Clinical Interventions in Aging

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ORIGINAL RESEARCH

Digital Inclusion Pathways and Influencing Factors Among Older Adults in Outpatient Settings: A Grounded Theory Study

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Purpose: Smart healthcare services in hospitals play a critical role in enhancing efficiency and quality. However, older adults often face varying degrees of challenges in accessing, adapting to, and using these technologies because of the effects of the Silver Digital Divide, including factors such as physical functioning, smart device access, and digital health literacy. This study aims to investigate the experiences, attitudes, and perceptions of older adults in outpatient regarding smart healthcare service in order to develop an explanatory digital inclusion pathway and construct a comprehensive path model for older adults.

Patients and Methods: We conducted semi-structured interviews with 27 older adults in outpatients in Chongqing, China to understand their experiences, attitudes, and perceptions of attending smart healthcare services through theoretical sampling. Interviews were recorded, transcribed, and translated to English; content was analyzed based on grounded theory to examine the role of each influencing factor in relation to digital inclusion and modeling digital inclusion pathways. The stimuli–organism–response theoretical framework was used to guide path model construction.

Results: Interview data of 27 older adults in outpatient settings were analyzed by exploratory interpretation, obtaining 79 initial concepts, 22 subcategories, seven main categories, and three dimensions, and constructing a theoretical model of the path of digital inclusion of older adults. Physical function, digital health literacy, personal perception, and digital attitudes demonstrated a direct impact on the digital inclusion of older adults. The support of smart devices, service scenario, social environments, and demographic attributes indirectly affect the digital inclusion of older adults.

Conclusion: This study identifies five pathways to enhance older adults' digital inclusion in outpatient smart healthcare, offering age-friendly insights for system design, medical service quality, and public health policy. These findings aim to bridge the silver digital divide, advance equitable healthcare transformation, and support the development of smart hospitals.

Keywords: older adults, smart healthcare service, digital inclusion, path analysis, grounded theory

Introduction

The population of China aged ≥60 years has reached 280 million,[1] with projections suggesting an increase to 485 million by 2050.[2] This demographic shift places China as one of the countries experiencing the most substantial aging population globally and significantly increases the demand for healthcare services among the older adults.[3] Such trends present critical challenges for the healthcare system.

Received: 17 January 2025
Accepted: 15 May 2025
Published: 27 May 2025

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Smart healthcare services refer to the application of advanced information technologies—such as the Internet, mobile communication, and the Internet of Things—to provide patients with integrated, one-stop medical services. These services typically include functions, such as appointment scheduling, online payment, medical report access, and self-service drug dispensing. By digitizing and streamlining various aspects of medical care, smart healthcare services aim to enhance the accessibility, efficiency, and overall quality of healthcare delivery.[4] However, owing to the effects of the "Silver Digital Divide",[5] most older adults face varying degrees of digital inclusion problems, often struggle to adapt or adapting slowly when using smart healthcare services. Digital inclusion refers to the ability of older patients to access and use intelligent healthcare services in the context of smart outpatient services—such as self-service kiosks and mobile platforms—without barriers. This includes the absence of technological, physiological, psychological, and social obstacles.[6] Owing to decreasing physical function and low digital health literacy, some older adults have difficulty hearing the caller's voice, reading the electronic screen and guide sheet, or finding the examination room,[7] which exacerbates feelings of isolation, inferiority, and obsolescence.[8] Meanwhile, smart healthcare services have significantly transformed the traditional healthcare-seeking behavior. However, many older adults lack trust in, feel insecure about, or remain indifferent to new technologies. Consequently, they tend to maintain traditional patterns of seeking care or relying on their children, making it difficult for them to access healthcare independently, and leading to reduced self-efficacy. Relevant surveys have indicated that nearly 70% of older adults still prefer queuing at hospitals for in-person registration, and approximately 80% continue to pay medical bills in cash or by bank card at manual service windows. Only 37.25% are relatively familiar with using computers or smartphones for online appointment booking.[9] Moreover, the lack of age-friendly design in these technologies prevents older adults from accessing fast and convenient healthcare services in the same way as young patients, leading to registration hurdles, medical advice delays, extended treatment waits, and aggravating healthcare disparities for this vulnerable group.[10] Overall, although a smart hospital provides a full range of convenient and efficient smart healthcare services, less attention is paid to whether older patients can truly adapt to a smart environment, where they use kiosks and mobile phones to participate in smart healthcare services without barriers. Therefore, the above technical, physical, psychological and social inclusion issues are significant and need to be addressed urgently.

Existing research shows diverse perspectives on digital inclusion for older adults. Previous studies have explored the digital engagement of older adults, analyzing their use of WeChat,[11] smartphones,[12] and the Internet[13] from micro-level perspectives on media communication. Additionally, studies have examined the digital inclusion within families,[14] communities,[15] and nursing homes[16] from sociological meso-perspectives, and have proposed digital inclusion strategies[17] through macro perspectives on demographic and social policy analyses. From the perspective of information ecology, although significant progress has been made in understanding digital inclusion, current studies have primarily relied on theories, such as the Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, and Theory of Planned Behavior, to explore the factors influencing the willingness and behavior of older adults, mainly using quantitative methodologies. However, most studies have primarily focused on product attributes, such as the usefulness and ease of use of technology, while overlooking older adults' needs for digital inclusion regarding physiological, psychological, and social factors. Furthermore, the dynamic process through which older adults engage with smart healthcare services in outpatients remains unclear. Moreover, the lack of a cohesive theoretical framework to guide research and interpret results undermines the comprehensive understanding required to assist older adults in overcoming the digital divide and successfully assimilating into digital healthcare services.

