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Understanding the service gap between caregivers and recipients in the smart bed system

(Work-in-Progress)

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ABSTRACT

With the advancement of medical technologies and low birth rates, the world's elderly population has risen sharply, and the aging society has increased more and more medical demand. Thus, how to provide a quality home care service is critical. To provide quality care, understanding the needs of the service system's users is an important step. This research aims to identify the gaps in service needs as expected between two types of system users – caregivers and recipients. The Internet of things (IoT) based smart-bed system developed by H Company was adopted as the research object. Caregivers and recipients were asked to fill in an analytic-hierarchy-process (AHP) questionnaire to rank the importance of smart-bed system functions. In current stage, this study finds that caregivers and recipients consider the forewarning function the most important. For care recipients, functions related to physical sensations (e.g., data analysis on detailed sleeping behaviors) are more important. While for caregivers, functions that can improve their work efficiency and quality (e.g., customized data reporting) are more important. While caregivers concern more about how to complete their tasks, care recipients value more on safety and comfort of the system. Future research can study the importance of service functions and the reasons causing the gaps in order to provide valuable suggestions for IoT companies to improve their future services development and product marketing.

Keywords: analytic hierarchy process, customer journey map, smart cloud service platform, homecare, long-term care.

INTRODUCTION

With the progress of society and the improvement of health and medical standards, all countries in the world are facing the phenomenon of population aging. Due to the rapid increase in the elderly population and the prolongation of the average life expectancy of the national, the demand for long-term care is also increasing. Under the aging social structure, the care and treatment need of elderly people continue to emerge, increasing huge medical expenditures. At the same time, due to the declining birthrate, the burden of care for young and middle-aged people is also increasing. These phenomena show that Asia is facing a worry of "increasing demand for care and shortage of care manpower".

However, with the vigorous development of Information and Communication Technology (ICT) and the advancement of technologies, such as the Internet of Things, wearable devices, sensors, and artificial intelligence, information technology has gradually played a pivotal role in the field of health care, also led to the development of Telehealth Care. Through the front-end sensing device, medical cloud and service connection, smart medical integrates the data collected by IoT devices and performs big data analysis and computing, which not only helps users to achieve self-health management; caregivers can also remotely monitor the care recipients. By extending the field of care from medical institutions to homes, medical resources can be used more effectively. Therefore, how to use technology in the medical care support environment has received extensive attention, and countries have also actively introduced information and communication technology into the field of long-term care, hoping to make the elderly more humane and healthier to enjoy their old age (Haslwanter, Garschall, Neureiter, Panek, & Subasi, 2018).

The application of smart medical care in elderly care, in addition to hospitals and other medical institutions, also has great demand in home and community care. The trend of future medical care management optimization is the introduction of smart technology and the establishment of cloud services. Combining the application of home long-term care and smart cloud system, the two complement each other, can build efficient and low-cost care services, and through the long-term and continuous home care model. At present, medical care institutions at all levels have regarded the information system as a strategic information system to improve the effectiveness and quality of care and maintain a competitive advantage. However, given the general shortage of information technology manpower (Haimi & Gesser-Edelsburg, 2022), how can long-term care institutions

properly select, plan, evaluate and introduce emerging information technology and technology, and provide smart and customized health care Nursing is still a major problem and challenge for general long-term care institutions.
This study aims to understand the service gap between caregiver and recipients in telehealth care system. It takes the smart bed as a focused object. The AHP questionnaire were developed and distributed to both parties. This study is expected to finally elicit the design needs for the development of the electronic health care system, so as to provide the most suitable system service development plan in the future, so that the caregivers and the care recipients can experience the most suitable services and valued smart medical solutions.

THEORETICAL BACKGROUNDS

Telehealth Care

With the advancement of communication technology and the popularization of the Internet of Things, information technologies have gradually begun to be used in medical care, which has also led to the development of telehealth care. Telehealth care is an emerging care model that uses remote video equipment or information and communication technology to facilitate communication between caregivers and care recipients in two places, and to provide medical services. It usually adopts medical diagnosis or treatment to conduct preventive medical interventions (Demiris & Hensel, 2009). For example, seniors who do not need daily care can communicate with healthcare providers by wearing a wearable or watch. At the same time, electronic health care also provides many potential advantages and benefits, such as eliminating geographical restrictions on care services, saving costs and time, reducing hospitalization rates, and improving service quality, etc. (Mort et al., 2015).

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was developed by Saaty (1977), a professor at the University of Pittsburgh, USA. It is suitable for decision-making problems with multiple evaluation criteria under uncertain circumstances. It is composed of tangible and intangible, qualitative and quantitative elements that interact with each other. AHP also continues to be applied in many fields, such as medical, road design and economic decision-making problems (Irfan et al., 2022; Panchal & Shrivastava, 2022; Wang, 2022).

