40
Age	15–25 years	24	18.5
	26–35 years	50	38.5
	More than 36	56	43.1
Educational level	School	43	33.1
	Diploma	46	35.4
	University	41	31.5
Experience	1–3 years	32	24.6
	3–6 years	63	48.5
	More than 3 years	35	26.9
Category	Disability	105	80.8
	Elderly	25	19.2
Device	Laptop	94	72.3
	Phone	22	16.9
	Others	14	10.8
Total		130	100

items if they were presented in English, three bilingual (Arabic and English) experts translated the questionnaire to ensure that respondents could understand the meaning of each item. The reliability and discriminant validity of the questionnaire survey were established using Cronbach's alpha coefficient. In this study, Cronbach's reliability for the total measure of perceived usefulness was $\alpha = 0.86$; for usage, $\alpha = 0.65$; for skills, $\alpha = 0.80$; for obstacles, $\alpha = 0.69$; and for inclusion, $\alpha = 0.71$. The data support measurement consistency, which relates to perceptions of IoT resources among the elderly and individuals with disabilities, as displayed in Table 2.

3.3. Procedures

The study was approved by the Ethics Committee of the Dean of Scientific Research at Najran University (010118-022124-DS). Proper verbal consent was obtained from the participants. Following this approval, the researchers proceeded to contact the participants and their families for recruitment in the study: The individuals were invited to voluntarily participate, and their verbal agreement was obtained for survey distribution. The authors sent the information survey to participants to collect the data, with assurances that the respondents' information would be kept confidential and that they would be anonymous in their voluntary participation in the study. The data were collected in the summer, between June 1 and 31, 2023. On average, participants took approximately 25 min to complete the survey questionnaire.

3.4. Data analysis

For data analysis, the questionnaire data were encoded and entered into SPSS version 22. Cronbach's alpha was calculated to explore the validity and reliability of the instruments. The descriptive statistics were also analyzed to obtain the values of the mean and standard deviation. Then, an independent sample *t*-test and a multivariate analysis of variance (MANOVA) were applied to evaluate the participants' perceived usefulness levels and the differences between their characteristics, such as gender, age, and other factors. In this study, a p-value less than 0.05 was considered statistically significant.

4. Results of the study

4.1. Perceived benefits of IoT resources

The results of the analyzed mean scores showed low-to-medium average scores that varied from 1.82 to 2.24, based on a 5-point Likert scale, indicating the level of perceived benefits of IoT resources among the elderly and individuals with disabilities. In particular, there was a moderate positive perception toward the use of IoT devices in day-to-day activities ($M = 2.06$, $SD = 0.328$), with usage obtaining the highest score ($M = 2.24$, $SD = 0.605$), followed by obstacles ($M = 2.18$, $SD = 0.353$), inclusion ($M = 2.16$, $SD = 0.365$), and lastly, skills ($M = 1.82$, $SD = 0.456$), as shown in Table 3. The top five items with the highest scores in perceived benefits of IoT resources were as follows: "IoT resources help me to get connected with others" ($M = 2.36$, $SD = 0.584$), "It facilitates personal participation in real-time activities" ($M = 2.33$, $SD = 0.821$), "I am worried that someone might be able to access personal information that is shared with a smart assistant" ($M = 2.32$, $SD = 0.599$), "I am aware of the dangers and vulnerabilities of smart devices connected to the Internet" ($M = 2.31$, $SD = 0.584$), and lastly, "They allow me to work independently" ($M = 2.29$, $SD = 0.576$).

