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Bridging the Digital Divide: An Investigation into the Factors Influencing the Digital Literacy Gap Among Older Adults

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Abstract: With the rapid advancement of digitalization, Chinese society is confronting the "digital divide" exacerbated by population aging. This study focuses on adults aged 60 and above in Zhengzhou City, employing multivariate logistic regression analysis and structural equation modeling (SEM) to investigate key factors influencing the digital divide across three dimensions: access gap, usage gap, and competency gap. Key findings include:(1) Internet usage is gradually integrating into the daily lives of older adults.(2) Personal characteristics of seniors and perceived information insecurity significantly hinder their adoption of digital products.(3) While demand-driven motivations propel older adults to bridge competency gaps, complex product operations and information security concerns remain critical barriers. This research provides actionable insights for formulating targeted strategies to narrow the digital divide and foster inclusive digital participation among older populations.

Keywords: Older adults; Digital divide; Logistic regression; Structural equation modeling (SEM)

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1. Introduction

According to the 2023 National Economic and Social Development Statistical Bulletin, by the end of 2023, China's population aged 60 and above reached 296.97 million, accounting for 21.1% of the total population [1]. It is projected that by around 2035, the population aged 60 and above will exceed 400 million, surpassing 30% of the total population, marking China's entry into a stage of severe aging [2]. To actively respond to population aging and ensure that older adults can share in the fruits of development and enjoy a happy life in their later years, the General Office of the State Council issued the "Opinions on Developing the Silver Economy and Enhancing the Well-being of Older Adults" on January 15, 2024, emphasizing the need for departments and regions to implement digital adaptation projects for older adults and promote the transformation of internet applications [3]. With the advent of the digital era, digital information and technology have become integral parts of daily life. While digital information and technology bring convenience, they also pose new challenges for an aging society, particularly the digital divide among older adults. The digital divide among older adults refers to the gap between older adults and other age groups in terms of access to and use of digital devices, as well as the ability to learn and master digital knowledge, which prevents them from keeping pace with the development of an information-driven society [4]. According to a statistical report from the China Internet Network Information Center,

the population aged 60 and above accounts for only 15.6% of the total internet users, making them the primary group of non-internet users, representing 39.8% of the total non-internet population [5]. A large number of older adults are not yet connected to the internet and lack the skills to use digital devices, which not only prevents them from enjoying the benefits of the digital era, such as online medical consultations, e-commerce, and mobile payments, but also exacerbates their sense of social isolation. For example, during the COVID-19 pandemic, many older adults were unable to present health codes due to their unfamiliarity with smartphones or digital operations, leading to significant inconveniences in travel, medical care, and shopping. Some older adults were even denied entry to malls, train stations, and other public places because they could not use health codes, severely impacting their daily lives. Therefore, bridging the digital divide among older adults has become a critical issue in the development of an aging society in China. Addressing the digital divide among older adults, understanding its underlying causes, and resolving the challenges of digital inclusion for older adults are essential for the development of the silver economy and the enhancement of older adults' well-being.

Current research on the digital divide among older adults, both domestically and internationally, primarily focuses on the causes of the digital divide and potential solutions. Scholars have used methods such as questionnaires [6], interviews [7], and case studies [8] to analyze the causes of the digital divide from various perspectives, including social support [8], capability poverty [9], power dynamics [10], and life course theory [11]. Other scholars have proposed strategies to bridge the digital divide at the individual, family, social, corporate, and governmental levels [14-20] through literature reviews [12] and case studies [13]. The digital divide among older adults is a complex social issue with multidimensional causes and interrelated factors. However, existing research lacks a systematic summary of the factors influencing the digital divide among older adults and has not thoroughly explored the relationships between these factors, which hinders the development of targeted solutions.

Given this, this study aims to address two core questions through empirical investigation and the construction of a three-dimensional analytical framework (access divide, usage divide, and capability divide): (i) to deeply analyze the typical characteristics and influencing factors of the digital divide among older adults; and (ii) to explore the relationship between the personal characteristics of older adults and their potential learning willingness. The ultimate goal of this study is to provide a scientific basis for formulating effective digital inclusion policies.

