

Evaluation Of the Application Effectiveness of Smart Home Health Monitoring Devices

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Abstract. With the rapid acceleration of population aging in China, the demand for elderly care and health management has increased dramatically. Home-based elderly care has become the mainstream model as it meets older adults' needs for independence and emotional companionship. However, traditional home-based elderly care models exhibit deficiencies in health monitoring and safety assurance. The rapid development of smart home technologies offers new possibilities for home-based elderly care. Although smart home technologies theoretically hold great potential, existing research primarily focuses on technological implementation and functionality testing, with limited studies evaluating the actual effectiveness of smart home devices in home-based elderly care. To bridge this gap, this study explores the practical application of smart home health monitoring devices in home-based elderly care. Addressing the various challenges faced by older adults in safety and health management, this study surveyed 152 elderly individuals who had firsthand experience using these devices. Through questionnaire data collection, this paper analyzed their subjective evaluations of key functions such as fall detection, vital sign monitoring, and emergency response. Based on the findings, this paper proposes targeted improvement suggestions, providing insights for the further optimization of smart home products and policy support.

Keywords: Smart health monitoring devices; home-based elderly care; elderly health management; elderly technology adaptation; user needs analysis.

1. Introduction

The rapid acceleration of population aging in China has led to a significant demographic shift. As of the end of 2023, the number of elderly individuals aged 60 and above reached 297 million, accounting for 21.1% of the total population [1]. This statistic highlights the increasing severity of aging-related issues in China, where the gradual decline of the working-age population imposes substantial pressure on various societal functions and services. By 2035, the elderly population aged 60 and above is projected to surpass 400 million, exceeding 30% of the total population. At that point, China will enter a stage of deep aging [2]. This demographic transition presents unprecedented challenges to the national economy, social security system, healthcare system, and various public services, resulting in a sharp increase in demand for elderly care and health management. The transformation of elderly care models has become an urgent priority and ensuring the physical and mental well-being of older adults while maintaining their quality of life remains a pressing social issue.

In the current social context, home-based elderly care has increasingly become the preferred choice for older adults. Compared to institutionalized nursing homes, home-based elderly care better meets the needs of older adults for independence and familial companionship. For those with poor health, mobility impairments, or a reluctance to leave familiar environments, the demand for home-based elderly care has been growing. While this model provides a certain level of emotional support and a comfortable living environment, traditional home-based elderly care systems exhibit considerable shortcomings in safety assurance and health management. Older adults living alone may struggle to obtain timely assistance in the event of sudden health issues, potentially facing emergencies such as falls or acute medical conditions that cannot be promptly addressed, thereby posing risks to their health and safety.

In recent years, the rapid development of smart home technologies has introduced new possibilities for addressing the limitations of traditional home-based elderly care in terms of safety assurance and

health management. The integration of technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI) has enabled smart home health monitoring devices to provide real-time functions, including fall detection, vital sign monitoring, and emergency response within the daily lives of older adults [3,4]. Through wearable devices and sensor-based systems, smart health monitoring solutions can continuously track key physiological indicators such as heart rate and blood pressure, allowing for the timely identification of potential health issues. Additionally, features such as fall detection and emergency response offer comprehensive safety support for older adults. In case of an accident or health emergency, the system can immediately issue alerts and notify family members or healthcare professionals, ensuring that older adults receive timely assistance [3,4]. The application of these technologies not only significantly enhances the quality of life for older adults but also helps them maintain a greater degree of independence, reducing their reliance on caregivers and allowing them to receive better health management services within the comfort of their own homes.

Despite the theoretical potential of smart home technologies, existing research primarily focuses on technological implementation and functional testing, with relatively few studies evaluating the actual effectiveness of smart home devices in home-based elderly care. The majority of existing literature emphasizes the technical aspects of these technologies while lacking empirical data on their real-world impact and their contribution to improving older adults' quality of life. Therefore, conducting an evaluation of the application effectiveness of smart home health monitoring devices based on user feedback is of critical importance.

