Perceptions of Digital Monitoring Technology for Activities of Daily Living (ADLs): A Semi-Structured Interview Study of Older Adults and Informal Caregivers

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Abstract: With China's rapidly aging population and the growing preference for aging in place, digital monitoring technologies have emerged as potential tools to support older adults in managing their activities of daily living (ADLs). This study explores the perceptions and acceptance of these technologies among elderly individuals living alone and their informal caregivers (ICs) in Nanshan District, Shenzhen. Grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), the study employed semi-structured and photo-elicitation interviews to analyze how performance expectancy, effort expectancy, social influence, and facilitating conditions shape technology adoption. The findings reveal clear intergenerational differences: caregivers show higher acceptance and a better understanding of the benefits and functionalities of wearable and environmental monitoring devices, while older adults often express skepticism due to concerns over privacy, usability, and cost. Many elderly participants also cite discomfort, technical complexity, and lack of training as barriers to adoption. Despite these obstacles, both groups acknowledge the potential safety and health benefits of such technologies. The study highlights the need for privacy-by-design features, customized user interfaces, and enhanced digital literacy programs tailored to both elderly users and their caregivers. The research contributes to a sociotechnical understanding of aging-in-place technologies in China and provides actionable insights for developers, policymakers, and healthcare practitioners aiming to enhance home-based elder care.

Keywords: Digital monitoring technology; Activities of daily living (ADLs); Aging in place; Informal caregivers; UTAUT model

1. Introduction

According to the National Bureau of Statistics of China [1], with the intensification of population aging, the population aged 65 and above in China has accounted for 13.5%, higher than the global average. Elderly care has become a key social issue, and aging in place has become the choice for more and more elderly people, especially empty-nest elderly, who account for 59.7% [2]. However, ensuring that older adults remain independent, safe, and healthy in activities of daily living (ADLs) has become a major challenge [3]. Digital monitoring technology, as discussed by Verloo *et al.*, is seen as a potential tool to address this challenge [4], but there are usability, accessibility, and privacy issues that remain obstacles to its widespread adoption [5].

2. Literature review

2.1. The advantages and challenges of aging in place

The positive outcomes of aging in place are that older adults feel secure at home, maintain independence, avoid being transferred to nursing homes, reduce medical costs, and improve their quality of life [6,7]. However, as their health condition declines, many elderly people face health and safety issues in their daily activities, with about one-third of them needing assistance in bathing, dressing, and eating [8]. Therefore, how to effectively utilize digital monitoring technology to support independent living and health management of the elderly has become a key issue.

2.2. The definition of activities of daily living

ADLs refer to the basic skills required for independent self-care, including activities such as eating, bathing, movement, etc. (**Figure 1**) [9]. Maintaining the independence of these activities is crucial for the self-care ability and quality of life of elderly people, and digital monitoring technology may help maintain their autonomy [4].
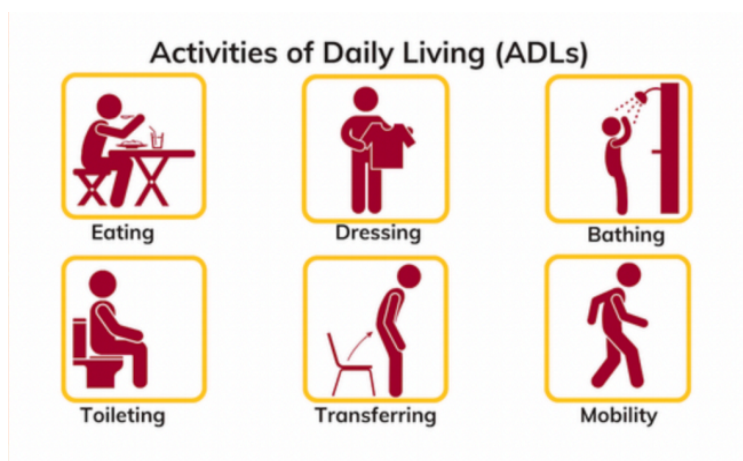

Figure 1. The six main components of activities of daily living

2.3. The application of digital monitoring technology in ADLs for the elderly

These technologies can be mainly divided into wearable devices and environmental sensors. Wearable devices, such as smartwatches, are attached to the human body to monitor health data, steps, heart rate, blood pressure, etc., and issue alerts in case of abnormalities, facilitating remote tracking and video consultation, reducing the burden of frequent medical visits [10]. And environmental sensors, such as indoor monitoring, are placed at home

to monitor room activities [11], which provide a safe living environment and enhance the independence of elderly people by monitoring temperature, humidity, falls, etc., while allowing family members to stay informed of their health status in real time [12].