2. Material and methods

2.1. Research participants

This study recruited 936 older adults (≥60 years) in Zhengzhou through multi-stage sampling, stratified by gender and occupation. Inclusion criteria required participants to: (i) possess basic communication capacity, and (ii) be free from severe cognitive/sensory impairments. To accommodate age-related challenges (e.g., vision/hearing decline), questionnaires were flexibly administered via researcher-assisted interviews (oral Q&A with recording) or self-completion. All participants provided informed consent after reviewing study protocols.

Demographic breakdown: 71.79% aged 60-75 vs. 28.21% ≥75; monthly income distribution: 20.22% (＞ CNY 2,000), 58.76% (CNY 1,000-2,000), 21.02% (≤CNY 1,000). Ethical approval was waived given minimal risk and non-interventional design.

2.2. Research instrument

A four-section questionnaire was developed integrating literature review and participant interviews: (i) Demographics: Gender, age, household structure, income, health status. (ii) Access gap: Internet availability and device ownership. (iii) Usage gap: Barriers in digital tool adoption. (iv) Competency gap: Digital literacy for life quality improvement, operationalized as ability to utilize digital services effectively. The instrument underwent reliability testing (Cronbach's α ＞ 0.80) and content validity verification.

2.3. Data collection

Field surveys yielded 936 valid responses from 990 distributed (94.5% efficiency). Anonymous data collection emphasized participant autonomy and confidentiality. Rigorous quality controls were implemented pre-, during, and post-survey.

2.4. Data analysis

Three-tier digital divide analysis: (i) Access/Usage gaps: Multivariate logistic regression identified key predictors (e.g., income, health). (ii) Competency gap: Structural equation modeling (SEM) mapped causal pathways between literacy, motivation, and barriers, revealing hierarchical progression from access to competency gaps.

3. Results

3.1. Establishment and Results of the Logistic Model

To identify determinants of usage barriers, we established the following model:

$$\ln\left(\frac{Y_i}{1-Y_i}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_5 x_5 + \delta_i$$

where Y represents the ordinal severity of usage barriers. Data for variables Y, X_1 (living arrangement), X_2 (education level), X_3 (sensory aging), X_4 (information processing speed), and X_5 (perceived cybersecurity) were analyzed using SPSS. The likelihood ratio Chi-square test yielded a statistically significant result ($\chi^2 = 58.641$, *p* < 0.001), confirming that at least one predictor significantly explained barrier classification. Goodness-of-fit tests (Pearson χ^2: *p* = 0.709; Deviance χ^2: *p* = 0.806) indicated satisfactory model fit. The parallel lines test (χ^2 *p* = 0.137) validated the proportional odds assumption, permitting ordered logistic regression.

Using $Y = 2$ (moderate barriers) with reference categories X_1–5 = 5, parameter estimates revealed significant associations:

$$\ln\left(\frac{Y_0}{1-Y_0}\right) = 1.366 - 0.558x_{1_{x_1=1}} - 0.656x_{1_{x_1=2}} - 2.025x_{1_{x_1=3}} + 0..941 \quad x_{5_{x_5=4}}$$

$$\ln\left(\frac{Y_1}{1-Y_1}\right) = 1.366 - 0.558x_{1_{x_1=1}} - 0.656x_{1_{x_1=2}} - 2.025x_{1_{x_1=3}} + 0..941 \quad x_{5_{x_5=4}}$$

$$\ln\left(\frac{Y_2}{1-Y_2}\right) = 1.366 - 0.558x_{1_{x_1=1}} - 0.656x_{1_{x_1=2}} - 2.025x_{1_{x_1=3}} + 0..941 \quad x_{5_{x_5=4}}$$

Living Arrangement (X_1): Older adults living alone exhibited 7.576 times higher odds (OR = $*e^{*2.025}$, *p* < 0.05) of severe barriers compared to those cohabiting with relatives, likely due to limited access to immediate assistance.