4.2. Perceived benefits of IoT and participants' profiles (gender, age and education levels)

An independent sample *t*-test was conducted to compare perceived usefulness and its dimensions, namely inclusion, usage, skills, and obstacles, based on participants' gender. The analysis of the groups in terms of gender (Table 4) revealed that, males had higher mean scores for perceived usefulness ($M = 2.068$, $SD = 0.327$) than females ($M = 2.063$, $SD = 0.333$), and they also had higher mean scores for obstacles ($M = 2.22$, $SD = 0.381$) and inclusion ($M = 2.168$, $SD = 0.356$) in comparison to females ($M = 2.11$, $SD = 0.297$ and $M = 2.161$, $SD = 0.381$, respectively). Furthermore, females had higher mean scores for usage ($M = 2.75$, $SD = 0.635$) and skills ($M = 1.85$, $SD = 0.517$) in comparison to males ($M = 2.21$, $SD = 0.588$ and $M = 1.81$, $SD = 0.413$, respectively). The results in Table 5 indicate no significant differences in the perceived benefits of IoT for people with disabilities ($t = 0.489$, $p = .626 > 0.05$; $t = 0.267$, $p = .790 > 0.05$; $t = 0.341$, $p = 734 > 0.05$; $t = 0.705$, $p = .482 > 0.05$; $t = 0.486$, $p = .628 > 0.05$ respectively). Based on the results, the male participants had more positive attitudes toward IoT technologies than did the female participants.

Based on the analysis of the groups by age (Fig. 1), elder participants had higher mean scores for perceived usefulness ($M = 2.128$, $SD = 0.319$) than participants aged 15–25 years old ($M = 1.902$, $SD = 0.160$), and 26–35 years old ($M = 2.075$, $SD = 0.374$). They also

Table 2
Cronbach's alpha reliability.

No.	Measure	Cronbach's value	Items No.
1	Perceived Usefulness	.862	24
2	Usage	.659	3
3	Skills	.803	8
4	Obstacles	.691	5
5	Inclusion	.717	8

Table 3
Perceived benefits of IOT usefulness subscales.

Variables	Mean	SD
Perceived Usefulness	2.06	.328
Usage	2.24	.605
Obstacles	2.18	.353
Inclusion	2.16	.365
Skills	1.82	.456

Table 4
Descriptive Statistics results for the Perceived benefits of IoT and participants' gender.

Variables	Male		Female	
	M	SD	M	SD
Perceived Usefulness	2.068	.327	2.063	.333
Usage	2.21	.588	2.75	.635
Skills	1.81	.413	1.85	.517
Obstacles	2.22	.381	2.11	.297
Inclusion	2.168	.356	2.161	.381

Table 5
Independent Sample *t*-test Results on the Perceived Benefits of IOT Usefulness Subscales Based on Gender Differences.

Variables	t-value	p-value
Perceived Usefulness	.489	.626
Usage	.267	.790
Obstacles	.341	.734
Inclusion	.705	.482
Skills	.486	.628

had higher mean scores for the usage dimension (M = 2.35, SD = 0.585) than younger groups aged 15–25 years old (M = 2.00, SD = 0.471) and 26–35 years old (M = 2.22, SD = 0.657). The results also revealed that the elder group scored higher on skills in using IoT technologies (M = 1.86, SD = 0.510) than the age groups of 15–25 years old (1.630, SD = 0.225) and 26–35 years old (M = 1.882, SD = 0.456). In terms of obstacles, the results showed the following mean scores: for elder participants, M = 2.285 and SD = 0.318; for 15–25-year-olds, M = 2.066 and SD = 0.225; and for 26–35-year-olds, M = 2.124 and SD = 0.409. Regarding inclusion, the results revealed that the group aged over 35 years old scored higher (M = 2.207, SD = 0.361) than participants in the groups aged 15–25 years old (M = 2.036, SD = 0.219) and 26–35 years old (M = 2.180, SD = 0.413). A MANOVA test was conducted to compare participants' needs, and the results (Table 6) showed no significant differences in the perceived benefits of IoT and its dimensions (MS = 0.432, F = 4.197, Sig. $0.017 < 0.05$; MS = 1.080, F = 3.035, Sig. $0.052 > 0.05$; MS = 0.584, F = 2.882, Sig. $0.06 > 0.05$; MS = 0.545, F = 4.615, Sig. $0.012 < 0.05$; MS = 0.255, F = 1.939, Sig. $0.148 > 0.05$). Based on the results, the older respondents had a higher perceived usefulness of IoT technologies.