METHODOLOGY

This study takes telehealth care system as the research object, and uses the AHP questionnaire method to analyze the needs of home caregivers and the care recipients when they using the electronic health care system. This study particularly analyzes the importance of needs of system services including the smart-bed and other related smart medical IoT products. The AHP structure is shown in the figure below. This research uses questionnaires to cross-examine users for comparison. Each major system will have compared with each other, then we'll use Export Choice software to compute the weights of every service in order to understand the importance of service order. After making narrative statistics on the importance and weight of each system service, in-depth interviews will be conducted in the future to obtain the causes of the gaps and a more in-depth service process design.

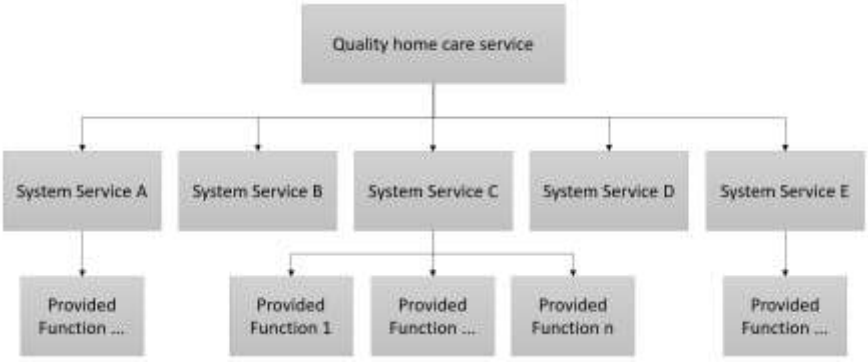

Figure 1: AHP Structure

In order to quickly provide professional medical services and real-time alerts, it is particularly important to measure the importance of both users to system functions. According to the introduction of the electronic medical care system provided by H Company, the AHP items of this research are developed and summarized into 5 major system functional areas, "A. Real-time Status", "B. Forewarning Functions", "C. Data Collection and Analysis", "D. Artificial Intelligence Application", "E. Expansion and Integration". There are more detailed functional sub-factors under each system functions, and the sub-items are described in Table 1.

Table 1: System Functions and Sub-factors

System Functions	***Sub-factors***
A. Real-time Status	A1. Real-time updates of safety status
	A2. Diversity of real-time safety status
	A3. Fast updates of real-time physical sensation
	A4. Diverse updates of real-time physical sensation
B. Forewarning Functions	B1. Apnea time

	B2. Over-breathing times
	B3. Slow-breathing forewarning
	B4. Wake up/get out of bed warning according to the bed position
	B5. Automatically cancel the system. reminder when returning to bed
	B6. Fast reminder of wake up/get out of bed
C. Data Collection and Analysis	C1. Automatic collection of physiological data
	C2. Detailed physiological data analysis
	C3. Customized physiological data report
	C4. Automatic collection of sleep behavior data collection
	C5. Detailed sleep behavior data analysis
	C6. Customized sleep behavior data report
D. Artificial Intelligence Application	D1. Automatic record of co-formulated roll over signal
	D2. AI bed: roll-over positioned time recording
	D3. AI bed: roll-over reminder according to degree of bedsore
	D4. Automatically calibrates and adjusts to fit various medical mattresses
	D5. Automatically calibrates and adjusts to fit various electric medical mattresses
	D6. Automatic calibration and adaptation for home, community and care facilities
E. Expansion and Integration	E1. Combine with IoT to automatically control the best sleeping environment
	E2. Integrate with face recognition system for positioning
	E3. Integrate applications with other health monitoring equipment
	E4. Care voice robot combination

PREMIMINARY FINDINGS

The survey samples of this study include both the care recipient and the caregiver. A total of 53 questionnaires were collected, 23 for the care recipients and 30 for the caregivers. The 53 questionnaires were tested for consistency one by one. When the Overall Inconsistency ≥ 0.1 (and C.R. ≥ 0.1), it means that the respondents have inconsistent answers. In this case, the questionnaire will be deleted. In the end, 13 questionnaires failed to pass the consistency test, including 8 for the care recipients and 5 for the caregivers, so they were deleted. Therefore, a total of 40 valid questionnaires were finalized in this study.

Based on the results, both parties believe that the "fast updates speed of real-time security status" is a very important function. The care recipient believes that the safety status is more important than the display of diversity, because only when the update speed is fast enough, the caregiver can immediately let the caregiver know when there is an abnormality in their own condition. Caregivers believe that instant safety status is important because it helps them understand the current situation of the care recipient easily and quickly.

Table 2: AHP Result of Real-time Status

A. Real-time Status	Recipient Weights(A)	Order	Caregiver Weight(B)	Order	Difference |A-B|	Difference Order
A.1 Real-time updates of safety status	12.82%	1	14.27%	1	1.45%	1
A.2 Diversity of real-time safety status	8.84%	2	8.15%	2	0.69%	2
A3. Fast updates of real-time physical sensation	4.44%	3	4.56%	3	0.12%	3
A4. Diverse updates of real-time physical sensation	3.87%	4	3.85%	4	0.02%	4

According to the results, the care recipients believe that the apnea time is the most important indicator. If they are not detected and dealt with immediately, their own lives may be endangered, so they regard it as the most important indicator. The second is the over-breathing times. The care recipient thinks that breathing too fast will be uncomfortable, causing inner panic, and over-breathing usually occurs suddenly and rapidly, so they hope that the care system can remind the caregiver as soon as possible.