The stimulus–organism–response (S–O–R) model[18] is a foundational theory in cognitive psychology primarily used to explain how environmental factors influence user emotions and behaviors, which provides valuable theoretical support for deeply exploring the dynamic adaptation process of digital inclusion among older adults, especially by considering their real experiences and emotions to understand this process. This theory provides a powerful theoretical framework for understanding how the external digital environment (stimulus) impacts the behavior (response) of the older adults to integrate into smart healthcare services through their internal psychology (organism). Additionally, grounded theory,[19] a research method that inductively derives theories from data, provides valuable methodological support for deeply exploring the dynamic process of digital inclusion among older adults, especially by focusing on their real experiences and emotions to understand this process.

This study was grounded in the S–O–R theory and employed semi-structured interviews to explore the experiences, attitudes, and perceptions of older outpatients using smart healthcare services. Although the S–O–R framework has been widely used in various fields, its application in smart healthcare service contexts remains limited. To assess the theory's adaptability in this domain, in order to enrich, extent, and contextualize it, this study adopted a post-positivist research paradigm[20] and employed grounded theory[19] for data analysis. Through this approach, the study sought to elucidate the pathways of digital inclusion and develop a conceptual model of digital inclusion among older adults in outpatient settings. The goal was to improve theoretical knowledge and practical approaches for enhancing age-friendly digital services, aiming to bridge the digital divide for older adults, thereby improving their access to healthcare and promoting their wellbeing.

Patients and Methods

Study Design and Participants

This qualitative study was performed in six smart hospitals in Chongqing, China between March 2023 and June 2023, involving 27 older adults who participated in semi-structured interviews and collected their basic demographic information using theoretical sampling. Face-to-face recruitment was conducted in the outpatient settings to achieve agreement from older adults. The inclusion criteria were as follows: (1) age of 60–85 years; (2) older adults who visited doctors at smart hospital outpatients; and (3) willingness to participate in this study and signed informed consent. The exclusion criteria were as follows: (1) individuals employed in medical or related professions; (2) critically ill patients with significantly impaired self-care abilities; and (3) patients unable to evaluate their own medical experiences.

Sample Size Calculation

Sample size calculation depended on whether interview information was saturated. When no new code and topic could be extracted, the information was saturated.[21] Finally, 27 participants were included.

Data Collection

Prior to the interviews, basic demographic information was collected from each participant, including age, sex, marital status, income, and educational level and relevant details, along with a single item assessing whether they had previously used smart healthcare services in outpatient settings and the types of services utilized. A semi-structured interview guide was developed in advance to ensure consistency across interviews. While the core questions were standardized for all participants, the guide included tailored prompts for two groups: those who had previously used smart healthcare services, and those who had not (Table 1). The guide aimed to explore personal experiences, perceived benefits and barriers, and attitudes toward smart services outpatient use in healthcare. Interviews were conducted in Chinese by a

Table 1 Interview Guide

Participants Types	Interview Questions
Participants who have ever used smart healthcare services	1. In connection with the various aspects of medical care, have you encountered any difficulties in using them, and what is the situation of smart healthcare services? 2. What do you think are the factors that discourage/enhance you from using smart healthcare services? 3. Would you be willing to use smart healthcare services for medical treatment if you had the conditions/opportunities to do so, and why? 4. Compared with the traditional mode of medical treatment in the past, how does smart healthcare service affect your daily medical treatment? 5. What do you think are the special needs of older adults when using smart healthcare services? 6. What kind of help do you think the government, hospitals, family members, etc. can provide for older adults?

(*Continued*)

Table 1 (Continued).

Participants Types	Interview Questions
Participants who have never used smart healthcare services	1. Have you tried to use it in conjunction with the various aspects of medical care, and how was the smart healthcare services? 2. Why do not you use outpatient smart healthcare services and what are the reasons? 3. If you have the conditions/opportunities, would you like to use smart healthcare services for medical treatment and why? 4. Compared with the traditional mode of medical treatment in the past, what is the impact of your smart healthcare service on your daily medical treatment? 5. What do you think are the special needs of older adults when using smart healthcare services? 6. What help do you think the government, hospitals, family members, etc. can provide for older adults?

trained researcher in hospital conference rooms, lasting 20–45 min. With participant consent, all interviews were audio-recorded, transcribed verbatim within 24 h by the interviewer, and anonymized to protect privacy.