Furthermore, the mean scores of the participants according to their education level are displayed in Fig. 2 below. The MANOVA results (Table 7) showed no significant differences in the perceived benefits of IoT and its dimensions (MS = 0.083, F = 0.769, Sig. $0.466 > 0.05$; MS = 0.099, F = 0.266, Sig. $0.767 > 0.05$; MS = 0.553, F = 2.72, Sig. $0.070 > 0.05$; MS = 0.000, F = 0.001, Sig. $0.999 > 0.05$; MS = 0.015, F = 0.109, Sig. $0.897 > 0.05$). The results indicated that, based on education level, respondents with higher degrees held a more positive perception of the usefulness of IoT technologies.

The analysis of usage experience (Table 8) revealed that individuals who used the IoT for more than 6 years scored a higher mean on perceived usefulness (M = 2.12, SD = 0.418) than participants in groups with 3–6 years of experience (M = 2.06, SD = 0.293) and 1–3 years of experience (M = 2.00, SD = 0.276). Individuals who used the IoT for more than 3–6 years also had higher mean scores on the usage dimension (M = 2.24, SD = 0.648) than participants in the group with more than 6 years of experience (M = 2.26, SD = 0.602), and 1–3 years of experience (M = 2.18, SD = 0.580). The results also indicated that participants who had more than 6 years of experience scored a higher mean on IoT skills technologies (M = 1.90, SD = 0.503) than participants in the groups with 3–6 years of experience (M = 1.80, SD = 0.474) and 1–3 years of experience (M = 1.78, SD = 0.362). In terms of obstacles, the results showed that participants who had more than 6 years of experience scored a mean of M = 2.22 and SD = 0.442, while participants in the group with 3–6 years of experience had a mean score of M = 2.18 and SD = 0.309, and the group with 1–3 years of experience had a mean score of M = 2.13 and SD = 0.327. Regarding inclusion, the result revealed that elder participants score higher mean (M = 2.23, SD = 0.442) than participants in the groups with 3–6 years of experience (M = 2.17, SD = 0.340) and 1–3 years of experience (M = 2.07, SD = 0.305). Lastly, the MANOVA results concerning the respondents' usage experiences (Table 9) revealed no significant differences in their perceived benefits of the IoT and its dimensions (MS = 0.125, F = 1.162, Sig. $0.316 > 0.05$; MS = 0.064, F = 0.172, Sig. 0.842 >