Education Level (X_2): Lower educational attainment substantially increased barrier risks relative to college graduates: elementary (OR = 12.756, $*e^{*2.546}$), junior high (OR = 17.975, $*e^{*2.889}$), senior high (OR = 10.014, $*e^{*2.304}$), and vocational education (OR = 19.240, $*e^{*2.957}$), confirming education as a critical mitigator of digital exclusion.

Sensory Aging (X_3): Participants who strongly agreed with hearing/vision decline faced higher barrier severity (OR = 0.160, $*e^{*-1.835}$, *p* < 0.05), suggesting self-awareness of sensory limitations exacerbates digital challenges.

Information Processing (X_4): Perceived slow processing speed predicted severe barriers, with "strongly disagree" (OR = 0.016, $*e^{*-4.088}$) and "neutral" responses (OR = 0.144, $*e^{*-1.940}$) showing significant effects (*p* < 0.05).

Cybersecurity Concerns (X_5): Moderate (OR = 0.240, $*e^{*-1.426}$) and high (OR = 0.390, $*e^{*-0.941}$) perceived information insecurity correlated with elevated barriers (*p* < 0.05), likely reflecting limited digital literacy in threat assessment and verification.

This analysis underscores the multifactorial nature of digital barriers, emphasizing the interplay between socio-

demographic factors, sensory capacity, and digital literacy in shaping older adults' technology adoption.

3.2. Structural Equation Model Fitting and Results

3.2.1. Model Assumptions

This study analyzed factors influencing elderly individuals' daily life, interpersonal communication, recreational activities, and learning behaviors using valid survey data. Observational variables were categorized into personal, product-related, and external causes, with corresponding question items summarized in **Table 1**.

Table 1. Observed Variable Settings and Corresponding Question Numbers

Latent Variable	Observed Variable	Corresponding Question Number
Personal Reasons	Hearing and Vision Aging	X1
	Decline in Mobility	X2
	Slowed Perception of Information	X3
	Insufficient Income Level	X4
	Limited Cultural Level	X5
	Fear of Trying New Things and Resistance	X6
Product Reasons	Poor Usability of Internet Courses	X7
	High Cost of Electronic Products	X8
	Inconvenient Platform Interface Operation	X9
	Unsafe Network Information	X10
	High Cost of Elderly Classes	X11
External Reasons	Busy Children, No Time to Teach	X12
	No Time to Learn	X13
	Lack of Family Support	X14
Daily Life	Showing Health Code During the Pandemic	Y1
	Making Electronic Payments	Y2
	Convenience in Daily Life (e.g., Online Registration, Utility Payments, Navigation)	Y3
Interpersonal Communication	Contacting Others (e.g., Phone Calls, Texting, Video Calls)	Y4
	Making New Friends	Y5
	Maintaining Old Friendships	Y6
Entertainment	Browsing Video Websites	Y7
	Playing Online Games (e.g., Chess, Mahjong, Poker)	Y8
	Online Shopping	Y9
Reading and Learning	Understanding News Events and Social Issues	Y10
	Learning New Knowledge	Y11
	Obtaining Personal Life Information (e.g., Cooking, Health Knowledge)	Y12

Note: This table presents the results of the reliability test using Cronbach's Alpha coefficient method. It shows the Cronbach's Alpha value and the number of items in the questionnaire, indicating that the questionnaire has good reliability.

H1-H4 posit that personal factors (exogenous latent variables) significantly affect elderly daily life/communication/recreation/learning (endogenous variables), with observational variables mediating these effects indirectly.

H5-H8 propose product factors significantly impact these domains through similar mediation.

H9-H12 hypothesize external factors similarly influence outcomes via observational variables.

3.2.2. Structural Equation Modeling

The model was validated using SPSS and AMOS to examine relationships among variables. Fit indices met standards: GFI=0.832, CFI=0.973, RMSEA=0.062 ($p<0.05$). All hypothesized paths achieved significance ($p\approx0$).