This study aims to fill this research gap by employing a user survey methodology to comprehensively assess the contributions of smart home health monitoring devices to improving the quality of life of older adults at a micro level. Through both quantitative and qualitative analyses of changes in older adults' well-being following the adoption of smart home devices, this research explores their actual effectiveness in enhancing safety, health management, and independent living capabilities. The findings will provide scientific evidence for the optimization of smart home devices, user training, and policy formulation, ultimately promoting the widespread adoption of smart home technologies in elderly care services.

2. Research Methodology

2.1. Research Background and Objectives

This study focuses on the user experience of middle-aged and elderly individuals in using smart health monitoring devices. By employing a questionnaire survey method, it aims to provide an in-depth analysis of their needs, usage frequency, functional preferences, and challenges encountered during the usage process. The specific research questions include: What are the primary needs of middle-aged and elderly users regarding smart health monitoring devices? What factors are associated with the frequency of device usage? What are their key concerns regarding device functionalities? What major challenges do they face during usage? By addressing these questions, this study seeks to provide empirical evidence for the improvement and promotion of smart health monitoring devices.

2.2. Survey Design

This survey targeted middle-aged and elderly individuals, with a total of 152 valid questionnaires collected. The sample selection considered multiple factors, including age, gender, living arrangements, and economic status, to ensure the broad representativeness of the research findings. The respondents were aged 50 and above, encompassing various living arrangements (such as living with a spouse, living alone, or living with children) and different income levels (low-income, middle-income, and high-income groups).

The questionnaire was structured around respondents' personal information, device usage, perceptions and needs regarding health monitoring devices, and the challenges encountered during usage. Specific aspects included basic demographic information such as gender, age, living

arrangements, and economic support; device usage frequency; types of devices used and their functional priorities; evaluation of the devices' contribution to health management, mental well-being, social activities, and overall living environment comfort; as well as difficulties encountered and suggestions for improvement. The questionnaire was designed in a multiple-choice format with concise and clear language to accommodate the reading habits of middle-aged and elderly individuals.

2.3. Data Collection

The questionnaire was distributed online through various channels, including social media platforms and email. During the data collection process, researchers provided necessary guidance and explanations to ensure the accuracy and completeness of responses. After a rigorous screening process, 152 valid questionnaires were retained. Data entry and analysis were conducted using Excel and SPSS software to ensure the standardization and accuracy of data processing.

3. Survey Results and Analysis

3.1. Basic Information and Device Usage

Descriptive statistical analysis revealed that 63.16% of respondents lived with their spouse or partner, 9.21% lived alone, and 9.21% lived with their children. The sample predominantly consisted of households with spousal or partner relationships. In terms of device usage, middle-aged and elderly individuals most frequently used smart wristbands or smartwatches and smart blood pressure monitors, with usage rates exceeding 80%, significantly higher than other types of smart health monitoring devices, as shown in Figure 1.

According to the Pearson correlation analysis, the usage of smart home health monitoring devices (Mean = 1.30, SD = 0.46) was found to have a significant negative correlation with average monthly income (Mean = 3.09, SD = 0.89) ($r = -0.23$, $p < 0.01$). This result indicates that as average monthly income increases, the likelihood of respondents using smart home health monitoring devices may decrease.

This phenomenon may be attributed to differences in health management needs and usage habits between high-income and low-income groups. High-income individuals generally have access to more health management resources and options, making them more inclined toward personalized and high-end medical services rather than relying on smart home health monitoring devices. Some high-income individuals may prioritize traditional health check-ups and private medical consultations over smart home devices as their primary health management tools. Additionally, the lifestyle and routines of high-income groups may reduce their dependence on such devices, as they may place greater emphasis on other aspects of life quality, such as fitness and dietary management. This could also be a contributing factor to the decline in device usage inclination among this demographic.