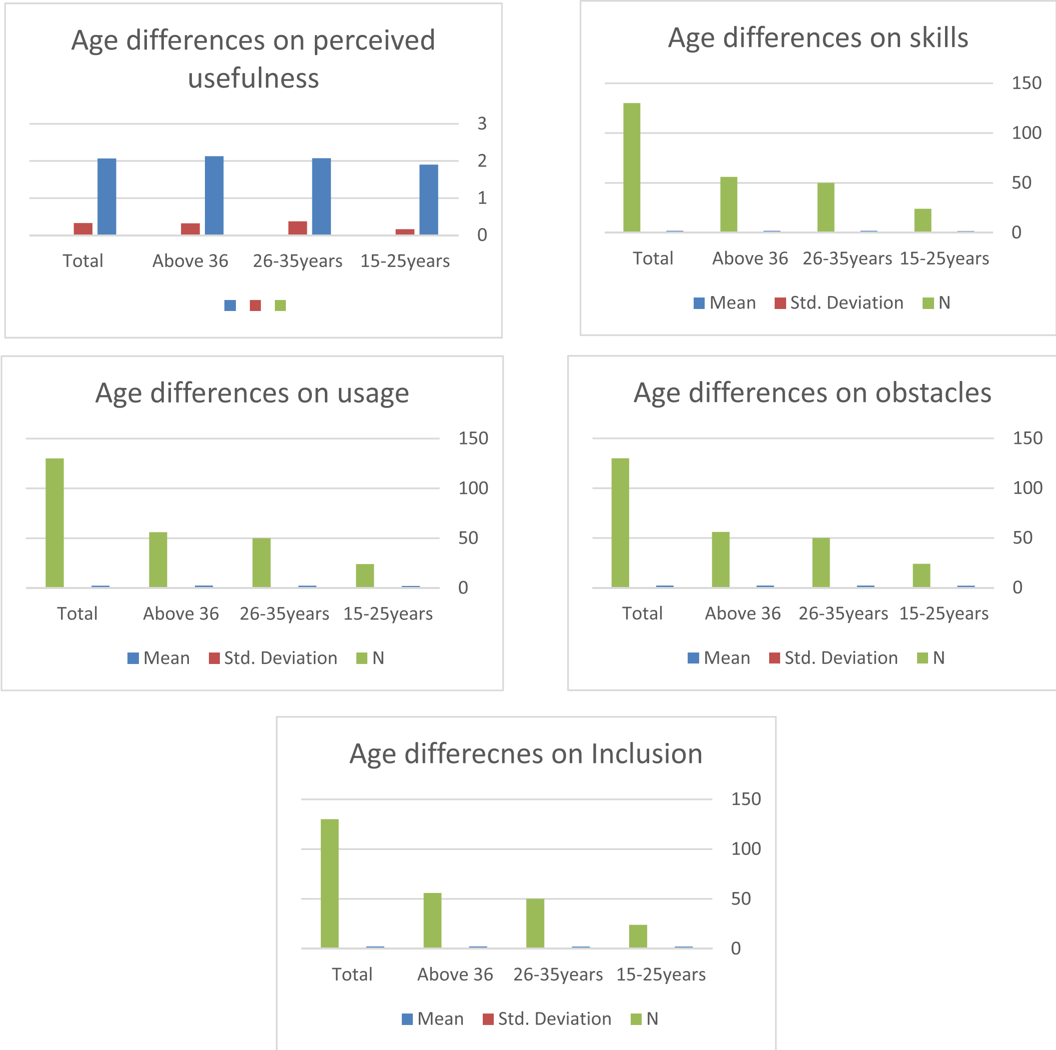

Fig. 1. Age differences on perceived usefulness of the IoT subscales.

Table 6
MANOVA Results on the Perceived Benefits of IOT Usefulness Subscales Based on age differences.

Variables	Mean Square	F-value	p-value
Perceived Usefulness	.432	4.197	0.017
Usage	1.080	3.035	0.052
Obstacles	.545	4.615	0.012
Inclusion	.255	1.939	0.148
Skills	.584	2.882	0.060

0.05; MS = 0.155, F = 0.741, Sig. 0.478 > 0.05; MS = 0.079, F = 0.632, Sig 0.533 > 0.05; MS = 0.214, F = 1.618, Sig. 0.202 > 0.05).

4.3. Perceived benefits of IoT and disability types

The study also used a MANOVA test to compare the means of respondents' disability types, and no significant differences were found in their perceived benefits of the IoT and its dimensions (MS = 0.277, F = 2.601, Sig. 0.109 > 0.05; MS = 3.742, F = 10.986, Sig. 0.001 < 0.05; MS = 0.218, F = 1.043, Sig. 0.309 > 0.05, MS = 0.069, F = 0.548, Sig. 0.460 > 0.05; MS = 0.050, F = 0.377, Sig. 0.540 > 0.05), as presented in Table 10. According to the results, disability types did not show any differences.

