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Effect of Customer Privacy Protection Activities in Developing Services for the Intelligent Elderly Care Sector

Yi FU[1], Sung-Eui CHO[2]

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Abstract

Purpose: The intersection of information technology and elderly care services has received widespread attention in recent times. This study investigates the influence of privacy protection activities on user satisfaction. **Research design, data and methodology:** This study identified five independent factors within privacy protection activities: new technologies, assurance, empathy, regulations, and support activities, and developed a theoretical model to present the connections between privacy protection activities, trust, digital literacy, and user satisfaction. **Results:** The findings of the study show that privacy protection activities significantly impact user satisfaction in intelligent elderly care services. Trust and digital literacy play significant mediating and moderating roles in these relationships. **Conclusions:** This study bridges the gap between IT, healthcare and older adults by addressing the privacy dimension of intelligent elderly care to promote improved quality of life and ensure that technological solutions are effective and trusted by users with the growing need for privacy protection in intelligent elderly care services in multiple scenarios, directions, and levels.

Keywords: Intelligent Elderly Care, Healthcare, Privacy Protection, User Satisfaction, Service Management

JEL Classification Code: I10, I12, I13

1. Introduction

In recent years, the intersection of information technology and elderly care services has received widespread attention. The continuously evolving technological landscape has changed the approach to elderly care services. Intelligent elderly care services have emerged in response to the two major trends of aging and digitalization, and have now become the novel method for alleviating elderly care challenges and meeting elderly care needs. The integration of IT into elderly care services can help improve the elderly population's quality of life. However, these benefits must be balanced with a firm commitment to protecting user privacy. The success of intelligent elderly care systems depends not only on technological innovations but also on their ability to protect user privacy and establish trust in systems that are designed to serve vulnerable groups. Ensuring the safety and respect of the personal and health data of the elderly is crucial for building their trust in these technologies and encouraging widespread adoption.

Previous research on privacy has examined the protection of the privacy rights of minors, young adults, and

1 First Author. PhD, Department of Management Information Systems, Gyeongsang National University, Korea. Email: fuyi4030@gmail.com
2 Corresponding Author. Professor, Department of Management Information Systems, Gyeongsang National University, Korea. Email: dcrsmk10@gnu.ac.kr

personal medical information (Morr Serewicz et al., 2007). However, the potential relationship between privacy protection and user trust, digital literacy, and satisfaction remains unclear. Limited studies have examined this relationship by incorporating privacy protection activities into comprehensive models to examine their impact on user satisfaction. Privacy protection activities concerning intelligent elderly care services refer to the measures, protocols, and strategies implemented to protect the personal data and sensitive information of the elderly in an environment where smart devices and systems are used to enhance care. In an attempt to cover the lack of studies focusing on privacy protection in providing intelligent elderly care services to the elderly, this study investigates the extent to which privacy protection activities prove to be satisfactory to older adults. Privacy protection activities related to intelligent elderly care services are divided into several components including new technologies, assurance, empathy, regulations, and support activities. This study examines the underlying processes through which privacy protection activities influence user satisfaction, specifically exploring the mediating role of trust and the moderating role of digital literacy in this relationship.

In the following sections, the general background, research purpose, and outline of the main content will be introduced in section 1. Then, section 2 presents the literature review, research hypotheses and research model. The third section offers the research methodology, data collection procedures and demonstrates the analysis. Finally, the conclusion will be provided in section 4, which includes the summary, discussion, limitations, and future research.

This study examines the relationship between privacy protection and user satisfaction in the digital age through empirical research, emphasizing the key influence of privacy protection on the continuous use of technology, user-centred intelligent elderly care services, and personal well-being. This is an unexplored area of research. This study goes a step ahead of traditional privacy protection mechanisms in that it innovatively integrates privacy protection into the overall user experience. This innovation represents a shift toward more proactive, transparent, and customizable privacy practices that can enable older adults and their caregivers to maintain control over personal and sensitive data while using intelligent care technologies. When privacy protection and user satisfaction are ensured, elderly individuals can overcome their concerns regarding intelligent elderly care services and use technology to improve their lives, health, and independence, while also fostering a technological environment that benefits society, empowers individuals, and promotes safe, sustainable innovation.

2. Background

2.1. Literature Review

2.1.1. Intelligent Elderly Care Services

There is an urgent need to establish an elderly care system that aligns with the contemporary cultural, socioeconomic, political, and medical landscape. With the continuous advancements in technology, particularly in the era of digital intelligence, the integration of IT and intelligent products into elderly care has resulted in the emergence of intelligent elderly care services. Intelligent elderly care represents the collision and integration of modern technologies such as data and information with the elderly care field using smart technology and human interaction to meet the basic material and spiritual needs of the elderly and provide more refined, intelligent, and humanized care, spiritual comfort, and medical care for the elderly through standard integrated intelligent health and elderly care services (Wu, 2018). In recent times, the intelligent elderly care services product market has been facing broader development prospects, with state-of-the-art technology products such as smartwatches, smart wristbands, and smart mattresses overwhelming the market.