2.4. The risks of digital monitoring technology in ADLs for the elderly

However, older adults are generally concerned about privacy issues. Research shows that elderly people are particularly concerned about the misuse of information and the feeling of surveillance (**Figure 2**) [13].
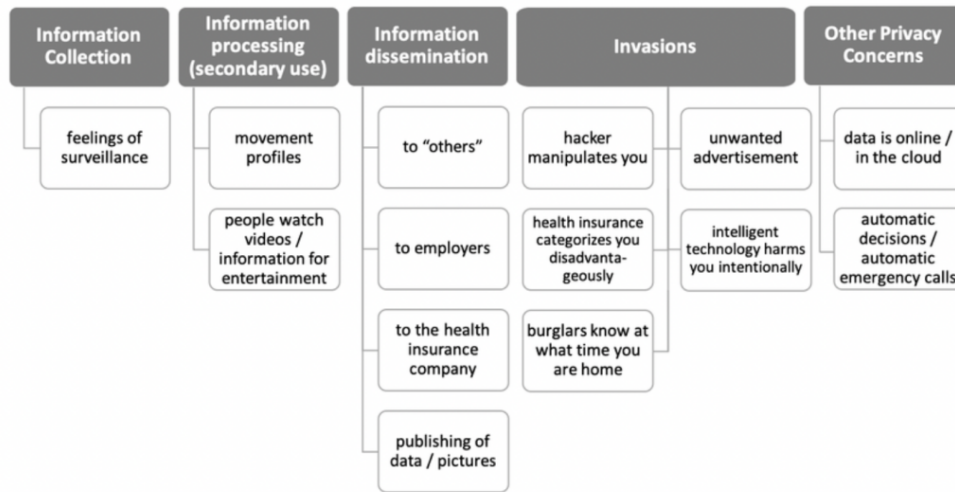
Privacy Concerns of Participants regarding technologies for Aging in Place.

Figure 2. Privacy concerns of participants regarding technologies for aging in place

Therefore, privacy issues, data security, as well as technical usability and economic costs, remain the main obstacles to the popularization of digital monitoring technology [13].

2.5. Older adults' acceptance of technology

The speed of digital monitoring technology among the aging in place population is slower than expected, and a key aspect of the dissemination of such technology is its acceptance. The barriers for elderly people to accept technology stem from a range of personal, social, and environmental factors. The physical and cognitive differences among older adults can affect their ability and willingness to use new technologies, and past experiences of using old devices make adapting to modern technology more difficult [14]. Meanwhile, the privacy issue mentioned before is still a major obstacle, as users often prioritize privacy risks over benefits.

In addition, the invasive nature of these technologies has changed daily life, invaded personal space, and further hindered adoption [13]. However, contrary to many biases, many elderly people are willing to try new technologies, but these technologies need to be matched with their specific needs and abilities [13].

2.6. Participation in the role of informal caregivers (IC) in families

Informal caregivers (IC) play an important role in the elderly who are aging in place. They are usually family members and provide care, typically unpaid, to people with whom they have a personal relationship [15]. In addition to providing physical care, many caregivers also help elderly people use technological devices. Research has

shown that caregivers' acceptance, support, and understanding of the technological needs of older adults directly affect their effective use of technology [16].