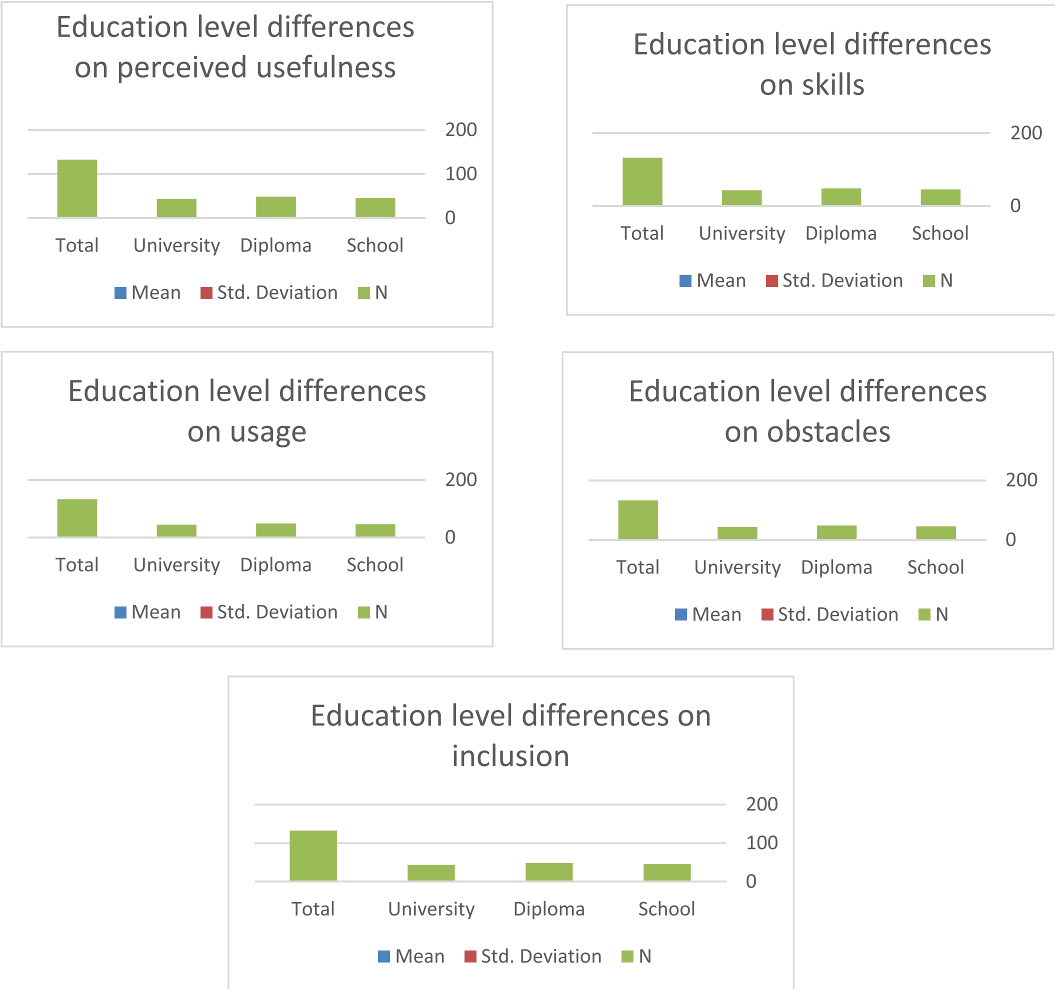

Fig. 2. Education level differences on perceived usefulness of the IoT subscales.

Table 7
MANOVA results on the perceived benefits of IOT usefulness subscales based on educational level differences.

Variables	Mean Square	F	p-value
Perceived Usefulness	.083	.769	0.466
Usage	.099	.266	0.767
Obstacles	.000	.001	0.999
Inclusion	.015	.109	0.897
Skills	.553	2.72	0.070

Table 8
Comparison of results on the perceived benefits of IOT usefulness subscales based on experience differences.

Variable	1–3 years		3–6 years		More than 6 years	
	M	SD	M	SD	M	SD
Perceived Usefulness	2.00	.276	2.06	.293	2.12	.418
Usage	2.26	.602	2.24	.648	2.18	.580
Obstacles	2.22	.442	2.18	.309	2.13	.327
Inclusion	2.23	.442	2.17	.340	2.07	.305
Skills	1.78	.362	1.80	.474	1.90	.503

Table 9
MANOVA results on the perceived benefits of IOT usefulness subscales based on usage experiences differences.

Variables	Mean Square	F-value	p-value
Perceived Usefulness	0.125	1.162	0.316
Usage	.064	.172	0.842
Obstacles	.079	.632	.533
Inclusion	.214	1.618	.202
Skills	.155	.741	0.478

Table 10
MANOVA Results on the Perceived Benefits of IOT Usefulness Subscales Based on disability types differences.