Data Analysis

All interview data were analyzed using QRS NVivo 12.0 (QRS International, Doncaster, Australia), employing the grounded theory method for content analysis. Although the S–O–R theory was adopted as a conceptual framework to inform the interpretation of findings, the coding process itself was inductive and data-driven, consistent with grounded theory methodology. The first step was open coding. Irrelevant interview content was excluded, while meaningful sentences were selected for detailed coding and organized into new concepts and categories. These concepts were refined to eliminate inconsistencies, resulting in a set of initial concepts and categories. The second step was axial coding. Relationships among categories were examined to identify main categories and dimensions. The third step was selective coding. Focus was placed on these main categories to outline core themes and relationships. For the fourth step, a model for digital inclusion pathways for older adults in outpatients was developed based on these themes and relationships. Two researchers independently coded the transcripts. Coding consistency was discussed regularly, and discrepancies were resolved through consensus. To enhance rigor, peer debriefing and iterative team discussions were conducted throughout the analysis process.

Theoretical Saturation Test

To further ensure the reliability of this study, a secondary analysis was conducted to assess theoretical saturation, defined as the point where no additional information or categories emerge. The analysis revealed that no new categories or theoretical insights could be derived from the data. Therefore, our model was deemed theoretically saturated.

Ethical Considerations

This study protocol was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University (2022–202) and conformed to the principles of the Declaration of Helsinki. All participants provided written consent, and their digital audios and transcripts of the interview could only be accessed by researchers. All participants provided both verbal and written informed consent for study participation. Their demographic and interview data were anonymized and treated with strict confidentiality. Participants' names were replaced with identification numbers, and only the research team had access to the audio recordings and personal information.

Results

Demographics

A total of 27 older adults were recruited in semi-structured interviews, with 14 women and 13 men, of which 11 (40.8%) had used three or more smart healthcare service, and 8 (29.6%) had never used smart service functions. Additional demographic information is presented in Table 2.

Table 2 Demographic Information of Participants (N=27)

Variables	N	%
Gender		
Male	13	48.1
Female	14	51.9
Age		
60~69	14	51.9
70~74	5	18.5
75~79	5	18.5
≥80	3	11.1
Marital status		
Married	19	70.4
Single/ divorced/ widow	8	29.6
Educational level		
Primary school and below	8	29.6
Middle school	10	37.1
Senior	5	18.5
College or above	4	14.8
Monthly income (cny)		
≤999	3	11.1
≤2999	11	40.7
≤4999	9	33.3
≥5000	4	14.9
Kinds of using smart service functions		
3 or more	11	40.8
1~2	8	29.6
None	8	29.6
Accompany with older adults to the hospital		
Children or grandchildren	11	40.7
Spouse	10	37.1
Alone	6	22.2
Have a smart phone or not		
Yes	6	22.2
No	21	77.8
Live with children or grandchildren		
Yes	16	59.3
No	11	40.7

Coding results

Through the three-level coding process of the grounded theory analysis method, we formed 79 initial concepts (a1~a79) and 22 categories (A1~A22) in the open coding stage, and obtained seven main categories (B1~B7) and three dimensions (C1~C3) from spindle coding (Table 3). Based on the findings of spindle coding, the "story line" map, typical relationships of the main categories, and the structure of the relationships and their connotations are summarized in Table 4.

Theoretical Model Construction

Through findings of the typical relations and interactions between the main categories and based on S–O–R theory, the digital inclusion path model for older adults in outpatients was constructed. As shown in Figure 1, internal and external environmental factors, along with psychological characteristics, influence digital inclusion and are interrelated. Between internal environmental factors and digital inclusion, physical functions and digital health literacy can directly affect digital inclusion and can also indirectly influence digital inclusion through personal perception and digital attitude. Between external factors and digital inclusion, smart device, service scenario, and social environmental supports

https://doi.org/10.2147/CIA.S518045

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Table 3 Coding Results Through the Three-Level Coding Process of Grounded Theory

Dimensions (C)	Main Categories (B)	Categories (A)	Initial Concepts (a)
C1 Psychological factors	B1 Personal perception	A1 Perceived usefulness	a1 recognizes the usefulness of the smart service (flexible management of medical appointments, free choice of doctors, improved efficiency of medical consultations); a2 does not experience the technological exclusivity generated by the use of smart services (only convenient for younger people, operates slower than younger people, burdens younger people); a3 remains neutral (whether used or not, it has little impact on medical treatment).
		A2 Perceived ease of use	a4 the operational steps are numerous and complicated, which is troublesome; a5 digital technology information is difficult to understand; a6 knows how to operate, relatively easy to learn; a7 contradiction: knows how to use but not all functions / wants to use but it's too difficult.
		A3 Perceived risk	a8 afraid of making a mistake and losing money; a9 worried about encountering scams; a10 concerned that registration and other processes will not be successful, wasting time and energy; a11 unable to use medical insurance or special disease discounts
	B2 Digital attitude	A4 Age prejudice	a12 self-age discrimination: feeling old, outdated, obsolete, and useless; a13 age discrimination from others: experiencing too many problems while using or learning to use, leading to being disliked or considered slow
		A5 Subjective initiative	Strong subjective initiative: a14 independent personality, not wanting to trouble others; a15 daring to try, diligent in hands-on and mental tasks; a16 interested in smart technologies
			Weak subjective initiative: a17 strong reliance mentality (depending on family members, guides, or accompanying medical staff for operation); a18 traditional medical habit and thinking; a19 not interested, not minded to use, repulsed
		A6 Techno fear	a20 feeling of losing control over the machine (panic, nervousness, helplessness, and resignation); a21 a dire need for a sense of security (requiring someone else to assist or guide beside the machine)
		A7 Self-efficacy	a22 learning outcomes (forgetting quickly, understanding only superficially, misunderstanding; encompassing both mastery and failure to learn); a23 effects of success or failure (success or failure affects feelings of frustration, abandonment, or achievement); a24 slow usage occupies machines excessively, wasting communal resources
C2 Internal Environmental factors	B3 Physical functions	A8 Health level and disease burden	a25 experiencing illness and discomfort; a26 neurological issues and early signs of dementia; a27 suffering from cancer.
		A9 Vision, hearing and memory problems	a28 deterioration of vision (presbyopia, cataracts, myopia); a29 hearing decline; a30 memory decline
		A10 Brain, hands, feet, lumbar spine and reactivity problem	a31 insufficient mental and physical energy; a32 Lack of dexterity in hands and feet, spinal issues; a33 slowed reflexes
		A11 Needs of going to the hospital	a34 high demand for medical care (chronic illness management, regular check-ups, and medication retrieval)
	B4 Digital health literacy	A12 Experiences with digital health	a35 Related to past experiences: work history, late exposure to the internet era; a36 Infrequent usage: unlike daily use platforms like WeChat or TikTok, resulting in a lack of experience and frequent forgetting of operational steps; a37 Medical consultation habits: frequency of visits to major hospitals
		A13 Knowledge and ability to understand digital health	a38 Mastery of digital information knowledge; a39 Ability to learn basic health knowledge
		A14 Adaptability to change with the times	a40 Information technology becoming increasingly intelligent, falling behind the pace; a41 Rapid upgrade and optimization of smart service systems