3. Research gaps

Based on previous literature analysis, research on the application of elderly monitoring technology in developing countries such as China is relatively scarce. Most existing studies focus on healthcare and computer science, which results in a lack of in-depth exploration from a sociological perspective. Moreover, insufficient attention has been paid to the acceptance and user experience of this technology among the elderly. While numerous quantitative studies have been conducted, there is a noticeable gap in qualitative research, leaving an incomplete understanding of how elderly individuals engage with and perceive these technologies.

3.1. Rationale
3.1.1. The particularity of the elderly group
Many elderly people, especially those with poor health or limited mobility, often require digital monitoring technology to maintain stability and safety in their daily lives [4]. Analyzing the advantages and risks of technology application from their perceptions can promote more active participation of the elderly in health management and meet the broader public health goal of individuals in vulnerable groups being able to participate in their care actively.

3.1.2. The importance of informal caregivers in families
In China, informal caregivers play a central role in the care of the elderly but often lack professional nursing knowledge and technical support [17]. By understanding their views on the use of digital monitoring technology by the elderly, the challenges and needs they face in the process of accepting technology are analyzed to promote more sustainable and effective models of home-based care.

3.1.3. The focus on the impact of digital monitoring technology on daily life activities
The application of digital monitoring technology in the ADLs of the elderly is a popularization of digital health products, which can help the elderly better integrate into modern health management systems, reduce barriers to technological access, narrow the digital divide, and thereby enhance the coverage and effectiveness of public health services.

3.2. Research objectives
This research aims to explore the acceptance and views of older adults on household daily activity monitoring technology and analyze the views and needs of informal caregivers in families regarding technology. Then, identify key factors influencing the perceptions of elderly individuals and family caregivers. Finally, propose directions for technological improvement and future research.

3.3. Theoretical framework
The theoretical framework of this study is based on the Unified Theory of Acceptance and Use of Technology (UTAUT), combined with various existing technology adoption models, and provides a comprehensive model for understanding the influencing factors of technology adoption. According to UTAUT, four constructs will directly

influence user acceptance and usage behavior: Performance expectations, effort expectancy, social influence, and facilitating conditions. The framework helps to clarify the motivations, barriers, and factors that influence older adults and their informal caregivers to adopt home monitoring technologies.

Specifically, performance expectancy refers to the degree to which people believe that the use of technology can improve productivity. For the elderly and caregivers, remote monitoring technology is expected to improve health management, help monitor daily activities, and ensure the safety of the elderly. Effort expectancy refers to the level of difficulty that users perceive in learning and using technology. For remote monitoring technology, overly complex systems may reduce the willingness to use it, especially considering the varying levels of familiarity among the elderly with the technology. Therefore, it is necessary to discuss whether the technology is user-friendly. Social influence refers to the influence of others on the adoption of personal technology, especially the impact of feedback from family members or communities on the acceptance of remote monitoring technology by the elderly. Facilitating conditions refer to the resources and support that individuals believe they can obtain, including equipment, service support, and training. In remote environments, this involves the stability of home monitoring networks, device usability and technical support, training, etc., especially interfaces designed for users with different physical or cognitive abilities.

3.4. Methodology

This research adopts interpretivism as the epistemology and employs a qualitative design to collect data on the perceptions of older adults and their informal caregivers through semi-structured and photo-elicitation interviews (PEIs). Older adults aged 65 and above living alone in Nanshan District, Shenzhen, as well as their informal caregivers, are recruited. The older adults need to meet the conditions that encountered difficulties in ADLs, but did not have mental illness, and were able to communicate clearly. Meanwhile, all participants are recruited through social media and personal social networks. The elderly must live independently in the community without receiving special home care and have access to a form of video call software. Additionally, the snowball sampling method was utilized, where the initial participants introduced others, facilitating trust-building within the interview. The data collection is expected to last for two weeks, with a sample size of three elderly individuals and three informal caregivers each.

The specific recruitment poster for participants is shown in **Appendix 1**. In the photo selection section of PEIs, respondents selected their commonly used smartwatches and indoor monitoring devices from wearable devices and environmental sensors. The product display is shown in **Appendix 2**. Therefore, subsequent research and discussions will revolve around these two digital monitoring technologies.