Variables	Mean Square	F-value	p-value
Perceived Usefulness	.277	2.601	0.109
Usage	3.742	10.986	0.001
Obstacles	.069	.548	0.460
Inclusion	.050	v	0.540
Skills	.218	1.043	0.309

4.4. Perceived benefits of IoT and devices used

As shown in Table 11, no significant differences were found between IoT devices used and the perceived benefits of the IoT and its dimensions (MS = 0.252, F = 2.384, Sig. 0.096 > 0.05; MS = 0.902, F = 2.517, Sig. 0.085 > 0.05; MS = 0.381, F = 1.851, Sig. 0.161 > 0.05; MS = 0.238, F = 1.938, Sig. 0.148 > 0.05; MS = 0.227, F = 1.724, Sig. 0.182 > 0.05). Individuals with disabilities made use of several IoT devices for their home activities, including sport watches, smart blood pressure monitors, and home aid tools (58 participants constituting 44.7 %), remote control devices (20 participants constituting 15.4 %), mobile remote controls (19 participants constituting 14.6 %), and laptops and desktops (33 participants constituting 25.38 %).

5. Discussion

The main objective of this study was to determine the perceived usefulness of the IoT among people with special needs and elderly individuals. Based on the results, participants had different views toward smart home devices, resulting in either a positive or negative perception of IoT device usage. Notably, positive attitudes toward IoT device usage influence one's intention to employ such a device in their daily life. Based on the results, participants' perceptions of IoT usefulness varied from low to moderate levels; some participants expected to see more intelligent features to meet their needs, their independence, and the management of the devices while ensuring their safety and security [22], whereas others emphasized the privacy and security related to smart home devices and the ambiguous potential to reap the benefits of the IoT. Based on [36], primary concerns with the IoT relate to usefulness, cost, privacy, and security. The results may be attributed to the use of different IoT devices, each characterized by distinct features and attributes, and to the participants' technical skills. The result is consistent with the results reported by Refs. [37,38] in their study of the IoT, which revealed technology cost and familiarity as major factors inhibiting technology adoption. The results may also be attributed to the level of awareness of IoT usage.

Regarding the second and third objectives, the results show partially significant differences in the perceived usefulness of the IoT, and its dimensions based on participant variables such as gender, age, education level, experience, category, and devices. Concerning participants' varied levels of perceived usefulness of the IoT devices in terms of their gender, age, level of education, work experiences, disability type, and used devices, no significant differences were found. This may be due to participants' similar perceptions and requirements of, satisfaction with, and awareness of using IoT in daily activities. This may be exemplified by the gender of the participants from different age categories and with different experiences who faced similar challenges in using IoT devices. No statistically significant differences in the gender variable were found. This may be due to the similar levels of awareness among the study sample regarding the importance of using the IoT in a smart home system for daily life and household activities and its role in facilitating their lifestyle, irrespective of their gender (male or female) [39]. Moreover, family members who are also caretakers mostly assist in the use of the IoT, raising awareness of its usability and usefulness in daily life at a similar level. The results showed a significant difference in the perceived usefulness of the IoT and its dimensions due to the age variable in favor of group participants aged over 36 years. This finding may be because young individuals are more willing to use and experiment with technology and are less afraid of it compared with older people [40]. The results also indicated no statistically significant differences due to the education level variable. This finding may be attributed to the role of family and educational settings in providing individuals with the opportunity to learn new things, especially technology and its key role in improving human life. In summary, this study broadened the research scope of IoT technologies in special needs settings. It provided a new perspective for people to understand how individuals with special needs perceive the usefulness of IoT technologies in performing their daily activities.

Table 11
MANOVA Results on the Perceived Benefits of IOT Usefulness Subscales Based on IoT devices used differences.