It is not a simple task to meet the diverse needs of elderly care services through the widespread use of artificial intelligence (AI), particularly in managing and protecting sensitive personal data. Cheng et al. (2023) report that technology-driven challenge stressors reduce technology anxiety, while hindrance stressors increase it. Zhang and Rui (2023) highlight the fragmentation in the elderly care sector, stressing the need for institutional reforms and integrated systems to provide comprehensive, life-cycle care services. The intelligent health care system collects private personal information on the habits and health of the elderly, such as ID card numbers, mobile phone numbers, medical records, and other pertinent details. This type of data can be abused, leaked, or hacked, resulting in serious personal privacy breaches. At the same time, since they are always connected to the internet, intelligent systems are more prone to scams and malware attacks. In addition, there is the risk that privacy data may be sold to third parties for targeted advertising placement, user behavior analysis, and other marketing strategies, further threatening users' privacy. Therefore, ensuring user privacy protection and security is a critical issue.

2.1.2. Service Quality Theory

With the recent changes in the elderly care environment, the gradual acceptance of intelligent elderly care by customers, and the urgency of addressing the various issues that come with it, research on service quality and customer satisfaction has become critical. The SERVQUAL scale,

which was developed by Parasuraman et al. (1985), contains multiple tools for quantifying consumers' perceptions of service quality. This scale was further refined (Parasuraman et al., 1991), and has since been applied across various industries to evaluate service quality effectively. The SERVQUAL model is widely used in the service industry to understand target customers' service needs and perceptions, and provides a set of methods for enterprises to measure and manage service quality. Service quality encompasses five elements, namely, reliability, assurance, tangibles, empathy, and responsiveness (Parasuraman et al., 1988). Although all these dimensions are important to customers, some dimensions have a more prominent role in the context of intelligent elderly care. This study evaluates assurance and empathy as the independent variables. Assurances of service quality and empathy are essential in intelligent elderly care services because they address users' functional and emotional needs. Elderly individuals and their families often have concerns about adopting new technologies; therefore, assurance of reliable, high-quality service can help build trust. Empathy is crucial for providing emotional support, reducing feelings of isolation, and ensuring that care is both effective and compassionate.

2.1.3. Privacy Protection Activities

The understanding of privacy has evolved significantly over time. Privacy is defined as an individual's right to determine when, how, and to what extent their personal information can be shared with others (Westin, 1968). It is shaped by personal values concerning information control, beliefs about managing data, and concerns about its consequences (Stone, 1981; Stone & Stone, 1990). Protecting privacy involves preventing the illegal collection, misuse, leakage, and abuse of personal data. Such protection is vital for attracting and retaining users (Park & Kim, 2003). Privacy concerns persist, particularly for vulnerable groups, despite advancements in online communication and technology. While disclosing more information can grant users access to better services, it also increases the risk of data breaches. As the privacy landscape is becoming more complex with advancing technology, it has become crucial to continuously refine technologies and strategies to address new risks.

Protection motivation theory (Rogers & Prentice, 1997) is an important framework for ensuring privacy protection and user satisfaction in intelligent elderly care services. When elderly people use care services, they decide whether to take protective actions through threat assessment and response assessment, which directly affect privacy protection and user satisfaction. Effective privacy protection measures, transparency, and self-efficacy can help reduce privacy concerns, enhance trust, improve user satisfaction, and aid the promotion of intelligent elderly care services. In contrast, if privacy protection is insufficient or users are unable to control their personal data, it can give rise to insecurity, resulting in avoidance of using the service and affecting users' overall satisfaction and acceptance.

Privacy is a significant concern for users of intelligent elderly care services, as they have distinct and complex needs compared to the general population. The communication privacy management theory provides a framework for understanding these complexities (Petronio, 2002) and has been validated in various contexts like family communication, parental privacy issues, online media, and healthcare. People believe that they can control their privacy boundaries and determine who can access their information and when it is off-limits (Schoeman, 1984; Hammonds, 2015). This study argues that elderly individuals face a tension between maintaining confidentiality and the need to disclose personal information when using intelligent care services. While the elderly may be concerned about potential privacy breaches and the negative consequences of public disclosure, they are often forced to share personal data to use these services. When users feel confident that their privacy is safeguarded, they are more likely to provide accurate medical information (Miller & Tucker, 2009).

To protect users' privacy, intelligent elderly care services must prevent illegal access and misuse of information. Cherdantseva and Hilton's (2013) reference model of information assurance and security addresses the limitations of previously proposed frameworks, classifying protection measures into technical, legal, human-oriented, and organizational categories. This study highlights the need to integrate new technologies, assurance, empathy, regulations, and support activities into privacy protection strategies for intelligent elderly care services.