3.5. Data analysis

The UTAUT model also guided the conduct of this semi-structured interview. The detailed interview guideline is shown in **Appendix 3**. In the data collection procedure, Microsoft Excel is used for data collection, SPSS is used for data visualization, and the bar chart of experimental results is given. A thematic analysis was applied to coding the interview results. The specific results are shown in **Appendix 4**.

In the overview of the perceptions of these two devices (**Figure 3**), most of the older adults mentioned that it is useful, but not for themselves, or they do not use it now. In addition, older adults mentioned more misunderstood about these devices than informal caregivers.

1 = "Useful, but for other health problems"
2 = "Useful, but not now"
3 = "Misunderstood"
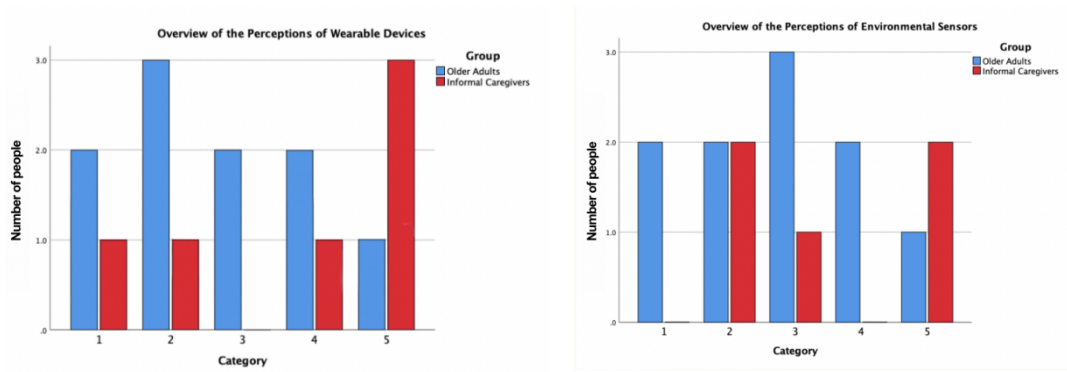4 = "Useful, but for someone else"
5 = "Useful now"

Figure 3. Distribution of older adults and informal caregivers' perceptions of wearable devices and environmental sensors

From the facilitators of technology use of these two devices, the 8 items mentioned most by the participants in the two groups were extracted separately (**Figure 4**), which can more intuitively show the different factors affecting their use behavior in the bar charts.

1 = "Lower price"
2 = "Easy to operate"
3 = "Comfort level"
4 = "Privacy Protection"
5 = "Help from family member"
6 = "Recommended by healthcare professionals"
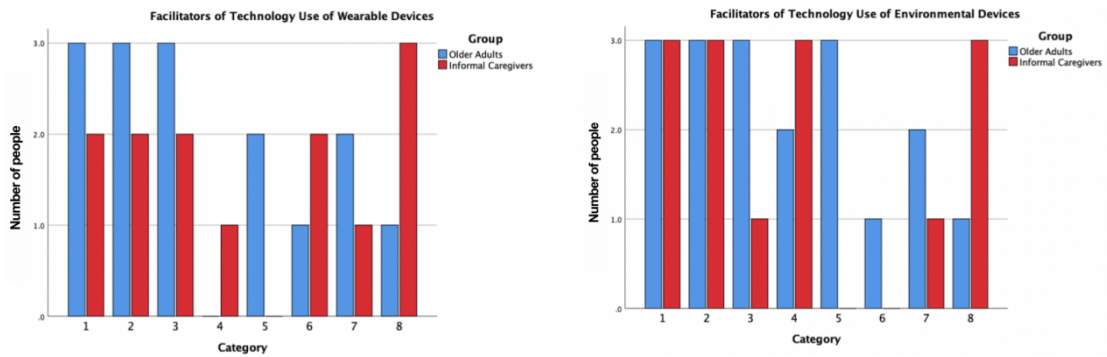7 = "Lessons on how to use the device"
8 = "In favor of progress"

Figure 4. Distribution of older adults and informal caregivers' facilitators of technology use of wearable devices and environmental sensors