C3 External environmental factors	B5 Smart device support	A15 Smartphones use level	a42 Only possesses a feature phone; a43 Owns a smartphone but uses it solely for making calls; a44 Has a smartphone and uses common apps like WeChat, TikTok, etc.; a45 Capable of utilizing various functionalities of a smartphone flexibly.
		A16 Smart services suitable degree of aging	a46 Special features for older adults in device usage: devices specialized for older adults, fingerprint, facial recognition functionalities, etc.
			a47 Highlight key functions, deemphasize idle features, and adopt a gradual and progressive approach
			a48 The interface design is simpler, drawing inspiration from familiar apps such as Meituan, Taobao, TikTok, etc.
			a49 Further streamline the registration process, not solely reliant on text, include visuals.
			a50 The machine's voice prompts are too soft to hear clearly and too specialized to be easily understood.
			a51 Overall font size.
			a52 Preference for using WeChat QR code scanning to directly display guiding text and explanatory images for understanding and learning purposes
		A17 Quality of human-computer interaction	a53 Optimizability (system issues such as app malfunctions, freezes, official website loading to a blank page, etc.).
			a54 Timeliness (quick consultations by doctors, assembly line operations, rapid updates of system content and messages)
			a55 Awareness rate: registration times, registration validity period, community clinics, online prescription or consultation processes, online invoicing, reimbursement lists, and special illness management procedures.
	B6 Services scenario support	A18 The digital touchpoints in various stages of medical treatment	a56 Login and binding information: entering one of the following—ID card, health insurance card, or phone number—automatically binds all, reducing the need for excessive input; guidance on the card binding process.
			a57 Uncertainty in triage before appointment registration: confusion over which department to choose for specific conditions, such as where to register for osteoporosis in older adults.
			a58 Difficulty of online registration: challenges in securing an appointment, slow operation, and lack of operational knowledge.
			a59 Uniformity of the sign-in and ticket collection process: issues with inconsistency between self-service kiosk sign-in and ticket collection and the triage desk sign-in and ticket collection.
			a60 Electronic guidance forms: numerous and disorganized, lacking orderly guidance, with key information such as time and location difficult to find.
			a61 Mobile payment issues: Sometimes health insurance cards and special disease discounts cannot be used, difficulty in reviewing payment details, and unclear processes for online invoicing and reimbursement.
			a62 Self-service report printing and medication collection: inconsistencies between machine-reported times and mobile-reported times, or lack of assistance after print failures; unclear prescription printing processes, inability to print traditional Chinese medicine prescriptions; and the medication collection process.
			a63 Follow-up visit order: preferential treatment for appointments solely for medication refills or examinations; triage policies favoring older adults.
			a64 Waiting environment: Proper organization and arrangement by guiding staff; noisy and chaotic; at times, the order is crowded and disorganized.
			a65 Feasibility of online consultations: The inability to interact face-to-face, limited communication and information exchange, slow typing responses.
		A19 Smart healthcare service environment	a66 Information on outpatient digital screens and display boards: introductions of doctors, sign-in and triage processes, medication collection processes, and triage screen displays of calling order.
			a67 Substitutability of smart services: Self-service machines are sometimes crowded, manual service windows are idle, operations are substituted by younger people, and accompanying consultation services are available.
			a68 Smart service medical staff: The central service desk guides are busy, guides stationed by machines providing patient or hurried instructions, substituting operations, and lack of assistance when sought.
			a69 Instruction manuals and promotional leaflets: Doctor introductions and scheduling leaflets/cards; educational leaflets for older adults on triage; smart service operation manuals (appointment registration, payment, self-service medication collection, self-service printing processes, etc.); online prescription services leaflets.
			a70 Environmental pressures: Appropriately retained manual service windows; the compulsion of the COVID-19 pandemic.