2.1.4. User Satisfaction

User satisfaction encompasses the personal sense of equilibrium between what is offered and what is received, the emotional responses experienced following a purchase, and the perceived gap between users' expectations and experience (Howard & Sheth, 1969; Oliver, 1981; Woodside et al., 1989; Fu et al., 2024). Elderly people's satisfaction with intelligent elderly care services depends on several factors. Active aging is an effective strategy and choice for addressing the aging process, as it strives to improve elderly people's satisfaction. Marsillas et al. (2017) proposed a new active aging model to improve the life satisfaction of older adults. Karlsson et al. (2013) investigated elderly individuals' satisfaction with nursing in public care and services. Bauld et al. (2000) measured elderly service users' satisfaction with social care. Intelligent elderly care services are now emerging as a new approach for improving the quality of elderly care services and enhancing elderly satisfaction. Therefore, research on privacy protection activities and elderly satisfaction provided by these services is extremely important.

2.2. Hypotheses Development

This study builds on previous research and theoretical frameworks and categorizes privacy protection activities into five areas: new technologies, assurance, empathy, regulations, and support activities. Trust is the proposed mediating factor and digital literacy is considered the moderating factor for examining the relationship between privacy protection activities and user satisfaction in intelligent elderly care services. The research hypotheses are presented in the following sub-sections.

2.2.1. New Technologies

In the context of this study, new technologies refer to emerging technologies that enhance privacy protection. The goal of these technologies is to protect user identity by providing anonymity, pseudonymity, unlinkability, and unobservability for users and data subjects (Fischer-Hübner, 2001; Pfitzmann & Hansen, 2008). In today's landscape, ensuring privacy and security is an increasingly vital challenge. Cybercrime attack methods and techniques have also undergone fundamental changes (Battista & Uva, 2023), rendering traditional protection measures inadequate for meeting current privacy needs. A new generation of privacy protection technologies that will transform intelligent elderly care and drive revolutionary changes and innovations is the need of the hour. Yang et al. (2024) have reviewed mainstream privacy protection technologies including access control, anonymity protection techniques, differential privacy, and privacy computing. Goldberg (2007) has proposed many useful privacy-enhancing technologies and demonstrated the real impact of privacy techniques on real people. Wang et al. (2023) argue that the positive relationship between IT innovation and data-breach risk will weaken when managers have IT expertise. Based on the above, we propose the following hypotheses:

H1a: New technologies positively affect users' trust in intelligent elderly care services.

H1b: New technologies positively affect user satisfaction in intelligent elderly care services.

2.2.2. Assurance

Assurance refers to the commitment or actions taken to guarantee privacy protection. Users expect privacy safeguards to be in place, whether through certifications, authentication, or other means. Privacy assurance refers to mechanisms that can reassure users that their personal information will be managed securely and that the organization collecting the information will serve as a responsible custodian to ensure its safety and confidentiality. According to Nemati and Van Dyke (2009), privacy assurance is a commitment to ensure data safety and address customer concerns during data collection and sharing, while a personalized declaration explains how personal information will be utilized. Privacy assurance confirms organizations' responsibility to protect customers' personal information (Gong et al., 2020). Mutimukwe et al. (2020) have developed models to explore the impact of privacy assurance on individuals' privacy concerns, perceptions, trust, and self-disclosure behavior. Based on the above, we propose the following hypotheses:

H2a: Assurance positively affects users' trust in intelligent elderly care services.

H2b: Assurance positively affects user satisfaction in intelligent elderly care services.

2.2.3. Empathy

Empathy refers to the extent to which caring individualized service is provided; this includes personalized services, individual care, understanding customer needs, and prioritizing customer interests (Parasuraman et al., 1988). This study defines empathy as providing care and personalized service from the users' perspective. Research on privacy has been criticized for considering the elderly as a homogeneous group and neglecting the diversity of their lives (Rasi & Kilpeläinen, 2016). Modern research on privacy is moving toward a more proactive and user-centric approach, aiming to address individual differences, including the unique needs of vulnerable groups. When empathy is brought into human-computer interaction similar to human emotions, it can encourage users to develop positive perceptions (Pelau et al., 2021). For example, compared to complex data, statistics, and scientific explanations, using stories and illustrations that draw from past experiences is more likely to attract the attention of older adults (Doraiswamy et al., 2020). Overall, humanized and intelligent elderly care services can enhance the experience and satisfaction of elderly users and dispel their doubts and reservations about intelligent elderly care services. Based on the above, we propose the following hypotheses:

H3a: Empathy positively affects users' trust in intelligent elderly care services.

H3b: Empathy positively affects user satisfaction in intelligent elderly care services.