4. Discussions

In general, informal caregivers and older adults are receptive to the use of technology, however, informal caregivers are more receptive to digital monitoring technologies than older people, and the two groups have different attitudes toward digital monitoring technology. Five out of six respondents cited cost as the main disadvantage. This suggests that developers need to overcome this in future development and need to find a

technique that is both beneficial and cost-effective. And every respondent found that the data was not always accurate, and it was not uncommon to have inaccurate health assessments. When they are given inaccurate health information, they are subjected to unnecessary anxiety or contempt. Meanwhile, every older person and two-thirds of informal caregivers felt that they were not experienced enough with indoor monitoring technology and wearable devices, and they found it challenging to learn how to operate them. Reduce their trust and frequency of use, which increases the likelihood that the technology will not work as planned [18].

4.1. Intergenerational differences

By combining the four core dimensions of UTAUT, the different perceptions of older adults and informal caregivers on the use of digital monitoring technology from the perspective of intergenerational differences help to understand their acceptance and adaptability in using digital monitoring technology.

4.1.1. Performance expectancy

The difference between older adults and informal caregivers in this dimension is mainly reflected in their expectations for digital monitoring technology to improve their quality of life and safety.

Two-thirds of elderly people indicate a lack of understanding of technological functions and believe that it has no significant impact on daily life, reflecting their marginalization in the digital society [5]. Due to a lack of confidence in the effectiveness of technology, they have lower expectations for it and are concerned about privacy risks.

Compared to this, informal caregivers have a deeper understanding of digital monitoring technology and consider that wearable devices can monitor data such as heart rate and blood sugar and remind the elderly to drink water, take medication, and eat. Indoor monitoring technology can also promptly notify nursing staff and medical institutions of emergencies [19]. Caregivers usually have high expectations for the benefits of technology, believing that it can help reduce caregiving burden and improve efficiency.

Therefore, due to intergenerational differences, there is a significant difference in the expectations of technology. Caregivers tend to believe in the benefits of technology, while older adults are skeptical about its effectiveness.

4.1.2. Effort expectancy

The differences between the two groups of people in this dimension are mainly revealed in the complexity of technology use and ease of operation.

Older adults generally find digital monitoring technology complex and difficult to operate, especially when using wearable devices or learning new skills, and they feel anxious and confused. Most of them tend to reduce the use of multiple digital devices and avoid learning new technologies. Research has shown that digital devices that are simple and capable of monitoring multiple activities will better meet the needs of older adults [11].

However, informal caregivers are more technologically adaptable than older adults and often have fewer operational barriers. Because informal caregivers are 32 years younger than older adults and have more access to technology in their daily lives, they see these devices as less complicated and more convenient to use. However, they still need to pay attention to older people's difficulties in using technology and help them reduce the difficulty of learning.

Generational differences make for differences between older adults and informal caregivers in the ease of use

of technology. The elderly are repelled by the complexity of the devices, while caregivers see these technologies as relatively easy to operate and help improve safety.

4.1.3. Social influence

This dimension is mainly shown in the influence of family caregivers on the technological acceptance of older adults.

Older adults are usually less influenced by others, especially in terms of technology usage [4]. However, five out of six elderly people say they would be more willing to try technology if their family or caregivers actively helped them use it. Therefore, social influence mainly comes from informal caregivers, and the support of caregivers can enhance the trust and sense of security of the elderly.

Two-thirds of informal caregivers consider that indoor monitoring technology promotes real-time video communication with the elderly, helping them observe their condition and alleviate their loneliness, thereby increasing their acceptance of technology.

As the younger generation, informal caregivers significantly influence the elderly's willingness to use technology. Through real-time video and other functions, caregivers can both virtually accompany and better care for the elderly, positively impacting their attitude toward technology.

4.1.4. Facilitating conditions

There are differences between the two groups in terms of training, equipment availability, and technical support in this dimension.

Older adults lack technical support and resources, leading to confusion and anxiety about digital monitoring devices [14]. Most older adults perceive that lack of personalized design and assistance makes it difficult for them to choose and use technology, with poor adaptability and low intention to use it.