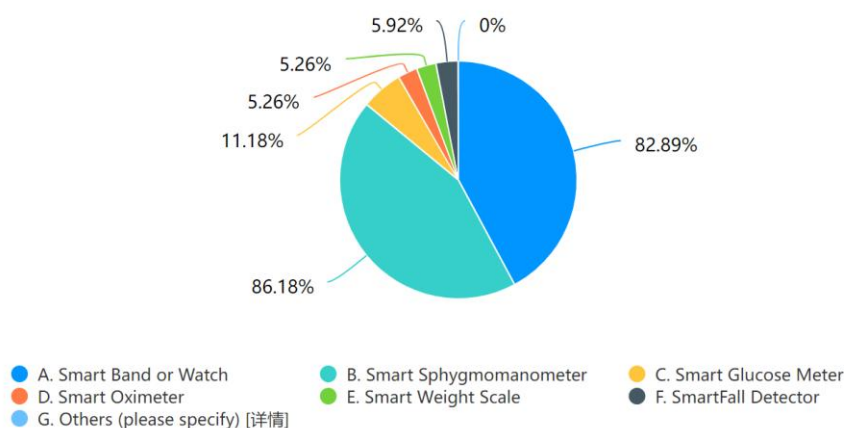


Fig. 1 Usage rates of different smart home health monitoring devices

3.2. Usage Frequency and Functional Priorities

The survey results indicate a significant correlation between the usage frequency of smart home health monitoring devices and the respondents' age group. According to the Pearson correlation coefficient analysis, there is a significant positive correlation between the respondents' age group and the frequency of using smart home health monitoring devices ($r = 0.73$, $p < 0.01$). This correlation suggests that as individuals age, their frequency of using smart home health monitoring devices increases correspondingly.

As physical functions tend to decline to varying degrees with aging, older adults exhibit greater concern for their health status, prompting them to engage more actively in daily health monitoring and data recording through smart health devices. This trend is closely related to the heightened awareness of chronic diseases and health risks among older populations. Older individuals are more likely to experience chronic conditions such as hypertension and diabetes, and smart home health monitoring devices provide a convenient and continuous means of tracking health data, enabling timely detection of potential health issues and facilitating appropriate health management measures. Consequently, with increasing age, respondents tend to rely more on these devices to better understand their health status and take preventive actions.

As illustrated in Figure 2, respondents prioritize health data monitoring functions in smart home health monitoring devices, particularly metrics such as heart rate and blood pressure. The growing awareness of health management has led an increasing number of older adults to recognize the importance of regularly monitoring their physical health. In the context of chronic disease management, timely access to health data enables them to better prevent and respond to potential health concerns. By providing real-time data monitoring, smart home health monitoring devices not only help older adults keep track of their health status at all times but also facilitate the integration of health data with medical services, offering patients professional health recommendations. In recent years, with continuous advancements in smart technology, these devices have gradually become essential tools for daily health management, serving as indispensable instruments for maintaining a healthy lifestyle among middle-aged and elderly individuals.

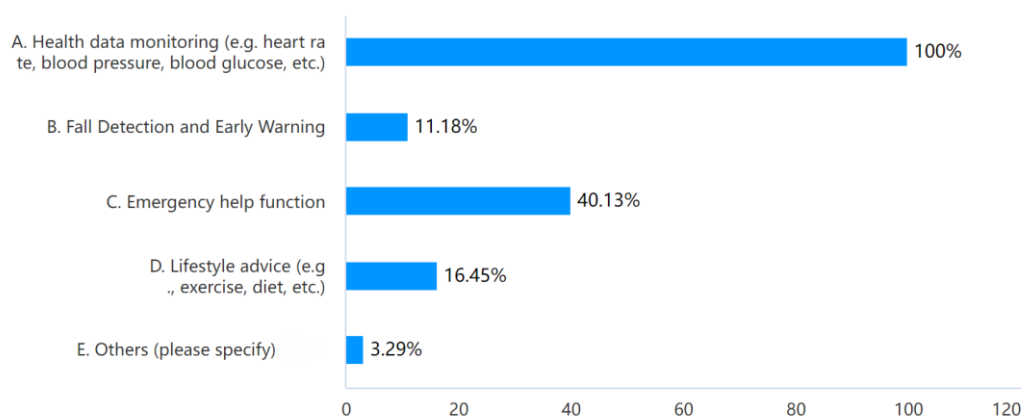


Fig. 2 Functions of smart home health monitoring devices that concern the elderly

3.3. Perceived Benefits of Devices

The vast majority of respondents provided positive evaluations of the extent to which smart home health monitoring devices are helpful. By continuously monitoring physiological indicators such as heart rate and blood pressure in real-time, these devices assist users in detecting potential health issues promptly, preventing possible diseases, and thereby fostering greater awareness and engagement in health management. This effect has been widely recognized among users, demonstrating that the value of smart health devices has been validated through practical applications.