(1) Personal Factors: Auditory/visual aging (0.813) and resistance to technology (0.793) were primary influences, followed by reduced mobility (0.712) and slowed processing (0.689).

(2) Product Factors: Cybersecurity concerns (0.810) dominated, followed by cost sensitivity (0.780-0.770). Usability (0.666) directly affected adoption willingness.

(3) External Factors: Family support (0.730) and time availability (0.663) were critical, with 64% co-residency rates emphasizing intergenerational reliance.

(4) Daily Life: Health code requirements (0.747) most impacted routines, while electronic payments showed weaker association (0.512) due to continued cash acceptance.

(5) Interpersonal Communication: Maintaining old relationships (0.682) slightly exceeded contacting others (0.654).

(6) Recreation: Video browsing (0.799) dominated leisure activities, with online shopping (0.432) limited by financial caution.

(7) Learning: Information acquisition (0.70-0.72) surpassed knowledge acquisition (0.543), reflecting declining cognitive engagement with age.

Personal factors correlated most strongly with external influences (0.543), followed by product factors (0.405), indicating bidirectional interactions between physical/psychological states and environmental/technological barriers.

Table 2. Correlation Between Factors

Path	Estimate
External Reasons <--> Product Reasons	0.352
Personal Reasons <--> Product Reasons	0.405
Personal Reasons <--> External Reasons	0.543

Note: This table displays the results of the validity test, including the KMO value and the results of Bartlett's sphericity test. The high KMO value and the significant chi-square value indicate that the questionnaire has good structural validity.

4. Discussion

Firstly, in terms of elderly individuals using digital products to meet daily life needs, product factors are the most influential. These factors mainly include perceived internet information insecurity, expensive product courses, and cumbersome digital product operations. If elderly individuals perceive internet information as insecure, they are more likely to reject using digital products, thereby exacerbating the ability gap. Secondly, personal factors cannot be ignored. The elderly have a lower ability to accept new things and a higher level of resistance, making it more difficult for them to meet their daily life needs and further complicating the elimination of the ability gap.

Secondly, in terms of elderly individuals using digital products to meet interpersonal communication needs, product factors also play a dominant role. Particularly, the cost of digital products, such as the consumption of data and call charges when making video calls without Wi-Fi, undoubtedly increases the financial burden on the elderly, making it difficult for them to meet their basic needs of contacting others and maintaining relationships with old friends.

Thirdly, in terms of elderly individuals using digital products to meet entertainment needs, product factors also play a crucial role. The complexity of digital product operations and the ease of use of online courses directly affect whether elderly individuals can pass their free time by playing games online. The more complex the operations and the less user-friendly the courses, the more difficult it is for the elderly to enjoy the entertainment provided by digital products, thereby highlighting the ability gap. Additionally, since online shopping involves monetary transactions, the elderly's perception

of the security of the online environment will directly affect their online shopping behavior. The more elderly individuals perceive the online environment as insecure, the more difficult it is for them to meet their online shopping needs.

Finally, in terms of elderly individuals using digital products to meet reading and learning needs, external factors are the most influential. Some elderly individuals, due to their children's busy work schedules, need to take care of their grandchildren, leaving them with little time and energy to focus on personal life-related aspects. This, to some extent, limits their reading and learning needs. Additionally, personal factors cannot be ignored. As age increases, physical functions gradually decline, and the worse the physical condition of the elderly, the more difficult it is for them to learn new knowledge, thereby widening the ability gap in reading and learning.