Informal caregivers typically have more technical resources and training and possess higher technical literacy [9]. Respondents reported being able to smoothly operate equipment and apply it to nursing, resulting in a higher tendency to use it.

Caregivers' advantages in technical support and resources make them key drivers for elderly people to adapt to technology, effectively improving their user experience.

4.2. Suggestions
4.2.1. Privacy protection (performance expectancy)

Privacy protection legislation should be developed and implemented to ensure that technology providers comply with relevant regulations. Meanwhile, incorporating privacy protection features into device design from the beginning enhances the trust and willingness of older adults to use technology [20,21].

4.2.2. Customized design (effort expectancy)

Technology should be tailored to the preferences and needs of users. It is necessary to strengthen interdisciplinary cooperation, including joint participation in technology, healthcare, social services, and other fields, to develop customized designs that meet the needs of the elderly [22].

4.2.3. Enhancing digital literacy (social influence and facilitating conditions)

Implementing tailored training and intergenerational learning initiatives aims to enhance the adaptability of older

adults and informal caregivers to digital technology, strengthen positive guidance and support for caregivers and their family members, reduce technology anxiety, and increase trust in technology [23].

5. Conclusion

5.1. Contributions

This research adopted an innovative approach that combines semi-structured interviews with PEIs to explore the application of digital monitoring technology in older adults, which emphasizes the necessity of customizing technology based on the complex attitudes and obstacles of different user groups, a topic that has not received sufficient attention in prior research. In addition, the study identified the disparity between the goals of technical services and their actual uses, which have not been fully investigated in previous research, providing valuable insights for future technological development.

5.2. Limitations

The absence of probability sampling may lead to the selected samples not being representative and omitting certain populations, which may introduce bias. Meanwhile, the study only focused on two types of technologies and did not involve other types of digital monitoring devices, which limits the broad applicability of the results. Due to the small sample size and short research period, the potential impact of gender on technology use was not fully considered. The participants are mainly older adults with mobility disorders, lacking diversity, and may not reflect the actual situation of others. Additionally, all participants have Internet access, which may make the results inapplicable to populations without such access. Finally, the study was only conducted in the Nanshan District, Shenzhen, with a limited sample size, which may lack broad representativeness.

5.3. Future research directions

There is a need to continue to pursue empirical evidence on the effectiveness and importance of digital monitoring technology and further identify the diverse needs of different user groups in technology use. Through collaboration between technical experts, home healthcare professionals, and users, explore how to more effectively utilize technology to improve the quality of life for the elderly. Meanwhile, it is crucial to investigate whether older adults may develop dependence, resistance, or other adverse experiences due to long-term use of technology products and pay attention to the long-term impact of technology on their lives. Finally, more focus on the aging population and the constantly changing use of technology to better adapt to the developing social needs and characteristics of the elderly population.

Disclosure statement

The authors declare no conflict of interest.

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Appendix

Appendix 1. Recruitment poster

Appendix 2. Products chosen by the participants. By spreading out all the photos on a table, the participants chose two products that were more useful in their daily lives.

(1) Performance expectancy

Older adults' guide

- Why do you need help daily?
- Follow-up questions (need for help):
    - o Explain to me how your usual day/week goes.
    - o What would help you more?

- It identifies expectations regarding outcomes and the technology's effectiveness in providing necessary assistance.

- o Do you think that any technologies could help you solve the problems we have just discussed?

- This explores the perceived usefulness of technology and how it could meet their needs or improve their daily life.

Informal caregiver's guide

- In which daily situations do you help xxx (spouse, parent, ...)?
    - o In practice, what does that consist of (type of assistance, frequency, duration)?
    - o How have you dealt with these situations so far?
    - o Can you give me an example of a situation where you helped xxx?
    - o In these cases, what makes your life easier?
    - o Do you have any personal strategies?
    - o What would help you more?
    - o Do you think that there are any technologies that could help you solve the problems of the person you help daily?

- Evaluates caregivers' beliefs in the potential benefits of technology to improve their caregiving role.

- o How could they help you in your role as a caregiver?