Most respondents also believe that these devices contribute to mental well-being, aligning with the findings of Hu, M. et al. Their research indicates that social isolation—defined by factors such as

living alone, limited social networks, infrequent social activities, and lack of support—adversely affects the health of older adults, increasing their risks of depression, anxiety, and mortality. Smart technology can facilitate online social engagement and potentially serve as an intervention tool to improve health outcomes [5]. Additionally, more than half of the respondents stated that using these devices enhances the comfort of their living environment. Many users reported that the health monitoring functions provided by these devices give them a greater sense of security in their daily lives, enabling them to enjoy a more comfortable and relaxed living environment. This phenomenon underscores the positive impact of smart home technologies on quality of life, particularly in enhancing the daily living experiences of elderly individuals.

Regarding safety, 29.61% of respondents acknowledged that smart home health monitoring devices offer some assistance in improving security, while 24.34% found them to be very helpful in this regard. With the ongoing advancement of smart technology, many smart devices can now monitor users' physical conditions in real time and automatically issue alerts in the event of abnormalities. This function is particularly crucial for older adults living alone, as they face higher health risks and emergency situations. Timely warnings from smart devices can effectively help them respond to sudden health incidents.

Furthermore, 52.63% of respondents agreed that smart home health monitoring devices contribute to enhancing the ability of older adults to live independently. This percentage reflects the widespread recognition of smart home technology in promoting elderly independence. With the increasing adoption of smart devices, more older adults can manage and monitor their health more effectively, reducing their dependence on others and enhancing their self-management skills and autonomy.

Smart home health monitoring devices also assist elderly individuals in daily health management, such as reminding them to take medications on time, engage in appropriate physical activity, and maintain a healthy diet. These functions enable older adults to take a more proactive role in self-care, mitigating challenges associated with memory decline or mobility limitations due to aging. Consequently, their self-management abilities are further strengthened. This self-management extends beyond physical health, providing psychological support as well. By maintaining good health, elderly individuals can also achieve greater psychological well-being and a sense of independence.

3.4. Learning Methods and Willingness to Recommend Devices

More than half of the respondents expressed a preference for learning how to use health monitoring products through family members or friends. This choice reflects the tendency of many older adults to seek assistance from familiar and trusted individuals when encountering new technologies, especially in health management, which directly affects their safety and well-being. As shown in Table 1, all respondents in the 50–59 age group opted to learn how to use health monitoring products through video tutorials. This suggests that users in this age range are more accustomed to modern digital learning methods and can independently acquire knowledge via online resources such as instructional videos. In contrast, the vast majority of respondents aged 60 and above preferred learning through family members or friends, indicating that older individuals are more inclined toward face-to-face interactions and direct assistance when resolving technical issues, rather than relying on self-learning through digital means.

According to Pearson correlation coefficient analysis, the correlation coefficient between age group and learning method was 0.74, reaching a statistically significant level ($p < 0.01$), demonstrating a strong positive correlation between the two variables. This finding indicates that as age increases, older adults are more likely to choose traditional, face-to-face interactions for learning, whereas younger individuals are more inclined to utilize modern digital tools such as online video tutorials and digital manuals for self-directed learning.

This reflects differences in technological adaptability across age groups. Younger users generally have a higher acceptance of new technologies, being accustomed to acquiring information from online platforms and resolving issues independently. As a result, they tend to prefer digital learning methods such as video tutorials and online courses. In contrast, older users may feel unfamiliar or

uncomfortable with new technologies, especially when lacking guidance, which can lead to confusion or anxiety. Consequently, older individuals often prefer learning how to use smart health monitoring devices through family members or friends. This face-to-face learning approach provides greater emotional support and immediate feedback, reducing the difficulty of mastering new technologies.