5. Conclusion and Implications

Under the dual social backdrop of digitization and aging, this paper takes the digital divide among elderly populations aged over 60 in Zhengzhou as an example, analyzing the typical characteristics of the digital divide among the elderly from five aspects: age, place of residence, occupation, culture, and income. This survey adopts the perspective of the elderly as the starting point, examining three aspects: access divide, usage divide, and ability divide. Among them, there is currently no unified academic standard for defining the third divide. Combining the more widely used knowledge divide and literacy divide, we define the third divide as whether individuals possess the ability to enhance their quality of life through digital products and the services they provide, i.e., the ability divide. Subsequently, we analyze the influencing factors of these three levels of divides: (1) The access divide is analyzed using the CART decision tree model, with the number of input variables reduced based on attribute importance, effectively minimizing redundancy and simplifying the decision tree for better understanding; (2) The usage divide is analyzed through multiple logistic regression, with the main factors influencing the usage divide derived from parameter estimation results; (3) By establishing a structural equation model to output a path coefficient diagram, the main factors influencing the ability divide are obtained, thereby outlining the formation path of the digital divide from shallow to deep. Finally, cross-tabulations are utilized to explore the relationship between the personal characteristics of the elderly and their preferred methods of learning, and the pathways for bridging the digital divide are analyzed. The research findings are as follows: (1) The Internet is integrating into the lives of the elderly. According to statistical data, 92.3% of the elderly have accessed the Internet, having crossed the first divide of the digital divide. (2) Personal characteristics affect the use of Internet products. Self-factors such as aging hearing and vision, and slow information perception inevitably cause difficulties for elderly populations in using digital products. Additionally, the insecurity of online information is another significant barrier for the elderly in crossing the usage divide. (3) Needs drive the bridging of the ability divide. Factors such as cumbersome product operations and insecure online information affect the elderly's needs in daily life, interpersonal communication, entertainment, and other aspects, while external factors such as lack of time for learning have the greatest impact on the elderly's reading needs.

This paper makes the following theoretical contributions: Firstly, by comprehensively applying various statistical methods, it deepens the understanding of the formation mechanism of the digital divide and provides new perspectives and evidence for related theoretical research. Secondly, it subdivides the digital divide into three levels: access divide, usage divide, and ability divide, and defines the specific connotation of the ability divide, which helps enrich and improve the theoretical framework of the digital divide. Finally, through empirical analysis, it reveals the relationship between the personal characteristics of the elderly and their choice of learning methods, providing a theoretical basis for understanding the digital skill learning behavior of the elderly. Based on the research findings, the following management or policy recommendations are proposed: Firstly, governments at all levels should exert their subjective initiative, fulfill their responsibilities and divisions of labor, establish working mechanisms, and solidly promote the high-quality implementation of various services for the elderly, so that they can have a greater sense of gain, happiness, and security in the development of informatization. Secondly, helping the elderly cross the "digital divide" cannot be achieved without their own initiative and the care of their families. Family members, especially children, can provide the most direct and effective support

through educational feedback. Finally, enterprises should be encouraged to develop products and services that meet the needs of the elderly, ensure their network information security, vigorously advocate and establish a lifelong education system, and focus on strengthening the construction of digital information infrastructure in underdeveloped areas.

However, this paper still has some limitations. Firstly, the research sample is limited to Zhengzhou, which may not fully reflect the overall situation of China's elderly population regarding the digital divide. Secondly, due to the complexity of questionnaire design and the cognitive limitations of the elderly, some data may be biased or omitted. In response to these limitations, future research can be expanded in the following directions: Firstly, expand the scope of the research sample to cover more regions and types of elderly populations to enhance the representativeness and universality of the research. Secondly, optimize the questionnaire design by using simpler and clearer questions and options to reduce the cognitive burden on the elderly. Finally, introduce more diversified research methods and technological means, such as experimental methods and in-depth interviews, to more deeply explore the formation mechanism and solutions of the digital divide among the elderly.

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Abbreviations

- CART: Classification and Regression Trees
- SEM: Structural Equation Modeling
- GFI: Goodness-of-Fit Index
- CFI: Comparative Fit Index
- RMSEA: Root Mean Square Error of Approximation
- PGFI: Parsimony Goodness-of-Fit Index
- PCFI: Parsimony Comparative Fit Index

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