- Directly relates to the perceived usefulness and impact on their tasks.

(2) Effort expectancy

Older adults' guide

- o Do you already use technologies or technological objects (purpose, frequency)?

- This gauges the perceived ease of use of current technologies and the frequency of interaction, highlighting usability aspects.

- o How did you start using this technology? (the one mentioned by the interviewee during the interview).

- It helps understand the initial ease of adoption and learning curve for the technology.

Informal caregiver's guide

- o What would make you want to use them?

- Seeks to uncover factors tied to the perceived ease of use, influencing their willingness to engage with new technologies.

(3) Social influence

Older adults' guide

- o Sometimes technologies are used to make life easier. What do you think?
- o What do you think about the help you get from XX?

  o Has anyone recommended similar products to you?

  o Do you know anyone who is using/has used this product?

- This assesses the influence of social norms and opinions on their view of technology use.

Informal caregiver's guide

  o Do you know anyone who is using/has used this product?

  o Sometimes technologies are used to make life easier. What do you think?

  o What do you think about the help you give to XX?

  o Has anyone recommended similar products to you?

  o Do you know anyone who is using/has used this product?

- Explores how social beliefs or norms affect the caregiver's perception of technology adoption in caregiving.

(4) Facilitating conditions

Older adults' guide

  o What would make you want to use them?

- Explores the conditions that need to be in place for them to adopt and use technology effectively.

  o On the contrary, what would hold you back?

- Identifies potential external barriers or supports (e.g., resources, technical help) that impact the acceptance of technology.

Informal caregiver's guide

  o Do you receive any third-party assistance (professional or other)?

- Investigates the presence of supportive structures that facilitate technology use.

  o Do you have any other additional resources, financial help, fitting out, moving...)

  o On the contrary, what would hold you back?

- Highlights barriers, such as lack of support, resources, or technical infrastructure, that might prevent adoption.

Appendix 3. Interview guideline

Participants' age:

Older adult 1: 78 岁

Older adult 2: 72 岁

Older adult 3: 76 岁

Informal caregiver 1: 43 岁

Informal caregiver 2: 42 岁

Informal caregiver 3: 44 岁

Older adult:

Technical practicality and comfort:

OA 1: " 要使用不同的设备才会有不同的功能，这增加了我们的学习负担 ."

OA 2: " 操作太复杂，我们不会用，出了问题也不知道怎么解决 ."

OA 2: " 戴时间长了会觉得不舒服，特别是夏天容易出汗 ."

OA 3: " 可穿戴设备对皮肤有刺激，有时候会发红 ."

OA 2: " 我觉得这些设备有点复杂，不会用也看不懂说明书 ."

Concerns about privacy:
OA 3: " 担心隐私被泄露，毕竟家里装监控不太自在。"
OA 2: " 监控让我觉得自己像被 ' 盯着 '，我觉得我的隐私没有被保护，生活有点不自然 ."

Be skeptical of the accuracy of the data:
OA 2: " 有时候检测不准，比如我只是坐下来，它就报警了 ."

Consideration of cost:
OA 1: " 这些设备挺贵的，我觉得价格不太合理 ."

Informal caregivers:
The practicality of the technology:
IC 1: " 可穿戴设备还能测心率、提醒喝水，对老年人身体健康也有帮助 ."
IC 2: " 手机上就能看到数据，还能收到提醒，方便我们随时关注老人的状态 ."
IC 2: " 知道家里装了监控，万一老人摔倒我们能及时赶到，心里更踏实了 ."
IC 3: " 这技术很有帮助，特别是我们不在家的时候，能更放心 ."
IC 1: " 我害怕设备突然坏了，影响到关键时刻的救助 ."
IC 3: " 这些设备的使用不算太复杂，跟着说明书就能安装下来就能用了 ."

Be skeptical of the accuracy of the data:
IC 2: " 接到几次误报电话后，我们对系统的准确性有些怀疑 ."

Consideration of cost:
IC 3: " 除了初装费，还有后续的服务费或维修费用，确实压力不小 ."

Appendix 4. Thematic analysis of results