2.2.4. Regulations

Regulations refer to the rules and regulations used to manage, guide, and control privacy protection. Elderly individuals often overlook privacy protection due to low self-awareness and a strong need for intelligent care services. He (2022) explored the interaction between new regulatory methods, data protection legal systems, and advanced digital technology in China's aging society, and proposed that privacy protection must be governed by clear regulations to

ensure the standardized development of intelligent elderly care services. Palaniappan et al. (2024) argue that current regulations may be insufficient as AI technologies can autonomously adapt and improve based on new data. Therefore, a global regulatory convergence for AI in healthcare would benefit developing as well as developed nations. Given the vulnerability of the elderly, robust privacy regulations are essential for improving user satisfaction with these services. Intelligent elderly care service contracts, which are often presented in the form of network service agreements, establish a consensus between the service and elderly users through click confirmation (Brown & Marsden, 2023). The continuous improvement of rules and regulations helps strengthen privacy protection. Based on the above, we propose the following hypotheses:

H4a: Regulations positively affect users' trust in intelligent elderly care services.

H4b: Regulations positively affect user satisfaction in intelligent elderly care services.

2.2.5. Support Activities

Support activities refer to actions that assist in ensuring elderly privacy protection. With the upgrading of the health and elderly care industry to the use of smart intelligent systems, the demand for information, professional expertise, and standardized talent have expanded. With this comes the need to study the impact of human factors on privacy protection. As the number of decisions made by individuals (particularly employees) rises, helping users make decisions that involve high-level security has become a top priority for many organizations (Bahreini et al., 2023). Not only employees of the concerned organization, but also employees of business partners, service providers, and authorities who handle organizations' information also need to be security-conscious (Cherdantseva et al., 2011; Cherdantseva & Hilton, 2013). In elderly care services, both service quality and execution are crucial. Poor implementation of elderly care can be attributed to service providers lacking care, interest, professionalism, and ethical standards, which usually occur due to inadequate training. Various strategies can be used to improve these circumstances, including education, training, awareness initiatives, cultural shifts, motivation, and ethical standards (Cherdantseva & Hilton, 2013). Intelligent elderly care services manage vast amounts of sensitive user information, which makes employees and service providers responsible for safeguarding user privacy. Therefore, to prevent privacy violations and achieve trust, it is important to ensure that these parties recognize the importance of privacy protection and understand the scope of user privacy. Based on the above, we propose the following hypotheses:

H5a: Support activities positively affect users' trust in intelligent elderly care services.

H5b: Support activities positively affect user satisfaction in intelligent elderly care services.

2.2.6. Trust

In this study, trust refers to users' expectations regarding privacy protection. Rotter (1967) defines trust as a generalized expectation generated by an individual's words, promises, or written statements toward an individual or group. While trust is essential across all age groups, research on trust among the elderly has been relatively overlooked, barring few existing studies on the topic. The Almere model proposes that trust directly affects elderly individuals' intentions of use (Heerink et al., 2010). Alaiad and Zhou (2014) assert that factors such as trust and privacy affect users' intention to use home healthcare robots. Effective implementation of privacy protection measures can help build trust between the elderly and technology-driven intelligent elderly care services. Users are more likely to adopt new technologies if they believe that their personal and health data will be safe and ethically managed. Based on the above, we propose the following hypotheses:

H6: Trust positively affects user satisfaction in intelligent elderly care services.

H7: Trust has a mediating influence on the relationship between privacy protection activities and user satisfaction in intelligent elderly care services.

2.2.7. Digital Literacy

Digital literacy refers to individuals' basic skills and abilities to use digital technologies confidently and critically in a digital society (access, select, use, criticize, and evaluate). It is a set of digital qualities and abilities that individuals must possess to effectively function in learning, work, and life in the digital society. Oh et al. (2021) assert that quantifying the digital literacy of the elderly is the first step in helping them leverage the digitalization trend in healthcare. It is becoming increasingly essential for the elderly to use digital technology to obtain information and solve practical problems. A lack of skills can make it difficult for them to gain technical experience and comfort. Research shows that computer literacy among older adults can help improve their self-efficacy, reduce their computer anxiety, and ultimately increase their overall life satisfaction (Karavidas et al., 2005). Digital literacy can reduce the cost of acquiring knowledge and effective information and help users achieve a sense of acquisition (Zhang, 2023). Based on the above, we propose the following hypothesis:

H8: Digital literacy has a moderating influence on the relationship between privacy protection activities and user satisfaction in intelligent elderly care services.

2.3. Research Model

We constructed and employed a model to explore new and richer correlations between privacy protection activities and user satisfaction in intelligent elderly care services, with the mediating effect of trust and the moderating role of digital literacy. The research model shown in Figure 1 presents an integrated version of our research hypotheses.