(*Continued*)

Table 3 (Continued).

Dimensions (C)	Main Categories (B)	Categories (A)	Initial Concepts (a)
	B7 Social environment support	A20 Family teaching	a71 Teaching conditions: Children are busy, do not live together, and lack the time and space to teach.
			a72 Proactive teaching: Children encourage and actively teach; parents proactively seek advice from their children; parents are taught only when they ask; children provide limited instruction.
			a73 Filial piety: Family members accompany the patient to consultations and perform operations on their behalf.
		A21 Friends communication	a74 Few social gatherings with friends; a75 Seek advice from friends based on what they say; a76 Avoid discussing one's own medical condition
		A22 Organizational training	a77 Opportunity to participate; a78 Willingness to participate; a79 Uncertain effectiveness.

https://doi.org/10.2147/CIA.S518045

Table 4 Typical Relational Structure of Main Categories

Typical Relation	Relation Structure	Connotation of Relation Structure
Path 1: Internal environmental factors → Digital inclusion	Causal relations	Physical functions and digital health literacy directly affect digital inclusion
Path 2: Psychological Factors → Digital Inclusion	Causal relations	Personal perception and digital attitude directly affect digital inclusion
Path 3: Internal environmental factors → Psychological factors → Use behavior	Mediating relations	Internal environmental factors indirectly affect use behaviors by influencing psychological factors
Path 4: External environmental factors → Psychological factors → Use behavior	Mediating relations	External environmental factors indirectly affect use behaviors by influencing psychological factors
Path 5: Demographics → Use behavior	Moderating relations	The use behavior is affected by economic level, educational level, marital status and conditions accompanying to the hospital

indirectly influence digital inclusion through psychological factors. Characteristics have a moderating effect on digital inclusion. The explanation of factors and path to digital inclusion of older adults and original statement are shown below.

Influence Path 1: Internal Environmental Factors → Digital Inclusion

The impact of the internal environment on older adults' digital inclusion primarily stems from two aspects: physical functions and digital health literacy.

Physical Functions

The physical condition of older adults, such as the decline in vision, hearing, and memory, directly restricts their ability to operate smart devices.

> As I've aged, staring at that screen for long periods. my head becomes groggy, and my memory isn't what it used to be. [P11]

> Even when our physical health is good, learning new technologies is a challenge, let alone when we are ill. [P18]

However, some older adults have become familiar with smart services because of their chronic illnesses requiring frequent hospital visits.

> I often go to the hospital for medication, regularly using my smartphone for appointments, becoming quite familiar with these procedures. [P3]

Digital Health Literacy

Older adults have limited exposure to electronic products and lack long-term experience, leading to a significant deficiency in their digital health literacy.

> I forget what I've learned shortly after, unlike functions like WeChat that I use daily. I might visit the hospital once a month, and likely forget by then. [P21]

Moreover, most older adults have a low education level and lack a basic understanding of information technology, making the use of smart services challenging for them.

> We were already of significant age when we first encountered the Internet, unlike young people. We are completely unfamiliar with it. [P15]

Influence Path 2: Psychological Factors → Digital Inclusion

The impact of psychological factors on digital inclusion is evident in two aspects: personal perception and digital attitude.