Additionally, older adults' demand for health monitoring products is often accompanied by concerns about device operation. They prefer receiving assistance from familiar individuals to ensure the safety and effectiveness of device usage. For these users, family members and friends serve not only as instructors but also as sources of emotional support.

Table 1. Preferred learning methods for elderly individuals using smart health monitoring devices

X/Y	Video tutorials	Graphic illustration	Learning through family or friends	Others
Aged 50-59	100%	0.00%	0.00%	0.00%
Aged 60-69	0.00%	6.82%	93.18%	0.00%
Aged 70-79	0.00%	24.24%	72.73%	3.03%
Aged 80 and above	0.00%	20%	70%	10%

3.5. Price and Willingness to Pay

As shown in Figure 3, respondents generally pay close attention to the price of smart home health monitoring devices. Only 26.32% of respondents are willing to pay extra for high-quality devices. This group values the performance and long-term utility of the devices, viewing them as an investment in quality and effectiveness. They tend to prioritize health management and are willing to incur additional costs in exchange for precise monitoring and other advanced features.

However, another group of respondents (40.79%) indicated that their willingness to pay depends on the price of the device, suggesting that cost remains a key factor in their decision-making process. For these respondents, while the functionality and quality of the device are important, their purchasing decisions are more constrained by budget considerations. Excessively high prices may deter them from making a purchase, leading them to opt for simpler, more affordable alternatives. This finding highlights the need for manufacturers to balance market demands when designing and pricing smart health devices. Offering products that combine high quality with strong cost-effectiveness can help cater to the purchasing preferences of different consumer groups.

The remaining respondents are unwilling to pay extra. Although health monitoring devices can improve quality of life and health security to some extent, some older adults tend to perceive these devices as "optional" rather than "essential." As a result, they adopt a more cautious and conservative approach when deciding whether to pay additional costs for higher-quality devices. Furthermore, the rapid advancement of technology and the potential for obsolescence may also influence respondents' willingness to pay. Given the fast-paced evolution of smart home technology, high-quality devices may be replaced by newer generations within a few years, raising concerns among some respondents about potential depreciation of their investment. Consequently, they are more inclined to choose reasonably priced, functionally basic devices that still meet their needs, thereby minimizing possible financial losses in the future.

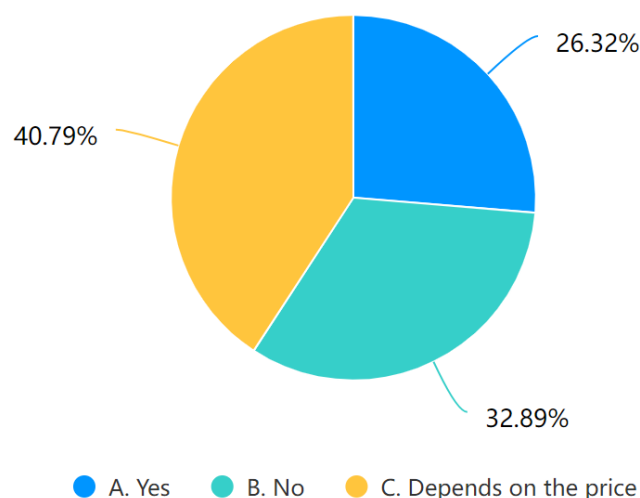


Fig. 3 Willingness of older adults to pay extra for high-quality smart home health monitoring devices

3.6. Challenges in Using Devices and Possible Improvements

Although smart home health monitoring devices have gained widespread recognition among users, the survey also identified several issues that need to be addressed, as they affect both user experience and adoption rates. When asked about suggested improvements, 83.55% of respondents expressed a desire for enhanced ease of operation, while 58.55% emphasized the need for greater accuracy. This indicates that the complexity of operation and the accuracy of data remain the primary concerns for most users. For those unfamiliar with technology, intricate user interfaces and potential technical difficulties often serve as major obstacles to device adoption.