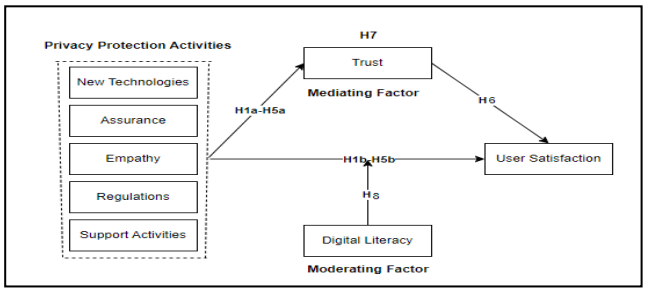

Figure 1: Research Model

3. Empirical Study

3.1. Research Methods

3.1.1. Measurement Development

The questionnaire for this study was developed by adopting and refining measurement items from previous research to align with the current research context of intelligent elderly services. The construct of new technologies was chosen based on the works of Cherdantseva et al. (2013) and Fischer-Hübner (2001). Assurance was measured by referring to the methods used by Parasuraman et al. (1985), Parasuraman et al. (1988), Parasuraman et al. (1991), and Nemati and Van Dyke (2009). Empathy was quantified by referring to studies conducted by Parasuraman et al. (1985), Parasuraman et al. (1988), and Parasuraman et al. (1991). Regulations and support activities were measured by referencing Cherdantseva et al. (2013). Trust was quantified by referencing the works of Rotter (1967) and Heerink et al. (2010). Digital literacy was measured by referencing Karavidas et al. (2005). Finally, customer satisfaction was assessed by referencing Howard and Sheth (1969), Oliver (1981), and Woodside et al. (1989). The responses to all the questions were collected using a 5-point Likert scale, with choices ranging from strongly disagree (1) to strongly agree (5).

3.1.2. Data Collection

The study questionnaire was distributed through China's widely used survey platform, Wenjuanxing (https://www.wjx.cn). This platform was chosen due to its high accessibility and user-friendly survey tools. This platform was chosen to enable participants, especially the elderly, to complete surveys with minimal technical difficulty. The extensive coverage of this platform enables research to collect data from large and diverse populations, thereby enhancing the statistical capabilities of the study. A random sampling method was employed to invite individuals with experience in using intelligent elderly care services to participate in the study. Family members were allowed to assist elderly participants who were unfamiliar with or found online questionnaires inconvenient, in filling the questionnaires. To ensure the questionnaire's accuracy, clarity, and effective communication with elderly Chinese participants, a two-way translation process was adopted by following established translation guidelines (Beaton et al., 2000).

Between August 13 and October 10, 2024, 342 questionnaires were collected. Out of these, 276 valid responses were selected based on our study criteria. Each participant was allowed only one submission. The completed questionnaires were examined for logical consistency, and only those meeting the criteria were included in the analysis. Of the respondents, 40.6% were male and 59.4% were female, with 39.1% aged between 18 and 44, followed by 25% aged between 45 and 59. In terms of education, 40.2% had completed college. Income was predominantly concentrated in the under 2,000 yuan category (33.3%), followed by the 2,000–4,000 yuan category (29%), and finally the 4,000–6,000 yuan category (24.3%). Regarding user experience, 60.1% of the respondents had used intelligent elderly care services for six months to two years, and 20.7% of them had used the services for more than two years. Additionally, 71.8% of the respondents reported using these services frequently. Table 1 presents the demographic details of the respondents.

Table 1: Demographics of Respondents (N = 276)

Measure	Value	Response	%
Gender	Male	112	40.6
	Female	164	59.4
Age	< 18	21	7.6

	18–44	108	39.1
	45–59	69	25.0
	60–89	39	14.1
	> 90	39	14.1
Education	Middle school	30	10.9
	High school	68	24.6
	College	111	40.2
	Master and above	67	24.3
Income (yuan)	< 2,000	92	33.3
	2,000–4,000	80	29.0
	4,000–6,000	67	24.3
	> 6,000	37	13.4
Usage time (months)	< 6	53	19.2
	6 –12	77	27.9
	12–24	89	32.2
	> 24	57	20.7
Frequency	Always	78	28.3
	Often	120	43.5
	Sometimes	74	26.8
	Rarely	4	1.4
Total		276	

3.2. Data Analysis

3.2.1. Reliability and Validity

This study applied exploratory factor analysis (EFA) using SPSS 27 to confirm the reliability and validity of the research model. To ensure accuracy and consistency, the internal consistency of the variables was assessed using Cronbach's alpha coefficients (Hair et al., 2006); all the values were over 0.7, indicating good consistency of the measured variables. Principal component analysis was used to identify eight factors with eigenvalues greater than 1, using a factor loading threshold of 0.5, and the varimax rotation method was applied for interpretation. These eight factors explained 69.834% of the variance, with a Kaiser–Meyer–Olkin value of 0.871, confirming the model's validity for the next step. The results of the reliability and validity tests are presented in Table 2.

Next, a confirmatory factor analysis was conducted using the AMOS 26 software package, which confirmed a good fit between the measurement model and data ($\chi 2/df = 1.347$; RMSEA = 0.036; GFI = 0.894; AGFI = 0.869; SRMR = 0.044; CFI = 0.964). The factor loadings ranged from 0.688 to 0.819 and the composite reliability of all variables exceeded 0.60 (Fornell & Larcker, 1981). Discriminant validity indicated that the square root of each construct's average variance extracted (AVE) was greater than its correlation with other constructs, demonstrating good differentiation of research concepts. Overall, the reliability and validity results supported further hypotheses testing.