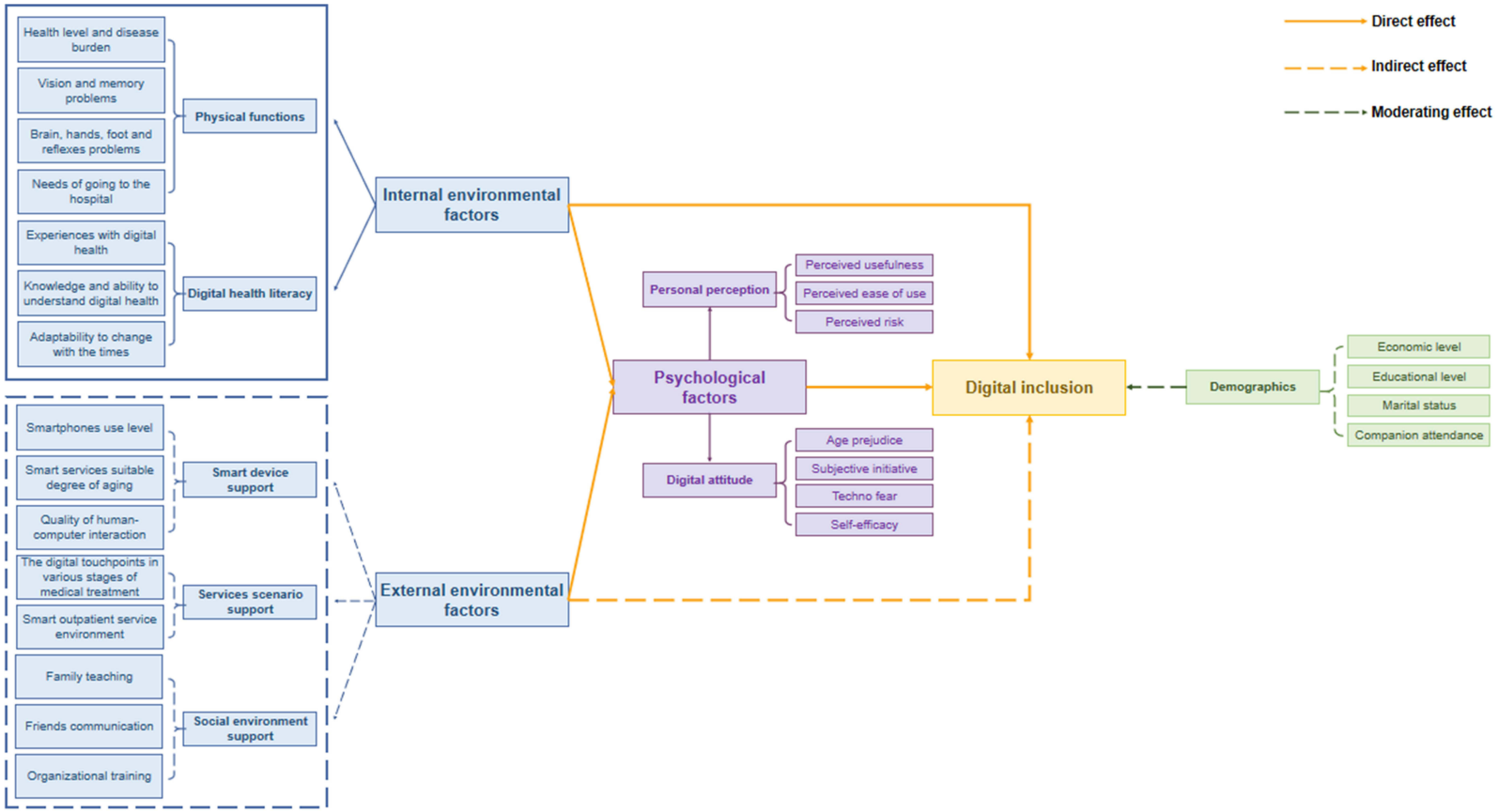

Figure 1 Theoretical model of digital inclusion path of older adults in outpatient settings.

https://doi.org/10.2147/CIA.S518045

Personal Perception

Many older adults who are not proficient in using smart services rely on manual registration and payment processes, thereby missing the convenience that these smart services provide.

> With the advancement of technology, it has become increasingly sophisticated, which, in turn, seems less convenient for older adults, seeing young people using it effortlessly leaves us puzzled on how to operate. [P15]

Furthermore, smart services, in general, are not perceived as sufficiently user-friendly for older adults, who commonly view the operations as overly complex.

> Decades ago, it was just about filling out a form, but now it involves machines and various documents, which are hard to comprehend, making the process of seeing a doctor for older adults more complicated. [P12]

Moreover, the complexity of operations and potential financial risks significantly concern older adults.

> It feels safer to go to the manual window, especially for payments, where pressing one extra number on the machine could mean hundreds or even thousands, which would be a hassle to refund. [P16]

Digital Attitude

Because of ageism, many older adults face self-stereotyping or urging and disdain from others, which severely affects their willingness to use smart services.

> I am willing to try new things. However, sometimes due to my less nimble fingers and slower cognitive response, my pace is slow, leading to disdain from others. [P12]

Additionally, in the area of subjectivity, some older adults are interested in digital technology and are happy to use it. Meanwhile, others are not accustomed to the intelligent mode of medical care and prefer manual windows.

> I don't like to bother others, I'm used to being independent, and I usually take my time to figure out how to make an appointment online. [P17]

Moreover, a significant number of older adults experience technological anxiety, feeling insecure when using the services and often preferring guidance from someone.

> Coming to the hospital alone makes me uneasy, not frequently using these machines. Once I touch the machine, I panic, fearing I might press something wrong, so I end up at the manual window alone. [P21]

Besides, many older adults face issues with poor learning outcomes and a diminished desire to use the services after unsuccessful attempts.

> My daughter taught me before, but it's too complicated. I might understand it this time, but then I forget by the next, not wanting to waste effort. [P22]

Influence Path 3: Internal Environmental Factors → Psychological Factors → Digital Inclusion

The decline in physical functions and insufficient digital health literacy contribute to older adults' psychological resistance toward using smart services, thereby affecting digital inclusion.

The decrease in physical ability presents challenges for older adults in using smart healthcare services, diminishing their inclination to try and learn new technologies.

> We come to the hospital to seek medical care; where do we find the leisure to engage with those machines? I'm feeling unwell, there's no energy left. [P10]

A lack of digital health literacy causes older adults to feel at risk when using smart healthcare services, fearing operational errors or potential internet fraud.

I used to work in information technology at the hospital, and I found it relatively straightforward. [P8]

Every time I go to the bank, the staff help me with the operations, honestly, if my money was transferred out, I wouldn't know. [P21]

Deficiency of digital health literacy leads to inconvenience and anxiety among older adults when attempting to use smart services.