Variables	Mean Square	F value	p-value
Perceived Usefulness	.252	2.384	0.096
Usage	.902	2.517	0.085
Obstacles	.238	1.938	0.148
Inclusion	.227	1.724	0.182
Skills	.381	1.851	0.161

6. Conclusion and implications

The present study investigated the perceptions of use of IoT technologies to enhance the quality of life of individuals with special needs in Saudi Arabia. This study is among the first to attempt to understand these individuals' perceptions of using IoT technologies. It was conducted to determine the perceived usefulness of IoT resources among people with disabilities and elderly individuals in Saudi Arabia. Data were collected using a questionnaire distributed to 130 participants who have experience with IoT device use. Although the use of IoT devices and technologies has become popular and was adopted as the study lens, the results regarding participants' levels of perceived usefulness of IoT technologies still range from low to moderate. Moreover, an assessment of the differences in participants' perceptions based on their demographic variables (gender, age, education level, usage experience, category, and devices) revealed that only age was statistically significant, with older people showing a higher perceived usefulness of IoT in their lives than the youngest participants. Furthermore, analysis of the differences in the perceived usefulness of IoT dimensions revealed that age was only statistically significant for the obstacle dimension, not for the usage, skills, and inclusion dimensions.

The dynamic progress in ICTs and the Internet in recent years is notable, paving the way for company management and product commercialization. Such a trend is particularly crucial to the tourism industry, where the use of such technologies can enhance product distribution, communication, promotion, and other management functions (e.g., relationship with providers, public administration, etc.). Nevertheless, research in special needs settings remains scarce, with few studies having been conducted to determine perceptions regarding the Internet and its long-term use among people with disabilities and elderly people. This paper thus aims to describe the current use of the Internet by these groups of individuals.

The study results contribute to both theory and practice. Theoretically, the study highlights the importance of technology literacy guidelines in enhancing IoT perceptions among people with disabilities and elderly people. The findings of the study can be used by the government to improve IoT usability for these individuals and enhance their quality of life – this is consistent with the Saudi Vision 2030. The study findings contribute to theory by extending technology management literature and empirical studies: It presents individual factors regarding the usefulness of IoT among people with disabilities and the elderly. However, despite general interest in the research topic within academic and industry circles, the literature must be further extended to highlight the possibilities and potential of the IoT, as suggested by previous studies [9,41–43], with a specific focus on the motivations behind and skills to use the IoT [44]. Past studies have largely ignored the perceived usefulness of the IoT among people with disabilities and elderly individuals, and the present study is an attempt to reduce this literature gap by examining, inter alia, gender, age, and education level among people with disabilities and the elderly and their perceptions of IoT use.

6.1. Limitations

The study enriches literature and practice through its findings, although, similarly to other studies, it has its limitations. The first limitation is the confined sample chosen from a single Saudi city. This may fall short of representing the general Saudi population. Future studies should thus use a study design and framework with individuals selected from various Saudi cities.

Second, the data collection method employed in this study (the self-report method) is insufficient to clarify the phenomena. Future studies should therefore include additional methods such as qualitative or mixed methods, which may aid in gathering accurate findings regarding perceptions of IoT resource usage in daily life.

Third, this study was conducted in Saudi Arabia; all participants were Saudis. Therefore, the results of this study cannot be generalized, as they might reflect the country's context. A similar study should thus be conducted in different countries to validate the study results.

Fourth, parents and teachers are essential to IoT services and should be considered a significant factor in IoT tools, especially among people with special needs. In summary, even though this study added to a better understanding of how IoT tools contribute to people in general and individuals with special needs in particular, the results should be regarded with caution due to significant limitations.

Data availability statement

The study was conducted in accordance with the declaration of Najran University and approved by the ethical committee at the Najran University. The research was conducted ethically, and data will be made available on request.

Ethical approval

This scientific research carries ethical approval from the Standing Committee for Scientific Research Ethics in the Research Deanship of Najran University, Saudi Arabia. Reference No: 010118-022124-DS. Accredited as a local committee by the National Committee for Bioethics at King Abdulaziz City for Science and Technology (HAPO-11-N-102).

CRediT authorship contribution statement

Turki Mahdi Alqarni: Writing – original draft. **Burhan Mahmoud Hamadneh:** Writing – review & editing. **Malek Turki Jdaitawi:** Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Turki Alqarni reports financial support was provided by Najran University. Turki Alqarni reports a relationship with Najran University that includes: funding grants. Turki Alqarni reports a relationship with King Abdulaziz City for Science And Technology that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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