Table 2: Reliability and Validity

Items	EFA	CFA	Alpha	CR	AVE
New technologies					
New technologies can protect privacy.	0.818	0.742	0.840	0.840	0.568
There are applications of new technologies.	0.820	0.753			
Provide multiple technological means.	0.802	0.724			
Support innovation in privacy protection technology.	0.834	0.795			
Assurance					
There is a guarantee for privacy protection.	0.782	0.735	0.838	0.840	0.568
Provide commitments and statements.	0.805	0.701			
Confidence and feasibility are expressed.	0.855	0.795			
The guaranteed service is reassuring.	0.827	0.780			
Empathy					
Provide individualized and personalized services.	0.845	0.812	0.842	0.842	0.573
The needs of customers are understood.	0.803	0.723			
Provide services that meet customer needs.	0.839	0.765			
Individual concerns and care can be discovered.	0.799	0.723			
Regulations					
Provide rules and regulations for privacy protection.	0.822	0.756	0.846	0.847	0.582
Established standards for privacy regulations.					
Provide a privacy contract.					

There are regulatory and punitive policies.	0.790	0.739			
	0.843	0.799			
	0.847	0.755			
Support activities					
Assist in completing privacy protection activities.					
Privacy protection education is possible.					
Opportunities exist to enhance cognition and literacy.	0.835	0.770	0.778	0.779	0.540
	0.820	0.688			
	0.811	0.745			
Trust					
Provide trustworthy statement.					
It's possible to keeps promises.					
The implementation process is scrupulous.	0.814	0.730	0.841	0.842	0.571
It's possible to feel believable.					
	0.849	0.805			
	0.812	0.748			
	0.812	0.738			
Digital literacy					
Digital learning and creativity are necessary.					
Digital communication skills are necessary.					
The ability to solve digital problems is necessary.	0.856	0.783	0.815	0.816	0.596
	0.839	0.775			
	0.855	0.758			
User satisfaction					
Intelligent health services are satisfactory.					
It can meet users' needs of privacy protection.					
It's a right choice to use.	0.831	0.753	0.840	0.841	0.571
It's possible to recommend to others.					
	0.816	0.741			
	0.861	0.819			
	0.769	0.705			

Note: EFA = Factor loadings from exploratory factor analysis; CFA = Standardized loadings from confirmatory factor analysis; Alpha = Cronbach's alpha; AVE = Average Variance Extracted; CR = Composite Reliability.

Table 3: Correlation Analysis

Construct	Mean	S.D.	1	2	3	4	5	6	7	8
NEWT	4.08	0.84	.75							
ASSU	4.05	0.87	.38**	.75						
EMPA	4.01	0.89	.18*	.20**	.76					
REGU	4.06	0.88	.31**	.39**	.40**	.76				
SUPP	4.01	0.86	.46**	.52**	.38**	.43**	.74			
TRUS	4.00	0.91	.36**	.40**	.39**	.46**	.45**	.76		
DIGI	4.02	0.96	.21**	.29**	.53**	.50**	.43**	.38**	.77	
USER	4.00	0.88	.29**	.34**	.40**	.43**	.59**	.33**	.43*	.76

Note: ** correlation is significant at the 0.01 level (two-tailed); * correlation is significant at the 0.05 level (two-tailed). The diagonal elements of the table represent the square roots of the average variance extracted (AVE); NEWT = New technologies = 1, ASSU = Assurance = 2, EMPA = Empathy = 3, REGU = Regulation = 4, SUPP = Support activities = 5, TRUS = Trust = 6, DIGI = Digital literacy = 7, USER = User satisfaction = 8.

3.2.2. Common Method Bias

This study collected cross-sectional data; therefore, recognizing that the data may be affected by common method bias, we took procedural controlled measures. Respondents were assured that their participation was voluntary and anonymous. In addition, informed consent was obtained from each participant in compliance with research ethics and legal standards. Considering the research subjects were elderly people with experience in using intelligent elderly care services, the survey process focuses on protecting the rights and privacy of vulnerable groups, which is not expected to have any psychological or physiological impact on them. As an additional measure to check for common method bias, Harman's single-factor test (Harman, 1976) was performed. The results of the test revealed that the total variance of a single structure was 26.6%, which is well below the 50% threshold (Podsakoff et al., 2003), indicating no substantial evidence of common method bias. Variance inflation factors ranged from 1.174 to 1.416, which are well below the 5.0 threshold (Neter et al., 1996), confirming no multicollinearity. Overall, it was concluded that common method bias does not have a significant impact on the data or conclusions of this study.

3.3. Research Results

3.3.1. Multiple Regression Analysis

A regression analysis was conducted to test the proposed hypothesis, the results of which are summarized in Table 4. The results revealed that 9 of the 11 proposed hypotheses were supported and 2 were not supported. The assumptions supported in the regression model with trust as the dependent variable were new technologies, assurance, empathy, reputations, and support activities; therefore, H1a, H2a, H3a, H4a, and H5a were supported. In the regression model with user satisfaction as the dependent variable, empathy, reputations, supporting activities, and trust were found to directly affect user satisfaction; therefore, H3b, H4b, H5b, and H8 were adopted. New technologies and assurance did not appear to affect user satisfaction, therefore, H1b and H2b were not supported.