It's very troublesome to operate, especially with payments, where adding or missing a zero makes a huge difference, and I don't know how to get a refund. [P25]

Influence Path 4: External Environmental Factors → Psychological Factors → Digital Inclusion

External environmental factors, including the support for smart services, smart scenarios, and social environment, indirectly influence the digital inclusion of older adults by affecting their personal perceptions and digital attitudes.

Smart Device Support

The system design and the level of support for using smart services directly influence the perception of older adults on ease of use and indirectly impact their acceptance of smart healthcare services.

I don't want to use it; I have a senior's phone, which doesn't have those apps installed. [P16]

The hospital's registration mini-program has too many functions, but what I really use it for is just registration, seeing the doctor, and checking reports. [P7]

Furthermore, the functionalities of online services are unclear for many older adults, leading to a generally low usage rate.

I didn't even know the functions of online medication services. Many older adults don't know about this. [P16]

Service Scenario Support

The digitalization level of the entire medical process, from appointment booking to medical treatment services, significantly affects the usage experience of older adults.

The order of registration and pre-payment often changes, it's all very confusing. [P5]

I go to the manual window for payments, the machines don't provide payment details. The processes for online invoicing aren't clear, and it's also unclear how to check them on the phone. [P6]

Social Environment Support

The education and support from families are particularly important for the self-efficacy of older adults in learning and using new technologies, thus influencing their usage behavior.

I usually come to the hospital alone, and I haven't operated these functions before, it's my children who help me register online. [P24]

Family members usually don't teach me, and I don't live with them, they're also busy with their work and families. [P25]

Additionally, older adults often do not enjoy discussing illnesses; therefore, proactive communication regarding smart medical experiences with peers is limited, making them rely more on themselves.

They also don't know this information, nor do they have the operational experience; it's all about slowly figuring it out on my own. [P1]

Moreover, organizational training related to the digital inclusion of older adults has not yet been widely implemented in society, with only a few older adults having the opportunity to receive training in senior colleges.

I've attended senior college and received this training, so it's not difficult for me to use. [P5]

Influence Path 5: Demographics → Digital Inclusion

Demographics, including economic status, educational level, marital status, and presence of companions during medical visits, moderate the digital inclusion of older adults in utilizing smart healthcare services.

The economic conditions and educational level of older adults significantly influence their ability to access and use smart healthcare services.

> With a lower level of education and poor eyesight, it becomes challenging to learn, making it almost pointless to explain it to me. [P14]

The social and family support network of older adults, such as their marital status and whether they have family members accompanying them for medical appointments, significantly affects their willingness and capacity to use smart services.

> My daughter-in-law is very supportive; she accompanies me to every doctor's appointment, solves any issues. [P26]

Discussion

In this study, a digital inclusion pathway model for older adults in outpatient settings was developed through semi-structured interviews with 27 older adults, utilizing the summary, organization and three-level coding of interview data based on grounded theory, in alignment with the S–O–R theory. The model provides an in-depth analysis of the pathways through which older adults adapt to the smart healthcare environment from the perspective of digital inclusion, identifying five digital inclusion pathways centered around seven core factors as follows: physical function, digital health literacy, intelligent device support, service scene support, social environment support, personal perception, and digital attitude.

This study demonstrated that internal factors, such as physical function and digital health literacy, directly affected the digital inclusion of older adults, as confirmed by numerous empirical studies[22,23] and evidence-based studies[5,10,24] on the use of digital health services. However, despite the inherent disadvantage faced by older adults, life course theory studies have indicated[25,26] that individuals aged between 55 and 75 years tend to have more free time, are well-informed, pay more attention to their own health, and have substantial information needs. Therefore, more attention should be paid to the relationship between medical demand, digital health literacy, and health outcomes in the field of digital health.[27,28]

Moreover, this study also identified external factors, such as technical support, hospital medical service support, and social environment (family, peers, and organization) support as the main determinants of the digital inclusion for older adults. Technology designed for aging population is a fundamental driver of digital inclusion. However, at present, the design of smart service system is oriented toward the preferences of younger individuals, with few "age-friendly" designs specifically tailored to older adults. Older adults' satisfaction with smart service is significantly lower than that of younger individuals, consistent with relevant studies.[26,29] The main reasons include the complex operation process, differing procedures, and substantial variations between medical platform operating systems.

The scene support provided by hospital medical service is a key factor in the digital inclusion of older adults, although current support remains inadequate, as observed in relevant studies. Currently, the medical guidance services provided by smart clinics to older adults are largely limited to superficial technical services, with the belief that the process is completed once older adults are taught basic actions, such as sliding the screen, clicking, and exiting among other demonstrations.[5] Additionally, algorithm discrimination exists in the re-engineering of medical process based on big data.[30] Network data tracking primarily relies on the usage patterns of young patients, resulting in data stratification that overlooks the preference of older adults. Furthermore, smart clinics face issues, such as insufficient number of medical guides, brief consultation times, poorly designed layouts of service windows, unclear location identification, and difficulty to find locations. Therefore, older adults should actualize their healthcare through visits, offline observations, and field visits to their healthcare clinics.