This finding highlights the need for manufacturers to fully consider users' practical needs during the design process. Optimizing user interfaces and improving data monitoring accuracy can help better meet user expectations.

Additionally, the survey revealed that 90.13% of respondents identified a lack of sufficient usage guidance as one of the main challenges they encountered when using these devices. The absence of clear and comprehensible instruction manuals or tutorials for installation, operation, and function configuration can leave older adults feeling confused or uncertain when using the devices. This issue is particularly pronounced among elderly users, who may not be familiar with complex technical terminology or operational procedures. When faced with new smart devices, they often require more intuitive and detailed assistance. If the instructions are too brief or overly technical, the learning process becomes more difficult, preventing users from fully utilizing the device's capabilities or even leading them to abandon its use altogether.

Technical issues, such as connectivity problems, also present a common challenge. Some devices may suffer from unstable Wi-Fi connections or failed Bluetooth pairing, causing unnecessary frustration for users. Such issues not only hinder the normal functioning of the device but may also undermine users' trust in product quality, negatively impacting their overall experience. This concern is especially relevant for older users, who may have a lower adaptability to new technologies. When faced with these technical difficulties, they often require additional technical support and guidance. Without timely assistance, they may choose to discontinue using the device or revert to more traditional health management methods.

Although modern smart home devices have become increasingly advanced, user-friendly interface design remains a critical issue, particularly for many older adults. Simplifying operational procedures, optimizing interface design, and providing clearer and more comprehensible user instructions can

effectively reduce the challenges older users face, thereby enhancing their overall experience and increasing the practical value of these devices.

4. Conclusion

This study provides an in-depth analysis of the needs, usage frequency, functional concerns, and challenges faced by the middle-aged and elderly population in using smart health monitoring devices, leading to several key conclusions.

The research found that the middle-aged and elderly individuals generally have a positive experience with smart health devices. Most respondents focused on the monitoring of health indicators, such as heart rate and blood pressure, reflecting their strong emphasis on health management. Although the devices are widely recognized for their health monitoring capabilities, a lack of sufficient usage guidance remains one of the primary challenges faced by older adults when using the devices. Technical issues, such as connectivity problems, are also commonly encountered. For older adults who are not familiar with technology, the user-friendliness and simplicity of smart devices are critical factors affecting their user experience.

The study also revealed that the frequency of device use is related to the respondents' age group. As the age of respondents increases, the frequency of using smart home health monitoring devices also rises. Additionally, respondents' willingness to pay is primarily influenced by the price of the devices.

Based on these findings, the paper offers several policy recommendations to promote the adoption of smart health monitoring devices and improve health management among the elderly. First, the design of smart health devices should focus more on simplification and optimization, especially when targeting the elderly population. The interface should be intuitive and easy to understand, and the operational process should be as simplified as possible. To help older adults overcome operational barriers, devices should provide clearer usage instructions, including not only written explanations but also video tutorials and assistance from family members, which should be key support tools for helping elderly users.

Moreover, device manufacturers should adopt differentiated pricing strategies based on the willingness to pay of different income groups. For higher-income groups, more advanced features and personalized services can be offered, while for lower-income groups, devices with higher cost-effectiveness and basic functionality should be launched to reduce the purchasing threshold and expand the device's reach. The government could also support the purchase of these devices by low-income groups through appropriate subsidies or tax incentives, fostering the widespread adoption of smart health monitoring devices. Furthermore, policies should encourage the enhancement of elderly individuals' awareness and education regarding smart health devices. Regular health management training could be conducted through community centers, senior universities, and other channels to help elderly users better understand and utilize smart devices, thereby increasing their trust in the technology.

Looking forward, there are many areas of research and application in the field of smart health devices that still require further exploration. Significant differences exist in health management concepts and technological adaptability among middle-aged and elderly populations across different cultural backgrounds. Future research could conduct cross-cultural comparative analyses to explore the differences in the needs of elderly populations in various countries or regions and the underlying reasons for these differences when using smart health devices.

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