Table 4: Hypotheses Testing Results

Hypothesis				Unstandardized Coefficient		t(p)	Test Result
				B	SE		
H1a	New technologies	→(a)	Trust	0.141	0.062	2.280 (0.023)	Accept
H2a	Assurance			0.158	0.062	2.553 (0.011)	Accept
H3a	Empathy			0.176	0.057	3.068 (0.002)	Accept
H4a	Regulations			0.202	0.061	3.307 (0.001)	Accept
H5a	Support activities			0.148	0.065	2.266 (0.024)	Accept
H1b	New technologies	→(b)	User satisfaction	0.028	0.058	0.481 (0.631)	Reject
H2b	Assurance			0.045	0.058	0.767 (0.444)	Reject
H3b	Empathy			0.168	0.054	3.116 (0.002)	Accept
H4b	Regulations			0.166	0.057	2.898 (0.004)	Accept
H5b	Support activities			0.358	0.061	5.851 (< 0.001)	Accept
H6	Trust	→(c)	User satisfaction	0.273	0.056	4.898 (< 0.001)	Accept

Note: Path (a) Trust: R2 = .276; Adj. R2 = .262; F = 20.566 (< .001); Path (b) User satisfaction: R2 = .311; Adj. R2 = .298; F = 24.340 (< .001); Path (c) User satisfaction: R2 = .081; Adj. R2 = .077; F= 23.991 (< .001).

3.3.2. Mediating Effect

The study employed mediation analysis using the bootstrap method to examine the mediating role of trust between independent factors (new technologies, assurance, empathy, regulations, and support activities) and user satisfaction. Using the PROCESS macro in SPSS (Hayes, 2012), Model 4 was employed to assess the indirect effects of trust on the relationship between each independent variable and user satisfaction, with 5,000 bootstrap samples. The bootstrap confidence intervals excluded zero, confirming significant indirect effects and strongly demonstrating the mediating role of trust. Table 5 shows that trust has significant positive effects on user satisfaction, mediating the relationship between all independent factors and user satisfaction: new technologies (Effect = 0.074, 95% CI [0.033, 0.129]), assurance (Effect = 0.073, 95% CI [0.029, 0.138]), empathy (Effect = 0.062, 95% CI [0.022, 0.119]), regulations (Effect = 0.064, 95% CI [0.017, 0.124]), and support activities (Effect = 0.045, 95% CI [0.005, 0.096]). Trust fully mediates the impact of new technologies and assurance on user satisfaction, while empathy, regulations, and support activities affect satisfaction both directly and indirectly through trust, indicating partial mediation (Baron & Kenny, 1986). In summary, trust is confirmed as the significant mediator in these relationships, fully supporting H7.

Table 5: Mediating Effect of Trust

Predictor	Effect	SE	LLCI	ULCI	Test Result
New technologies	0.074	0.024	0.033	0.125	Accept
Assurance	0.073	0.028	0.029	0.137	Accept
Empathy	0.061	0.024	0.022	0.114	Accept
Regulations	0.064	0.028	0.016	0.125	Accept
Support activities	0.045	0.023	0.005	0.096	Accept

Note: Effect = Estimated indirect effect of X on Y; SE = Standard error of the effect; LLCI = Lower limit of the bootstrap 95% confidence interval; ULCI = Upper limit of the bootstrap 95% confidence interval.

3.3.3. Moderating Effect

To test the moderating effect of digital literacy on the relationship between privacy protection activities and user satisfaction mediated by trust, a linear regression analysis with Model 5 of Process Macro (Hayes, 2012) was performed. A significant interaction was found between assurance, empathy, regulations, and digital literacy: assurance (Effect = 0.144, 95% CI [0.024, 0.264]), empathy (Effect = 0.119, 95% CI [0.022, 0.214]), and regulations (Effect = 0.121, 95% CI [0.016, 0.226]). However, no significant interactions were found between new technologies, supporting activities, and digital literacy: new technologies (Effect = 0.102, 95% CI [−.023, 0.226]) and supporting activities (Effect = 0.094, 95% CI [−0.019, 0.207]). In summary, digital literacy moderates the

interactions of assurance, empathy, and regulations with user satisfaction. However, the moderating effect of digital literacy was not found in the interactions of new technologies and support activities with digital literacy.