Moreover, external environmental factors did not directly influence the digital inclusion of older adults, but rather indirectly influenced them through personal perception and digital attitudes. This finding aligns with those of current research on older adults' digital inclusion from the "relative deprivation theory",[31–33] which emphasizes the role of individual perceptions and attitudes toward their circumstances. In particular, relative subjective deprivation holds more significance than absolute objective deprivation.[33] This provides a more comprehensive explanation for understanding the psychological digital divide and digital inclusion among older adults in this study. For example, in the smart

healthcare scenario, some older adults still do not use smart services, despite having knowledge and ability, access to smart devices and support from their social environment and other factors. This may be attributable to low perceived usefulness, as the artificial window is perceived as either no different or more efficient. It may also be caused by a lack of subjective initiative, such as a disinterest in idigital services, a preference for traditional medical treatment models, or reluctance to change and depend on others. For example, although some older adults use the appointment registration function, their usage rate of self-service payment is lower than that of younger individuals, which may be attributed to technical anxiety[34] and low self-efficacy.[35] Older adults may be more likely to encounter online fraud and lose money because of wrong clicks. Moreover, some older adults with limited support from both internal and external environments generally exhibit low usage rate of smart services. This may be attributable to increased vulnerability to age discrimination,[31] technical anxiety, and low self-efficacy.[36] These individuals are often marginalized in the digital era, facing psychological barriers, such as panic, fear of learning, and fear of damaging devices.

Therefore, promoting the digital inclusion of older adults is essential for enhancing their smart healthcare experience and improving the service quality in smart hospitals. This study identified that digital inclusion is not a binary phenomenon.[33,37] Although older adults often lag significantly behind younger individuals in digital technology, and are commonly termed "digital refugees", such generalizations oversimplify the diversity of their digital experiences. In the context of smart healthcare services, digital inclusion among older adults can be categorized into three tendencies: "positive use tendency", "conditional use tendency", and "negative use tendency", based on a comprehensive consideration of technical, physiological, psychological, and social factors. This categorization offers a more nuanced and inclusive framework for understanding their digital inclusion.

In conclusion, the five digital inclusion pathways can assist older adults in adapting to the smart healthcare environment, thereby addressing health inequality exacerbated by digitalization. First, addressing age-related limitations is critical; providing older adults with various smart medical information, guidance, and services can increase their exposure to and understanding of smart healthcare systems. Implementing interventions aimed at improving digital health literacy as a means and maintaining health as a goal[38] increase their perceived usefulness, foster their subjective initiative, and encourage positive digital inclusion. Second, leveraging key drivers, such as smart device support, healthcare service scene support, and family support, is essential. Smart service systems should be tailored to meet the needs of older adults. Hospitals should patiently assist older adults in improving their operational and practical skills through guidance. Optimizing the streamlined medical process for older adults and embedding the concept of age-friendly services throughout the pre-diagnosis, diagnosis, and post-diagnosis phases can ensure a closed-loop system of older assistance. Families should also provide frequent, engaging, and face-to-face feedback.[38] Finally, attention must be provided to cultural factors driving differences in access to and use of information and communication technology. Actively fostering an inclusive digital environment and prioritizing intangible services—such as respect and encouragement, the elimination of age discrimination, security, peer effect, and mutual learning—are vital.

This study employed grounded theory to construct a pathway model of factors influencing digital inclusion among older outpatients. However, some limitations should be acknowledged. First, although qualitative methods allow for an in-depth exploration of underlying mechanisms, they do not provide statistical validation of the strength or significance of relationships among variables. Future studies could address this limitation by employing large-scale survey data combined with structural equation modeling to quantitatively test the hypothesized pathways. Second, the study sample was limited to older outpatients in the central urban areas of Chongqing, which may restrict the generalizability of the findings. Nevertheless, the sample included participants with diverse demographic characteristics (eg, age, marital status, income, and education), enhancing the regional representativeness and explanatory power of the results. Finally, the complexity of the research topic may lead to some information loss during the organization of extensive interview data, potentially causing deviations in the categorization process. Given the close interaction among medical staff, family members, social network members, and older adults, future research should integrate the perspectives of these core stakeholders in the field of smart services. Incorporating diverse viewpoints will corroborate, enrich, and enhance the study findings.

Conclusion

In the context of the development of smart hospitals and age-friendly healthcare, enhancing older adults' adaptability to smart healthcare environment is essential for promoting equitable access and optimizing service quality. This study, employing

grounded theory, systematically explored three dimensions, seven core categories, and 22 subcategories, ultimately identifying five action pathways that facilitate digital inclusion among older adults. These findings not only enrich the theoretical understanding of older adults' interaction with smart healthcare but also provide a foundation for designing smart outpatient service systems that are both scientifically grounded and practically responsive to their needs. Furthermore, this research contributes to the discourse on inclusive digital transformation in healthcare and offers practical implications for policymakers, system designers, and future studies aiming to advance age-friendly smart healthcare systems.

Data Sharing Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The study protocol was approved by the Ethics Committee of The First Affiliated Hospital of Chongqing Medical University (Approval No. 2022-202) and conformed to the principles of the Declaration of Helsinki. Participants who agree to join in the study can only enter the study after signing informed consent.

Acknowledgments

The authors thank all the participants who kindly shared their stories and teachers who help the study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by Chongqing Municipal Education Commission's 14th Five-Year Key Discipline Support Project (grant 20240102).

Disclosure

The authors report no conflicts of interest in this work.

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