From a caregiver's point of view, apnea is less visible and more critical and needs to be dealt with as soon as possible, so apnea time is considered to be the most important. The second is the early warning of slow breathing. Contrary to the care recipient's belief that breathing is too fast, the caregiver thinks that the early warning of slow breathing is more important, because it may be a manifestation of poor body function or critical illness, and it is also not easy to detect, so that the warning of slow breathing is more important.

Table 3: AHP Result of Forewarning Functions

B. Forewarning Functions	Recipient Weights(A)	Order	Caregiver Weight(B)	Order	Difference |A-B|	Difference Order
B1. Apnea time	14.12%	1	11.97%	1	2.15%	1
B2. Over-breathing times	9.40%	2	7.38%	3	2.02%	2
B3. Slow-breathing forewarning	2.49%	4	2.80%	4	0.31%	3
B4. Wake up/get out of bed warning according to the bed position	2.15%	5	2.37%	5	0.22%	4
B5. Automatically cancel the B4. reminder when returning to bed	8.20%	3	8.26%	2	0.06%	5
B6. Fast reminder of wake up/get out of bed	2.06%	6	2.06%	6	0.00%	6

The "automatic physiological data collection" with the largest gap, caregivers think it is more important, because it can save them some care time and effort. Compared with caregivers, care recipients consider other functions to be more important, because the collection of physiological data does not directly affect the quality of care, but the analysis of the collected data is more important.

Table 4: AHP Result of Data Collection and Analysis

C. Data Collection and Analysis	Recipient Weights(A)	Order	Caregiver Weight(B)	Order	Difference |A-B|	Difference Order
C1. Automatic collection of physiological data	1.77%	3	3.13%	2	1.36%	1
C2. Detailed physiological data analysis	1.66%	5	2.35%	3	0.69%	2
C3. Customized physiological data report	2.98%	1	3.61%	1	0.63%	3
C4. Automatic collection of sleep behavior data collection	1.72%	4	2.33%	4	0.61%	4
C5. Detailed sleep behavior data analysis	1.14%	6	1.62%	6	0.48%	5
C6. Customized sleep behavior data report	2.67%	2	2.31%	5	0.36%	6

Both parties believe that it is an important function that the AI mattress can be reminded to turn over according to the degree of bedsores. The care recipient believes that sometimes the caregiver doesn't always remember to roll them over, so it would be great to have a rollover reminder tailored to their situation. Caregivers believe that bedsores can sometimes lead to more serious illness and sometimes forget to roll over, so it is important to have rollover reminders.

Table 5: AHP Result of Artificial Intelligent Applications

D. Artificial Intelligence Application	Recipient Weights(A)	Order	Caregiver Weight(B)	Order	Difference |A-B|	Difference Order
D1. Automatic record of co-formulated roll over signal	1.31%	6	2.36%	2	1.05%	1
D2. AI bed: roll-over positioned time recording	2.58%	2	1.69%	5	0.89%	2
D3. AI bed: roll-over reminder according to degree of bedsore	2.16%	4	1.73%	4	0.43%	3
D4. Automatically calibrates and adjusts to fit various medical mattresses	2.95%	1	2.58%	1	0.37%	4
D5. Automatically calibrates and adjusts to fit various electric medical mattresses	2.29%	3	1.94%	3	0.35%	5
D6. Automatic calibration and adaptation for home, community and care facilities	1.60%	5	1.47%	6	0.13%	6

The care recipients believe that if the IoT can be combined with the automatic control of the care environment, such as lighting, temperature, etc., it will not only improve the comfort of the care environment, but also reduce the caregivers' problems. Therefore, it is more important for the care recipients to "optionally combine with IoT to automatically control the optimal sleeping environment" compared to caregivers.

Table 6: AHP Result of Expansion and Integration

E. Expansion and Integration	Recipient Weights(A)	Order	Caregiver Weight(B)	Order	Difference |A-B|	Difference Order
E1. Optionally combine with IoT to automatically control the best sleeping environment	1.59%	2	2.73%	1	1.14%	1
E2. Optionally integrate with face recognition system for positioning	2.66%	1	2.04%	2	0.62%	2
E3. Optionally integrate applications with other health monitoring equipment	1.48%	3	1.34%	3	0.14%	3
E4. Optionally Care Voice Robot Combination	1.04%	4	1.07%	4	0.03%	4

CONCLUSION

This research has identified the service expectations from both caregivers and care recipients of telehealth care system through AHP questionnaires. We found that caregivers and care recipients have several expectation priorities in common with the system services. Yet, in terms of their major needs, we shall develop the product with satisfied functionalities to serve as a safe and ease of use system. In the future, this research will conduct more in-depth system requirements analysis and design, and develop different functions required by different users for the system, and carry out feasibility studies. Then, through the prototype method, a test system will be first established for different users to test. By further survey study, we can obtain more user feedbacks on the system prototype, and modify and optimize functions according to the results, and finally develop the actual system for the market.

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