Table 6: Moderating effect of digital literacy

Predictor	Effect	SE	p	LLCI	ULCI	Test Result
NEWT ×DIGI	0.102	0.063	0.108	−0.023	0.226	Reject
ASSU ×DIGI	0.144	0.061	0.019	0.024	0.264	Accept
EMPA ×DIGI	0.119	0.049	0.016	0.022	0.214	Accept
REGU ×DIGI	0.121	0.053	0.024	0.016	0.226	Accept
SUPP ×DIGI	0.094	0.057	0.103	−0.019	0.207	Reject

Note: Effect = Estimated indirect effect; SE = Standard error of the effect; LLCI = Lower limit of the bootstrap 95% confidence interval; ULCI = Upper limit of the bootstrap 95% confidence interval. NEWT = New technologies, ASSU = Assurance, EMPA = Empathy, REGU = Regulation, SUPP = Support activities, TRUS = Trust, DIGI = Digital literacy, USER = User satisfaction.

4. Conclusion

4.1. Summary and Discussion

This study investigated the relationship between privacy protection and user satisfaction based on five factors, namely, new technologies, assurance, empathy, regulations, and support activities. The findings lead to three noteworthy conclusions.

First, the study finds that empathy, regulations, and support activities directly and positively impact user satisfaction, and that trust has a mediating role in this relationship. When users feel understood through empathetic interactions, obtain effective and easily accessible support activities, and are confident that the service complies with relevant regulations, their trust in technology will significantly increase. This trust will promote a positive user experience as users are more likely to feel safe and valuable during interactions. Establishing trust enhances elderly users' overall satisfaction with technology, as they feel confident that the service is reliable, ethical, and able to meet their needs.

Second, the direct impact of new technologies and assurance on user satisfaction has not yet been demonstrated; however, their influence on trust is evident. The lack of support for the direct impact of new technologies and assurance on user satisfaction may be due to various factors such as users' previous experience, technological adaptability, and expectations. The use and abuse of cutting-edge technology can spell crises in daily life (Battista & Uva, 2023). Yang et al. (2024) found that various privacy protection technologies have limitations when applied to different scenarios. Furthermore, many elderly users struggle to adopt new technologies due to their complexity. In addition, vague or unfulfilled service guarantees or unstable service quality can result in lower satisfaction. However, the influence of new technologies and assurance on trust is relatively clear. New technologies build trust through innovation, enhancing user acceptance and intention to use. At the same time, similar to security and transparency, assurance reduces uncertainty and anxiety and boosts trust. Thus, although the impact of new technologies and assurance on user satisfaction is unclear, organizations indirectly promote user acceptance and satisfaction with technology by enhancing user trust.

Third, digital literacy has a moderating role in the relationship between assurance, empathy, regulations, and user satisfaction. Users with digital literacy can better understand privacy policies, security features, and service guarantees, recognize and appreciate empathetic interactions, experience enhanced feelings of being understood, and have a deeper understanding of regulations and their role in protecting consumers, thereby improving overall satisfaction. However, the moderating effect of digital literacy on the relationship between new technologies, support activities, and user satisfaction is not evident. This may be because many technologies and activities are designed to be intuitive and user-friendly (particularly for elderly users), enabling participation regardless of digital skills. Therefore, users with differing levels of digital literacy can still effectively use new technologies. Since most elderly users have limited digital literacy, the moderating role of digital literacy remains minimal.

4.2. Limitations and Future Research

Firstly, due to limited existing research on privacy protection in intelligent elderly care services, there is a need for further expansion of research in this field. Secondly, the small sample size of this study limits its generalizability to a wider population, and the narrow sample selection combined with insufficient data makes the results susceptible to subjectivity. Future research can improve the generalizability of the study by increasing the sample size, diversifying the sample population, and considering other methods. In addition, the results obtained from examining Chinese users may not necessarily apply to other regions due to differences in culture, policies, technological infrastructure, and population aging. Therefore, future research needs to be expanded to different regions. Additionally, the results of this study can be further classified based on factors such as income, gender, age, and education to examine subtle

differences more comprehensively and provide a more accurate basis for improving intelligent elderly care solutions. Finally, limited research time has imposed certain limitations on the research process and results, so it is necessary to conduct persistent research and exploration in the future. For example, future research needs to incorporate structural equation modelling (SEM) or additional statistical validation to analyze the key mediating role of trust to further improve the reliability of research results. In addition, the regulatory role of digital literacy should also be explained in more detail and further explored.

At present, the academic community focuses on optimizing the privacy and usability of privacy protection technologies, and pays limited attention to usage costs and universality. It is crucial to recognize that dynamic changes in data and continuous changes in society impose higher requirements for the dynamic and sustainable development and updating of new technologies (Zhu et al., 2022; Gao et al., 2024). With the growing need for privacy protection in intelligent elderly care services in multiple scenarios, directions, and levels, and the continuous updating and diversification of cyberattack and hacking methods, existing single-perspective privacy protection solutions are inadequate. Future intelligent elderly care services and privacy protection activities must integrate various advantages of new technologies, management, users, and other aspects, and coordinate development to conform to contemporary trends. Establishing a balance between people, technology, services, and privacy is essential for the successful application of intelligent technology. Therefore, future research should focus on establishing stronger and more meaningful relationships between technology and users.

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